JAE GUNNPAL

OBJECTIVE TYPE QUESTIONS AND ANSWERS

IN

CHEMICAL ENGINEERING

Dr. RAM PRASAD
Asstt. Professor
Department of Chemical Engineering
Harcourt Butler Technological Institute
KANPUR-208002

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Preface to the Second Edition

It gives me a great pleasure to present the Second Edition of the OBJECTIVE TYPE QUESTIONS AND ANSWERS IN CHEMICAL ENGINEERING. Various suggestions of the readers have been incorporated to meet the latest patterns of examinations. These include the questions of the **Fill in the blanks and Matching the two parts types and important Definitions in addition to the Multiple choice type of questions.** A new Chapter on Renewable Sources of Energy is the additional feature of this edition. The printing errors in the previous edition are also corrected. I hope the book in the present form will prove to be more useful to the young chemical engineers.

Ram Prasad

Preface to the First Edition

Now-a-days objective type questions are asked in almost all written examinations conducted by various organisations to recruit young engineers. With the objective of providing a number of questions related to almost all the main branches of Chemical Engineering and Chemical Technology, this book has been presented. There are about 3000 questions which have been methodically selected and presented starting from basic fundamentals to the current topics of industrial importance.

This book will be primarily helpful for fresh graduates of Chemical Engineering and Chemical Technology who can prepare themselves soundly for both written as well as oral examinations. At the same time this can be used as a readily available handbook for quick reference by practising engineers.

The author will greatly appreciate being informed of suggestions for the improvement of the book.

Ram Prasad

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1

Fluid Mechanics and Solid Handling

DEFINITIONS

Acoustical Velocity. The velocity of sound through a continuous material medium. It is defined by

$$a = \sqrt{g_c \left(\partial P / \partial \rho\right)_s}$$

The subscript S denotes the isentropic restraint on the process.

Bond Crushing law. The work required to form particles of size D_r from very large feed is proportional to the square root of the surface-to-volume ratio of the product. This leads to the relation

$$\frac{P}{m} = \frac{K_b}{\sqrt{D_P}}$$

where P is power required by the machine, m is feed rate, K_b is constant.

Boundary layer. That part of a moving fluid in which the fluid is influenced by the presence of a solid boundary.

Brownian movement. Random motion imparted to the particle by collisions between the particle and the molecules of the surrounding fluid.

Buckingham Pi theorem. The number of dimensionless groups is equal to the difference between the number of variables and number of dimensions used to express them.

Buoyancy force. The product of the mass of fluid displaced by the particle and the acceleration from the gravity force.

Comminution. A generic term for size reduction.

Compressible fluid. The changes in density of the compressible fluid are significant with moderate changes in temperature and pressure.

Crushing efficiency. The ratio of surface energy created by crushing to the energy absorbed by the solid.

Darcy friction factor. Four times Fanning friction factor.

Darcy's law. The flow of liquids through porous media is directly proportional to pressure drop and inversely proportional to fluid viscosity.

Drag. The force in the direction of flow exerted by the fluid on the solid.

Drag coefficient. The ratio of drag force per unit sectional area of the sphere normal to the velocity to the product of density of fluid and velocity head $(\overline{V}^2/2g_c)$.

Fanning friction factor. The ratio of the wall shear stress to the product of the density of fluid and the velocity head $(\overline{V}^2/2g_c)$.

Form friction. When boundary layer separates and forms wakes, additional energy dissipation appears within the wake and friction of this type is called form friction.

Free settling. When the particle is at sufficient distance from the boundaries of the container and from other particles, so that its fall is not affected by them, the process is called free settling.

Hindered settling. If the motion of the particle is impeded by other particles, which will happen when the particles are near each other even though they may not actually be colliding, the process is called hindered settling.

Ideal fluid. Incompressible fluid of zero viscosity.

Incompressible fluid. Fluids for which density changes are insignificant with moderate changes in temperature and pressure.

Kick's law. The work required for crushing a given mass of material is constant for the same reduction ratio, that is, the ratio of the initial particle size to the final particle size. This leads to the relation

$$\frac{P}{m} = K_k \ln\left(\frac{\overline{D}_{sa}}{\overline{D}_{sb}}\right)$$

Kinematic viscosity. The ratio of dynamic viscosity to the density of the liquid at the same temperature.

Kinetic energy correction factor, α. It is defined by

$$\alpha = \frac{1}{S}\int_S \left(\frac{u}{\overline{V}}\right)^3 dS$$

Mach number. The ratio of the speed of the fluid to the speed of sound in the fluid under conditions of flow.

Manometer. A device for measuring pressure difference.

Mass velocity. Mass flow rate divided by the cross sectional area of flow.

Mohr stress circle. A circle with a radius $(p_V - p_L)/2$ and its center on the horizontal axis at $p = (p_V + p_L)/2$ where p_V is applied pressure, p_L is normal pressure and p is pressure at any angle.

Momentum correction factor, β. It is defined by

$$\beta = \frac{1}{S}\int_S \left(\frac{u}{\overline{V}}\right)^2 dS$$

Newton's law of viscosity. Shear stress is proportional to the rate of shear in the direction perpendicular to motion.

Newtonian fluid. The fluid for which the plot of shear stress versus shear strain is a straight line passing through the origin.

Potential flow (Irrotational flow). The flow of an ideal fluid.

Reopectic fluids. The shear stress at constant shear rate increases with time.

Rittinger's law. The work required for crushing is proportional to the new surface created. It is written as

$$\frac{P}{m} = K_r\left(\frac{1}{\overline{D}_{sb}} - \frac{1}{D_{sa}}\right)$$

where $\overline{D}_{sa}$ and $\overline{D}_{sb}$ are volume-surface mean diameter of feed and product, respectively.

Skin friction. Friction generated in unseparated boundary layers.

Sphericity, ϕ_S. The surface to volume ratio for a sphere of diameter D_P divided by the surface to volume ratio for the particle whose nominal size is D_P.

$$\phi_S = (6/D_P)/(S_p/v_p)$$

Streamline. An imaginary curve in a mass of flowing fluid so drawn that at every point on the curve the net-velocity vector is tangent to the stream line.

Stream tube. A tube of small or large cross section and of any convenient cross-sectional shape that is entirely bounded by streamlines. It can be visualized as an imaginary pipe in the mass of flowing fluid through the walls of which no net flow is occurring.

Terminal velocity. Maximum attainable velocity of a particle through a fluid.

Thixotropic fluids. Break down under continued shear and on mixing give lower shear stress for a given shear rate.

Viscosity (dynamic or absolute). The ratio of the applied shear stress to the rate of shear.

Work index. The gross energy requirement in kWh per ton of feed needed to reduce a very large feed to such a size that 80% of the product passes a 100 μm screen.

Yield stress. The shear stress that must be developed in the liquid to initiate flow.

1. A fluid is a substance that
(*a*) always expands until it fills any container
(*b*) is practically imcompressible
(*c*) deforms continuously when subjected to a shear stress, no matter how small that shear stress may be
(*d*) cannot be subjected to shear stress.

2. Newton's law of viscosity relates
(*a*) pressure, velocity, and viscosity
(*b*) shear stress and rate of angular deformation in a fluid
(*c*) temperature, viscosity, and velocity
(*d*) pressure, temperature, viscosity, and rate of angular deformation in a fluid.

3. Falling drops of rain acquire spherical shape on account of
(*a*) temperature (*b*) viscosity
(*c*) compressibility (*d*) surface tension.

4. A perfect gas
(*a*) is incompressible
(*b*) has zero viscosity
(*c*) cannot develop shear stresses
(*d*) has constant specific heats and satisfies $PV = nRT$.

5. The bulk modulus of elasticity for a liquid
(*a*) is independent of temperature
(*b*) increases with the pressure
(*c*) has the dimensions of volume
(*d*) is independent of pressure.

6. The bulk modulus of elasticity for a liquid has the units
(*a*) kg/m^3 (*b*) N/m^2
(*c*) m^3 (*d*) N.

7. The bulk modulus of elasticity for an incompressible fluid is
(*a*) 0 (*b*) ∞
(*c*) 1 (*d*) equal to its density.

8. What is the bulk modulus of elasticity if the pressure of any volume V of liquid is increased by dP and the corresponding volume decrease is $-dV$?
(*a*) $-\frac{dP}{dV}$ (*b*) $-\frac{dP}{V}$
(*c*) $-\frac{dP}{(dV/V)}$ (*d*) $-dP$.

9. The bulk modulus of elasticity for an ideal gas at constant temperature T_g is given by

(*a*) $\frac{RT_g}{M}$ (*b*) $\frac{\rho R T_g}{M}$
(*c*) $\frac{\rho}{P}$ (*d*) $\frac{\rho R}{M}$
where M = molecular weight

10. Viscosity has the dimensions
(*a*) $FL^{-2}T^{-1}$ (*b*) $F^{-1}L^2T^{-1}$
(*c*) $FL^{-2}T$ (*d*) $F^{-1}L^2T$
where dimensions F, L, and T are used for force, length and time.

11. Viscosity has the dimensions
(*a*) $ML^{-1}T^{-1}$ (*b*) $M^{-1}LT$
(*c*) $ML^{-1}T^{-3}$ (*d*) MLT^{-3}.
where dimensions M, L, and T are used for mass, length and time.

12. Newton's law of viscosity states that for a given rate of angular deformation of fluid.
(*a*) the shear stress is directly proportional to the viscosity
(*b*) the shear stress is inversely proportional to the viscosity
(*c*) the shear stress is independent of the viscosity
(*d*) the shear stress is directly proportional to the square of viscosity.

13. The resistance of a fluid to shear depends
(*a*) upon cohesion only
(*b*) upon its rate of transfer of molecular momentum only
(*c*) upon its cohesion and rate of transfer of molecular momentum
(*d*) upon other factors than its cohesion and rate of transfer of molecular momentum.

14. Surface tension has the dimensions
(*a*) FL^{-2} (*b*) FL
(*c*) $F^{-1}L^3$ (*d*) FL^{-1}.

15. Capillary is due to
(*a*) adhesion
(*b*) cohesion
(*c*) both adhesion and cohesion
(*d*) neither adhesion nor cohesion.

16. The specific weight (γ) of a substance
(*a*) is its weight per unit volume
(*b*) is its mass per unit volume
(*c*) does not change with location
(*d*) is not a convenient property when dealing with fluid statics.

17. In order to avoid a correction for the effect of capillary in manometers used for measuring pressure, the diameter of the tube should be
(*a*) less than or equal to 3 mm

(*b*) more than 3 mm but less than 5 mm
(*c*) equal to 5 mm
(*d*) greater than or equal to 0·5 inch.

18. Surface tension is due to
(*a*) cohesion only
(*b*) difference in magnitude between the forces due to adhesion and cohesion
(*c*) adhesion between liquid and solid molecules
(*d*) frictional forces.

19. Weight of liquid that rises in capillary tube is supported by
(*a*) the vertical component of force due to surface tension
(*b*) the local atmospheric pressure
(*c*) the viscous force
(*d*) the horizontal component of force due to surface tension.

20. The capillary rise in water is on account of
(*a*) adhesion being greater than cohesion
(*b*) cohesion being greater than adhesion
(*c*) adhesion being equal to cohesion
(*d*) vapor pressure being small.

21. The capillary rise or depression in a small diameter tube is
(*a*) directly proportional to the surface tension
(*b*) inversely proportional to the surface tension
(*c*) directly proportional to the diameter of the tube
(*d*) inversely proportional to the diameter of the tube.

22. The pressure difference between inside and outside of a liquid drop is given by

(*a*) $\frac{2\sigma}{d}$ (*b*) $\frac{8\sigma}{d}$
(*c*) $\frac{16\sigma}{d}$ (*d*) $\frac{4\sigma}{d}$.

23. The pressure within a soap bubble is
(*a*) less than the external pressure
(*b*) greater than the external pressure
(*c*) equal to the external pressure
(*d*) equal to the vapour pressure at the prevailing temperature.

24. The capillary rise of water is maximum for glass tube of size
(*a*) 10 mm (*b*) 5 mm
(*c*) 3 mm (*d*) 1 mm.

25. Spherical shape of droplets of mercury is due to its
(*a*) high adhesion (*b*) low vapour pressure
(*c*) high surface tension (*d*) high density.

26. Surface tension of water in contact with air at 20°C is
(*a*) 0·0731 lbf/ft (*b*) 0·0731 N/m
(*c*) 0·0731 dyn/cm (*d*) 0·731 kgf/m.

27. Two capillary tubes of different diameter are dipped in water. The rise of water is
(*a*) greater in the tube of smaller diameter
(*b*) greater in the tube of larger diameter
(*c*) same in both tubes
(*d*) zero in both tubes.

28. A soap bubble of initial radius r is to be blown up. The surface tension of the soap film is σ. The surface energy needed to double the diameter of the bubble without change of temperature is
(*a*) $4\pi r^2\sigma$ (*b*) $12\pi r^2\sigma$
(*c*) $24\pi r^2\sigma$ (*d*) $16\pi r^2\sigma$.

29. Rain drops fall from a great height under gravity. Select the only correct statement from the following :
(*a*) Their velocities go on increasing until they hit the earth with the same velocity
(*b*) Their velocities go on increasing as they hit the earth, but final velocities of different drops are different
(*c*) They fall with a terminal velocity which is the same for every drop
(*d*) They fall with terminal velocities which are different for drops of different size.

30. Kinematic viscosity has the dimensions
(*a*) $M^{-1} L^{-1} T^{-1}$ (*b*) $L^2 T^{-1}$
(*c*) $L^{-2} T$ (*d*) MLT^{-2}.

31. The absolute viscosity of a fluid is a property which
(*a*) is a function of the motion of the fluid
(*b*) is independent of pressure and temperature
(*c*) is a function of the shear stress in the fluid.

32. Which of the following is most viscous fluid ?
(*a*) Water (*b*) Glycerine
(*c*) Coal tar (*d*) Ethyl alcohol.

33. The SI unit of dynamic viscosity is
(*a*) N.s/m^2 (*b*) N/m.s
(*c*) m^2/s (*d*) kg.s/m^2.

34. Stoke (St) is the unit of kinematic viscosity and one stoke is equal to
(*a*) 1 m^2/s (*b*) 1 ft^2/s
(*c*) 1 cm^2/s (*d*) 1 mm^2/s.

35. Poise (P) is the unit of dynamic viscosity and one Poise is equal to
(*a*) 1 N.s/m^2 (*b*) 1 lb/ft.hr
(*c*) 1 g/cm.s (*d*) 1 kg/m.s.

36. Absolute viscosity, expressed in poises, is converted to the SI unit of viscosity by multiplication by
(*a*) 1 (*b*) 0·1
(*c*) 0·01 (*d*) 0·001.

37. In converting from the poise to lb/ft.hr, one multiplies by
(*a*) 2·04 (*b*) 0·41
(*c*) 2·42 (*d*) 145·2.

38. To convert for the stoke to ft^2/s, one multiplies by
(*a*) 1 (*b*) $(30{\cdot}48)^2$
(*c*) $(30{\cdot}48)^{-2}$ (*d*) 144.

39. The numerical value of g_c, Newton's law proportionality factor, is
(*a*) 32·174 lbm.ft/lbf.s^2 (*b*) 9·806 kg.m/kgf.s^2
(*c*) 1 kg.m/N.s^2 (*d*) any of these answers.

40. For $\mu = 2{\cdot}49$ Poise, sp. gr = 0·83, ν, in Stokes, is
(*a*) 2·07 (*b*) 0·3
(*c*) 3 (*d*) 3×10^{-3}.

41. For $\nu = 3$ St and $\rho = 0{\cdot}80$ g/cm^3, μ, in N.s/m^2, is
(*a*) 0·375 (*b*) 3·75
(*c*) 0·24 (*d*) 2·4.

42. The viscosity of a gas
(*a*) increases with increase in temperature
(*b*) decreases with increase in temperature
(*c*) remains unaffected with change in temperature
(*d*) is greater than the viscosity of a liquid.

43. The viscosity of a liquid
(*a*) remains unaffected with change in temperature
(*b*) decreases with increase in temperature
(*c*) increases with increase in temperature
(*d*) is dependent on pressure only.

44. The property of a fluid by virtue of which it offers resistance to shear is known as
(*a*) density (*b*) surface tension
(*c*) viscosity (*d*) vapor pressure.

45. The law similar to Newton's law viscosity used in the solid mechanics is called
(*a*) Newton's second law of motion
(*b*) Archimedes principle
(*c*) Hooke's law
(*d*) Newton's third law of motion.

46. An ideal fluid is one which
(*a*) is very viscous
(*b*) is frictionless and incompressible
(*c*) has negligible surface tension
(*d*) obeys Newton's law of viscosity.

47. A Newtonian fluid is one which
(*a*) is frictionless and incompressible
(*b*) has a linear relationship between the magnitude of applied shear stress and the resulting rate of deformation
(*c*) has a nonlinear relationship between the magnitude of applied shear stress and the resulting rate of deformation
(*d*) has a vapor pressure of 1 N/m^2 at 25°C.

48. Fluid continuum is a concept in which
(*a*) the actual molecular structure is replaced by a hypothetical continuous medium
(*b*) fluid particles are widely scattered in space
(*c*) fluid is non-homogeneous
(*d*) fluid density is very low.

49. An incompressible flow is one in which
(*a*) the fluid is frictionless
(*b*) the fluid compressibility is greater than zero
(*c*) the density does not change with pressure and temperature
(*d*) the temperature of fluid remains constant.

50. Which curve in Fig. 1·1 represents Newtonian fluids ?
(*a*) A (*b*) B
(*c*) C (*d*) E.

51. Which curve in Fig. 1·1 represents Bingham plastics ?
(*a*) A (*b*) B
(*c*) C (*d*) D.

52. Which curve in Fig. 1·1 represents pseudoplastic fluids ?
(*a*) B (*b*) C
(*c*) D (*d*) E.

53. Which curve in Fig. 1·1 represents dilatent fluids ?
(*a*) A (*b*) C
(*c*) D (*d*) B.

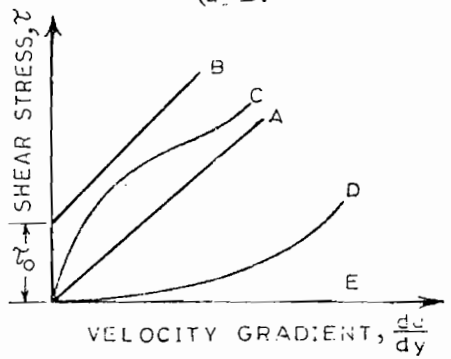

Fig. 1·1. Shear stress versus velocity gradient at constant temperature and pressure for Newtonian and non-Newtonian fluids.

54. Which curve in Fig. 1·1 represents an ideal fluid ?
(*a*) A (*b*) C
(*c*) D (*d*) E.

55. An example of Newtonian fluid is
(*a*) non-colloidal solution (*b*) sewage sludge
(*c*) rubber latex (*d*) quicksand.

56. An example of a pseudoplastic fluid is
(*a*) gas (*b*) rubber latex
(*c*) sewage sludge (*d*) quicksand.

57. An example of Bingham plastic is
(*a*) gas (*b*) non-colloidal solution
(*c*) sewage sludge (*d*) rubber latex.

58. An example of dilatent fluid is
(*a*) non-colloidal solution (*b*) quicksand
(*c*) rubber latex (*d*) sewage emulsion.

59. Power law is given by

$$\tau_{yx} = -m\left|\frac{dv_x}{dy}\right|^{n-1}\frac{dv_x}{dy}$$

Power law reduces to Newton's law of viscosity for
(*a*) $n < 1$ (*b*) $n > 1$
(*c*) $n = 1$ and $m \neq \mu$ (*d*) $n = 1$ and $m = \mu$.

60. Power law behaviour is pseudoplastic for
(*a*) $n = 1$ (*b*) $n < 1$
(*c*) $n > 1$ (*d*) $n = 0$.

61. Power law behaviour is dilatent for
(*a*) $n = 0$ (*b*) $n < 1$
(*c*) $n > 1$ (*d*) $n = 1$.

62. A 2·0 kg object weighs 1·9 kgf on a spring balance. The value of g at this location, in m/s^2, is
(*a*) 9·806 (*b*) 9·316
(*c*) 10·322 (*d*) 0·95.

63. At a location where $g = 31{\cdot}0$ ft/s^2, 3 slugs is equivalent to how many pounds mass ?
(*a*) 90·00 (*b*) 93·00
(*c*) 0·01 (*d*) 96·522.

64. The weight, in pounds force, of 6 slugs on a planet where $g = 5{\cdot}362$ ft/s^2 is
(*a*) 193·044 (*b*) 1035·166
(*c*) 32·174 (*d*) 6·0.

65. A pressure of 225 psi applied to 10 ft^3 liquid causes a volume reduction of 0·03 ft^3. The bulk modulus of elasticity, in psi, is

(*a*) 750 (*b*) 7500
(*c*) –75000 (*d*) 75000.

66. A shear stress of 6 dyn/cm^2 causes a Newtonian fluid to have an angular deformation of 2 rad/s. Its viscosity, in centipoise, is
(*a*) 300 (*b*) 3
(*c*) 12 (*d*) 1200.

67. A plate, 0·6 mm distant from a fixed plate, moves at 0·24 m/s and requires a force per unit area of 1 N/m^2 to maintain this speed. The fluid viscosity of the substance between the plates, in N.s/m^2, is
(*a*) 0·4 (*b*) 2·5
(*c*) $2{\cdot}5 \times 10^{-3}$ (*d*) $0{\cdot}4 \times 10^3$.

68. The density of O_2 at 10°C and 20×10^5 N/m^2 abs, in kg/m^3, is
(*a*) 769·8 (*b*) 0·85
(*c*) 870·6 (*d*) 27·2.

69. How many kilograms of carbon monoxide gas at 20°C and 2×10^5 N/m^2 are contained in a volume of 0·12 m^3 ?
(*a*) 3·62 (*b*) 0·276
(*c*) $9{\cdot}85 \times 10^{-3}$ (*d*) 4·04.

70. The molecular weight of air is 29. The value of R for air, in N.m/kg. K, is
(*a*) 241048 (*b*) 8312
(*c*) 285·6 (*d*) 63·3.

71. Assuming ideal gas behaviour, calculate the number of cubic feet of carbon dioxide gas at 68°F and 2 atm pressure which may be obtained from 50 lbs of dry ice
(*a*) 1·14 (*b*) 28·2
(*c*) 219 (*d*) 344.

72. Mercury is used in barometers due to
(*a*) its very low vapour pressure
(*b*) its high density
(*c*) its low compressibility
(*d*) negligible capillary effect.

73. Vapour pressure of a liquid is due to
(*a*) the existence of free surface
(*b*) the fluid pressure
(*c*) the pressure of air above the free surface
(*d*) the molecules of liquid which hang over the free surface.

74. The vapour pressure of water at 100°C is
(*a*) 13·6 cm of Hg (*b*) 100 cm of Hg
(*c*) 76 cm of Hg (*d*) 100 N/cm^2.

75. The vapour pressure of liquid
(*a*) remains unaffected with change in temperature
(*b*) decreases with increase in temperature
(*c*) increases with increase in temperature
(*d*) increases linearly with increase in temperature.

76. The problems of fluid statics are influenced by
(*a*) frictional and surface tension forces
(*b*) gravity and surface tension forces
(*c*) gravity and pressure forces
(*d*) frictional and pressure forces.

77. The differential equation for pressure variations in x-, y-(vertical upward), and z-directions at any point in an unaccelerated fluid may be written as
(*a*) $\partial P/\partial x = 0,\ \partial P/\partial y = 0,\ \partial P/\partial z = -\gamma$
(*b*) $\partial P/\partial x = -\gamma,\ \partial P/\partial y = 0,\ \partial P/\partial z = 0$
(*c*) $\partial P/\partial x = 0,\ \partial P/\partial y = -\gamma,\ \partial P/\partial z = 0$
(*d*) $\partial P/\partial x = -\gamma,\ \partial P/\partial y = \gamma,\ \partial P/\partial z = 0$
where $\gamma = \rho\, g/g_c$.

78. Select the correct statement for the hydrostatic pressure variation with depth in an unaccelerated incompressible fluid in a constant gravitational field.
(*a*) It increases linearly with the increase in depth
(*b*) It decreases with the increase in depth
(*c*) It remains constant with the change in depth
(*d*) It increases exponentially with the increase in depth.

79. The hydrostatic equation of pressure variation in an incompressible fluid.
(*a*) $P = \rho/h$ (*b*) $P = \gamma/h$
(*c*) $P = \rho h$ (*d*) $P = \gamma h$
where γ = specific weight.

80. In an isothermal atmosphere, the pressure
(*a*) decreases linearly with elevation
(*b*) decreases exponentially with elevation
(*c*) remains constant with change in elevation
(*d*) and density remain constant.

81. How deep can a diver descend in ocean water ($\gamma = 64$ lbf/ft^3) without damaging his watch which will withstand an absolute pressure of 80 lbf/in^2 ?
(*a*) 146·9 ft (*b*) 180 ft
(*c*) 1·02 ft (*d*) 1·25 ft.

82. The specific weight of a substance has the units
(*a*) N/m^3 (*b*) kg/m^3
(*c*) N/m^2 (*d*) kg/m^2.

83. The pressure in the air space above an oil (specific gravity = 1·2) surface in a tank is 2 psi. The pressure 6 ft below the surface of oil, in feet of water, is
(*a*) 9·62 (*b*) 45·83
(*c*) 11·82 (*d*) 7·20.

84. 'The pressure at a point in a static or uniformly moving fluid is equal in all directions'. This statement is known as
(*a*) Newton's law of gravitation
(*b*) Archimedes principle
(*c*) Pascal law
(*d*) Toricelli's theorem.

85. Pressure at a point in a static mass of liquid
(*a*) depends upon specific weight of liquid and depth below the free liquid surface
(*b*) depends upon the shape of the boundary container
(*c*) depends upon the size of the boundary container
(*d*) is the same for all liquids.

86. Gage pressure is given by
(*a*) absolute pressure—local atmospheric pressure
(*b*) absolute pressure + local atmospheric pressure
(*c*) standard atmospheric pressure—vacuum pressure
(*d*) standard atmospheric pressure + vacuum pressure.

87. The recommended air pressure in the back tyre of Vijay Super Scooter is 30 psig. Assuming that the atmospheric pressure is 14·7 psia, what is the absolute pressure in kilopascals ?
(*a*) 207 (*b*) 308
(*c*) 2310 (*d*) 66600.

88. Select the three pressures that are not equivalent
(*a*) 14·696 psi, 29·92 in. Hg, 33·94 ft H_2O
(*b*) 14·696 psi, 29·92 in. Hg, 1·01325 bar
(*c*) 29·92 in Hg, 33·94 ft H_2O, $1{\cdot}01325 \times 10^5$ N/m^2
(*d*) 29·92 in. Hg, 2116 psf, 1·01325 Pa.

89. For the standard atmosphere upto the stratosphere, temperature of air decreases uniformly at the rate of
(*a*) 0·65°C/m (*b*) 0·065°C/m
(*c*) 0·0065°C/m (*d*) 0·00065°C/m.

90. The atmosphere frequently is assumed to have a constant temperature gradient, expressed by

$$T = T_0 + \beta y$$

For the standard atmosphere, $\beta = -0{\cdot}0065°C/m$ upto the stratosphere. At $y = 0$, pressure and temperature are P_0 and T_0 respectively. The relation between P and y is given by

(*a*) $\frac{P}{P_0} = \left(1 + \frac{\beta y}{T_0}\right)^{g/g_c R\beta}$

(*b*) $\frac{P}{P_0} = \left(1 + \frac{y}{\beta T_0}\right)^{g/g_c R\beta}$

(*c*) $\frac{P}{P_0} = \left(1 + \frac{\beta y}{T_0}\right)^{-g/g_c R\beta}$

(*d*) $\frac{P}{P_0} = \left(1 + \frac{y}{\beta T_0}\right)^{-g/g_c R\beta}$

91. Mercury is generally used in manometer for measuring
(*a*) very low pressures only
(*b*) low pressures accurately
(*c*) large pressures only
(*d*) all pressures except the small ones.

92. Manometers are important devices for measuring
(*a*) absolute pressures
(*b*) vacuum pressures
(*c*) local atmospheric pressures
(*d*) pressure differences.

93. The device which may be used for measuring small differences in pressures is
(*a*) U-tube manometer (*b*) inclined manometer
(*c*) mercury barometer (*d*) hydrometer.

94. In a mercury differential manometer used for measuring pressure differences across a venturimeter in a water pipeline, if an error of 1 mm has been made in observing a differential head of 20 mm, the percentage error in pressure difference is
(*a*) 4·76 (*b*) 0·05
(*c*) 5 (*d*) 1.

95. A mercury-water manometer has a gage difference of 0·7 m (difference in elevation of menisci). The difference in pressure, measured in metres of water, is
(*a*) 0·7 (*b*) 9·52
(*c*) 8·82 (*d*) 9·17.

96. The simplest form of differential manometer is shown in Fig. 1·2. The pressure difference, P_a—P_b, is given by
(*a*) $\frac{g}{g_c} h_2 (\rho_A - \rho_B)$ (*b*) $\frac{g}{g_c} h_2 \rho_A$
(*c*) $\frac{g}{g_c} h_1 (\rho_A - \rho_B)$ (*d*) $\frac{g}{g_c} h_1 \rho_A$.

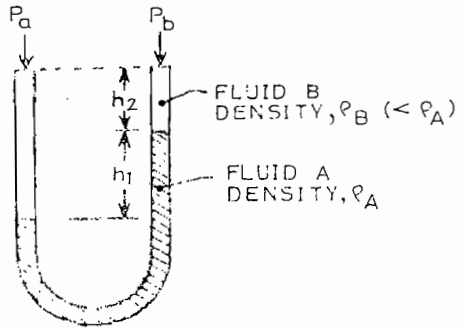

Fig. 1·2.

97. The pressure 20 in. Hg abs. with barometer reading 29·50 in. Hg may be expressed as
(*a*) 20 in. Hg vacuum
(*b*) 9·50 in. Hg vacuum
(*c*) 29·50 in. Hg vacuum
(*d*) 9·92 in. Hg vacuum.

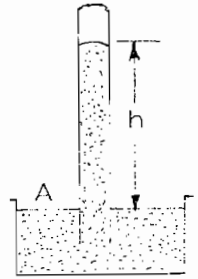

Fig. 1·3.

98. A mercury barometer is shown in Fig. 1·3. If the vapour pressure of mercury is h_v cm Hg and h is measured in metres, the pressure, in cm Hg, at A may be expressed as
(*a*) $h + h_v$ (*b*) $100h + h_v$
(*c*) h_v (*d*) $100h$.

99. A mercury ($\gamma = 13{\cdot}6\ \gamma_{water}$) barometer has a column height of 29 in. The barometric pressure, in psi, is
(*a*) 14·696
(*b*) 14·24
(*c*) 0·23
(*d*) not determinable from data given.

100. For the manometer shown in Fig. 1·4, the absolute pressure at A is given by

(*a*) $P_D = \gamma_W (S_{Hg} h_1 - h_2)$
(*b*) $P_D = \gamma_W (h_2 - S_{Hg} h_1)$
(*c*) $P_D = P_{atm} + \gamma_W (h_2 - S_{Hg} h_1)$
(*d*) $P_D = P_{atm} + \gamma_W (S_{Hg} h_1 - h_2)$

where S_{Hg} is the specific gravity of mercury and γ_W is the specific weight of water.

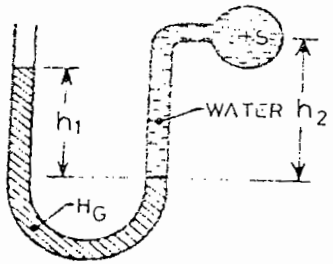

Fig. 1·4.

101. When the barometer reads 740 mm Hg, 20×10^3 N/m^2 suction is the same as
(*a*) 8·027 m Hg abs (*b*) 8·027 ft H_2O abs
(*c*) 8·027 m H_2O abs (*d*) 8·027 cm H_2O abs.

102. With the barometric reading of 28 in Hg, 10 psia is equivalent to
(*a*) 37·57 psi suction (*b*) 10 psi suction
(*c*) 13·757 psi suction (*d*) 23·757 psi suction.

103. A U-tube of uniform cross-section is partially filled with a liquid A. Another liquid B which does not mix with liquid A is poured into one side. It is found that the liquid levels of the two sides of the tube are the same, while the level of liquid A has risen by 2 cm. If the specific gravity of liquid A is 1·1, the specific gravity of liquid B must be
(*a*) 1·12 (*b*) 1·1
(*c*) 1·02 (*d*) 1·0.

104. A tube of length h, which is wide enough to make surface tension effects negligible, is closed at one end. It is then lowered into a tank of mercury of depth h and the mercury rises to a distance x into the tube. If the mercury barometer stands at h also, then
(*a*) $(2h-x)(h-x) = h^2$ (*b*) $h(h-x) = h^2$
(*c*) $(2h-x)(h+x) = h^2$ (*d*) $2h(h-x) = h^2$.

105. The buoyant force on a floating/submerged body is
(*a*) a force due to gravity and acts downward
(*b*) equal to the weight of liquid displaced by the body and acts vertically upward

(*c*) the resultant force on a body due to the fluid surrounding it
(*d*) the force necessary to maintain equilibrium of a submerged body.

106. A floating body displaces a volume of liquid equal to
(*a*) its own weight (*b*) its submerged weight
(*c*) its own volume (*d*) its submerged volume.

107. A hydrometer
(*a*) is used to measure the absolute pressure
(*b*) uses the principle of buoyant force to determine specific gravities of liquids
(*c*) is used to determine viscosities of liquids
(*d*) is used to measure the local atmospheric pressure.

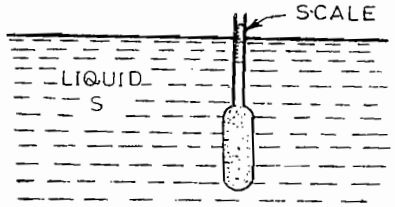

Fig. 1·5.

108. A hydrometer shown in Fig. 1·5 has a stem diameter of 0·6 cm and a mass of 0·050 kg. What is the distance on the scale between specific gravity (S) marking 1 and 1·03 ?
(*a*) $5{\cdot}30 \times 10^{-3}$ cm (*b*) $1{\cdot}32 \times 10^{-3}$ cm
(*c*) 5·30 cm (*d*) 1·32 cm.

109. Steady flow occurs
(*a*) when the velocity at a given point changes steadily with time
(*b*) when the velocity at a given point does not change with time
(*c*) when the velocity does not change with respect to space
(*d*) when $(\partial V/\partial t)_{x0, y0, z0} \neq 0$.

110. Unsteady flow occurs when
(*a*) $(\partial V/\partial t)_{x0, y0, z0} \neq 0$
(*b*) the velocity at a given point changes with time
(*c*) the velocity at a given point does not change with time
(*d*) the velocity does not change with respect to space.

111. Uniform flow occurs
(*a*) only when, at any instant, the velocity vector is identical at every point in the flow field
(*b*) when $\partial V/\partial S \neq 0$, where V is velocity vector and S represents space coordinates
(*c*) whenever the flow is steady
(*d*) only when, at any instant, the velocity vector may change its direction but its magnitude does not change with respect to space.

112. One dimensional flow is
(*a*) one which neglects changes in transverse direction
(*b*) also known as uniform flow
(*c*) also known as steady uniform flow
(*d*) restricted to flow in a straight line.

113. A stream line
(*a*) is always the path of a particle
(*b*) is a line drawn in the flow region such that the tangent drawn at any point on the line indicates the direction of velocity
(*c*) is a line drawn in the flow region such that there is mass flow across the line
(*d*) is not fixed in steady flow.

114. The continuity equation in fluid mechanics is a mathematical statement using
(*a*) the principle of conservation of momentum
(*b*) the principle of conservation of energy
(*c*) the principle of conservation of mass
(*d*) the principles of conservation of mass and energy.

115. The continuity equation
(*a*) relates mass rate of flow along a stream tube
(*b*) expresses the relation between energy and work
(*c*) requires that the Newton's second law of motion is satisfied at every point in the fluid
(*d*) relates the momentum per unit volume for two point on a stream line.

116. The form of continuity equation which must hold for every point in the flow, steady or unsteady compressible or incompressible is

(*a*) $\vec{\nabla} . \vec{V} = 0$ (*b*) $\vec{\nabla} . \rho\vec{V} + \frac{\partial \rho}{\partial t} = 0$

(*c*) $\vec{\nabla} . \vec{V} + \frac{\partial \rho}{\partial t} = 0$ (*d*) $\vec{\nabla} . \rho\vec{V} - \frac{\partial \rho}{\partial t} = 0$

where $\vec{V} = \vec{i}u + \vec{j}v + \vec{k}w$

117. If the flow is steady and incompressible, the continuity equation is

(*a*) $\vec{\nabla} \times \vec{V} = 0$ (*b*) $\vec{\nabla} . \vec{V} = 0$

(*c*) $\vec{\nabla} . \rho\vec{V} + \frac{\partial \rho}{\partial t} = 0$ (*d*) $\vec{\nabla} . \vec{V} = \rho$.

118. The flow is irrotational if

(*a*) $\vec{\nabla} . \vec{V} = 0$ (*b*) $\vec{\nabla} . \vec{V} = \rho$.

(*c*) $\frac{\partial \rho}{\partial t} = 0$ (*d*) $\vec{\nabla} \times \vec{V} = 1$.

119. Which four of the following assumptions are made in the derivation of Bernoulli's equation ?

(1) flow is uniform	(2) flow is irrotational
(3) flow is turbulent	(4) fluid is compressible
(5) flow is frictionless	(6) fluid is incompressible
(7) flow is steady.	
(*a*) 1, 2, 4, 7	(*b*) 2, 3, 5, 6
(*c*) 2, 4, 5, 7	(*d*) 2, 5, 6, 7.

120. The Bernoulli's equation written in the conventional form

$$\frac{P}{\gamma} + Z + \frac{v^2}{2g} = \text{constant}$$

has the units of

(*a*) m. N	(*b*) m. N/N
(*c*) m. N/kg	(*d*) m^2/s^2

where $\gamma = \rho\, g/g_c$.

121. The Bernoulli's equation written in the form

$$\frac{P}{\rho} + gz + \frac{v^2}{2} = \text{constant}$$

represents
(*a*) total energy per unit volume
(*b*) total energy per unit weight
(*c*) total energy per unit mass
(*d*) total energy per unit specific weight.

122. The Bernoulli's equation written in the form

$$P + \gamma Z + \frac{\rho v^2}{2} = \text{constant}$$

represents
(*a*) total energy per unit volume
(*b*) total energy per unit weight
(*c*) total energy per unit mass
(*d*) total energy per unit specific weight.

123. The Bernoulli's equation written in the conventional form

$$\frac{P}{\gamma} + Z + \frac{v^2}{2} = \text{constant}$$

represents
(*a*) total energy per unit volume
(*b*) total energy per unit weight
(*c*) total energy per unit mass
(*d*) total energy per unit specific weight.

124. The velocity head representing the kinetic energy per unit weight of fluid is denoted by

(*a*) $\rho v^2/2$ (*b*) $v^2/2$

(*c*) v (*d*) $v^2/2g$.

125. The work that a liquid is capable of doing by virtue of its sustained pressure, in m. N/N, is

(*a*) P/ρ (*b*) P

(*c*) $\rho P/\gamma$ (*d*) P/γ.

126. A fluid of specific weight γ (N/m^3) and mass density ρ(kg/m^3) is flowing at a discharge rate of Q(m^3/s). If the average velocity, pressure, and elevation at a flow section are v(m/s), P(N/m^2), and Z (m) respectively the total energy passing through the section is

(*a*) $Q\left(\frac{P}{\gamma} + Z + \frac{v^2}{2g}\right)$ (*b*) $\rho\left(\frac{P}{\gamma} + Z + \frac{v^2}{2g}\right)$

(*c*) $\gamma\left(\frac{P}{\gamma} + Z + \frac{v^2}{2g}\right)$ (*d*) $\gamma Q\left(\frac{P}{\gamma} + Z + \frac{v^2}{2g}\right)$.

127. The hydraulic grade line in pipe flow indicates the variation of

(*a*) pressure head in the direction of flow

(*b*) velocity head in the direction of flow

(*c*) piezometric head in the direction of flow

(*d*) elevation head in the direction of flow.

128. The total energy grade line in pipe flow is a graphical representation of Bernoulli's equation and represents the sum of elevation head, pressure head, and velocity head measured above

(*a*) the centre line of pipe

(*b*) the top of the pipeline

(*c*) the bottom of the pipeline

(*d*) the arbitrary horizontal datum.

129. The vertical distance between the total energy grade line and hydraulic grade line represents

(*a*) the pressure head (*b*) the velocity head

(*c*) the elevation head (*d*) the piezometric head.

130. The Bernoulli's equation can be written in the form

$$\frac{P}{\gamma} + Z + \frac{v^2}{2g} = \text{constant}$$

The "constant" for points lying on the same streamline and those which lie on other streamlines will have the same value only if the flow is

(*a*) steady (*b*) uniform

(*c*) incompressible (*d*) irrotational.

131. According to Buckingham π-theorem, any physical problem including n quantities in which there are m dimensions, the quantities can be arranged into

(*a*) n independent dimensionless parameters

(*b*) m independent dimensionless parameters

(*c*) $(n\text{-}m)$ independent dimensionless parameters

(*d*) $(m\text{-}n)$ independent dimensionless parameters.

132. Which of the following has the form of a Reynolds number (N_{Re}) ?

(*a*) $\frac{Dv\mu}{\rho}$ (*b*) Dv/μ

(*c*) $\frac{Dv\rho}{\mu}$ (*d*) $D\rho\mu/v$.

133. Which of the following has the form of a Mach number (N_{Ma}) ?

(*a*) $v/\sqrt{gl}$ (*b*) v/c

(*c*) $P/\rho v^2$ (*d*) $\frac{v^2 l\rho}{\sigma}$.

134. Which of the following has the form of a Froude number (N_{Fr}) ?

(*a*) $P/\rho v^2$ (*b*) $v/\sqrt{gl}$

(*c*) $\sqrt{gl}/v$ (*d*) $v^2\, l\rho/\sigma$.

135. Which of the following has the form of a Euler number (N_{Eu}) ?

(*a*) $P/\rho v^2$ (*b*) $v/\sqrt{gl}$

(*c*) $Dv\rho/\mu$ (*d*) $v^2\, l\rho/\sigma$.

136. Which of the following has the form of a Weber number (N_{We}) ?

(*a*) $v^2\, l\rho/\sigma$ (*b*) $v^2\, l\rho/\mu$

(*c*) $v^2\, l\mu/\rho$ (*d*) $v^2\, l\sigma/\mu$.

137. The Reynolds number may be defined as the ratio of inertial forces to

(*a*) gravity forces (*b*) elastic forces

(*c*) pressure forces (*d*) viscous forces.

138. The Mach number may be defined as the ratio of inertial forces to

(*a*) elastic forces (*b*) pressure forces

(*c*) gravity forces (*d*) surface tension forces.

139. The Froude number may be defined as the ratio of inertial forces to

(*a*) elastic forces (*b*) gravity forces

(*c*) pressure forces (*d*) viscous forces.

140. The Euler number may be defined as the ratio of

(*a*) pressure forces to surface tension forces

(*b*) pressure forces to inertial forces
(*c*) inertial forces to elastic forces
(*d*) elastic forces to surface tension forces.

141. The Weber number may be defined as the ratio of
(*a*) inertial forces to surface tension forces
(*b*) surface tension forces to pressure forces
(*c*) pressure forces to viscous forces
(*d*) viscous forces to gravity forces.

142. The geometrical similarity exists between model and prototype
(*a*) if the different ratios are used for horizontal and vertical dimensions in model and prototype
(*b*) if the ratios of all corresponding dimensions in model and prototype are equal
(*c*) if the ratios of velocities of homologous praticles are equal
(*d*) if the ratios of all homologous forces in model and prototype are the same.

143. The kinematic similarity exists between model and prototype
(*a*) if the ratio of all corresponding dimensions in model and prototype are equal
(*b*) if the paths of homologous moving particles are geometrically similar and the ratios of the velocities of homologous particles are equal
(*c*) if the ratios of all homologous forces in model and prototype are the same
(*d*) if the forces are the same in model and prototype.

144. Dynamic similarity is
(*a*) the similarity of shapes
(*b*) the similarity of streamline pattern
(*c*) the similarity of forces influencing the fluid motion
(*d*) the similarity of discharge.

145. For model and prototype, when gravity and inertia are the only forces influencing fluid motion, the ratio of flows is equal to the ratio of length dimension
(*a*) to the three-halves power
(*b*) to the five-halves power
(*c*) to the seven-halves power
(*d*) to the one-halves power.

146. For conditions laid down in question 145, the velocity ratio is equal to the ratio of length dimension
(*a*) to the five-halves power

(*b*) to the one-halves power
(*c*) to the three-halves power
(*d*) to the seven-halves power.

147. Select the quantity in the following that is not a dimensionless parameter
(*a*) Fanning friction factor
(*b*) Specific gravity
(*c*) Euler number
(*d*) Newton's law proportionality factor, g_c.

148. Select the quantity in the following that is a dimensionless parameter
(*a*) Specific gravity (*b*) Specific weight
(*c*) Angular velocity (*d*) Specific volume.

149. A body falls freely for distance S from rest. An equation for velocity (v) could take the form
(*a*) $v = KSg$ (*b*) $v = K\sqrt{Sg}$
(*c*) $v = K\,(Sg)^2$ (*d*) $v = K(Sg)^{3/2}$.

150. A body falls freely from rest for time t. An equation for velocity (v) could take the form
(*a*) $v = Kgt$ (*b*) $v = K\sqrt{gt}$
(*c*) $v = K(gt)^2$ (*d*) $v = K(gt)^{3/2}$.

151. Water ($\nu = 1 \times 10^{-6}$ m^2/s) at 15°C flows at 3m/s in a 0·15 m pipe. At what velocity must fuel oil ($\nu = 3 \times 10^{-2}$ cm^2/s) at 32°C flow in a 7·5 cm pipe in order that the Reynolds number shall be the same
(*a*) 0·18 m/s (*b*) $1{\cdot}8 \times 10^3$ m/s
(*c*) 18×10^4 m/s (*d*) 18 m/s.

152. If the flow Q of an ideal liquid through an orifice depends on the density of liquid ρ, the diameter of the orifice d, and the pressure difference ΔP, the formula for flow Q could take the form
(*a*) $Q = Kd^2\,(\rho/\Delta P)$ (*b*) $Q = Kd^2\,(\Delta P/\rho)$
(*c*) $Q = K\,d^2\sqrt{(\Delta P/\rho)}$ (*d*) $Q = K\,d^2\sqrt{(\rho/\Delta P)}$.

153. Potential flow is the flow of
(*a*) incompressible fluids with no shear
(*b*) incompressible fluids with shear
(*c*) Newtonian fluids
(*d*) non-Newtonian fluids.

154. In potential flow (or irrotational flow)
(*a*) neither circulations nor eddies can form within the stream
(*b*) there is no dissipation of mechanical energy into heat

(*c*) there is no wall drag
(*d*) all of the above.

155. The effect of the solid boundary on the flow is confined to the boundary layer except for

(*a*) fluids moving at low velocities only
(*b*) fluids possessing high viscosities only
(*c*) fluids possessing low viscosities only
(*d*) fluids moving at low velocities or possessing high viscosities.

156. The mass velocity is expressed in

(*a*) kg/s m^2 (*b*) kg/s
(*c*) m/s (*d*) m^3/s.

157. For the steady flow and constant cross-section, the mass velocity is

(*a*) independent of temperature only
(*b*) independent of pressure only
(*c*) independent of both temperature and pressure
(*d*) dependent on both temperature and pressure.

158. The maximum depth from which water may be pumped by a suction type (shallow well) pump is

(*a*) 76 ft. (*b*) 29·92 ft.
(*c*) 13·6 ft (*d*) 33·94 ft.

159. Pascal's law is applicable for

(*a*) a static fluid
(*b*) a uniformly moving fluid
(*c*) an accelerating frictionless fluid
(*d*) all of these answers.

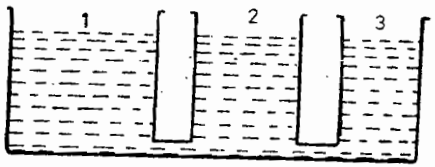

Fig. 1·6.

160. If water is poured into tank 1 (Fig. 1·6), it will flow into tank 2 and tank 3 until the water level is

(*a*) the highest in tank 1 (*b*) the highest in tank 2
(*c*) the highest in tank 3 (*d*) the same in all three tanks.

161. The Prandtl mixing length is

(*a*) zero at the pipe wall
(*b*) a universal constant

(*c*) useful for analysing laminar flow problems
(*d*) all of the above.

162. A pipe 18 ft. in diameter is to carry water at 250 psi. For an allowable tensile stress of 9000 psi, the thickness of pipe wall is

(*a*) 0·25″ (*b*) 0·33″
(*c*) 4″ (*d*) 3″.

163. A 6·0 in. ID steel pipe has a 1/3″ wall thickness. For an allowable tensile stress of 9000 psi, what is the maximum pressure ?

(*a*) 2250 psi (*b*) 9000 psi
(*c*) 500 psi (*d*) 1000 psi.

164. In rotating centrifuge a layer of incompressible fluid is thrown outward from the axis of rotation and is held against the wall of bowl by centrifugal force. If the bowl is a circular cylinder, the rise of liquid from its vertex to the wall of the cylinder is

(*a*) $wR^2/2g$ (*b*) $w^2R/2g$
(*c*) $w^2R^2/2g$ (*d*) w^2R^2/g.

where w = angular velocity
R = radius of the centrifuge bowl.

165. In an industrial centrifuge, if r_1 is the radial distance from the axis of rotation to the free liquid surface and r_2 is the radius of the centrifuge bowl, the pressure difference for incompressible liquid between a point on free liquid surface and a point on the wall of the bowl is equal to

(*a*) $\dfrac{w^2\rho\left(r_2^2 - r_1^2\right)}{2g_c}$ (*b*) $\dfrac{w\rho\left(r_2^2 - r_1^2\right)}{2g_c}$

(*c*) $\dfrac{w^2\rho\left(r_2 - r_1\right)}{2}$ (*d*)

where w = angular velocity
ρ = density of liquid.

166. A forced vortex

(*a*) occurs when fluid rotates as a solid about an axis
(*b*) occurs where each particle moves in a circular path with a speed varying inversely as the distance from the centre
(*c*) has the velocity decreasing with radius
(*d*) always occurs in conjunction with a free vortex.

167. A free vortex

(*a*) occurs when fluid rotates as a solid
(*b*) occurs where each particle moves in a circular path with a speed varying inversely as the distance from the centre

(*c*) always occurs in conjunction with a forced vortex
(*d*) has the velocity decreasing with radius.

168. A liquid of specific gravity 1·2 is rotated at 200 r.p.m. about a vertical axis. At one point, A, in the liquid 2 ft. from the axis, the pressure is 10 psi. What is the pressure at a point B, 2 ft higher than A and 3 ft from the axis ?

(*a*) 1589·6 lbf/ft^2 (*b*) 149·6 lbf/ft^2
(*c*) 4140 lbf/ft^2 (*d*) 3841 lbf/ft^2.

169. The Reynolds number

(*a*) is only applied to pipe flow
(*b*) is dimensionless
(*c*) of 2100 is always the boundary between laminar and turbulent.
(*d*) has a dimension of length.

170. In laminar flow

(*a*) the fluid particles move in irregular and haphazard paths
(*b*) the fluid particles move in layers, with one layer gliding smoothly over an adjacent layer
(*c*) Newton's law of viscosity does not apply
(*d*) lateral mixing takes place.

171. In turbulent flow

(*a*) the fluid particles move in irregular and haphazard paths
(*b*) the fluid particles move in layers, with one layer gliding smoothly over an adjacent layer
(*c*) the action of viscosity damps out turbulent tendencies
(*d*) there are neither cross-currents nor eddies.

172. Laminar flow through a circular tube was studied experimentally by

(*a*) Pascal (*b*) Hagen and Poiseuille
(*c*) Prandtl (*d*) Newton.

173. The distinction between laminar and turbulent flow was first demonstrated in a classic experiment by Osborne Reynolds, reported in 1833. The experiment used by Reynolds for determining the type of flow in pipes involved

(*a*) measurement of point velocity by Pitot-tube
(*b*) observation of the condition of colored water which became irregular at the onset of turbulence
(*c*) measurement of volumetric flow rate only
(*d*) measurement of pressure drop.

174. The most essential feature of a turbulent flow is

(*a*) high velocity
(*b*) that the velocity at a point remains constant with time
(*c*) that the instantaneous velocity and instantaneous pressure at a point fluctuates rapidly
(*d*) large discharge.

175. The lower limit of the critical Reynolds number below which all sources of turbulence in pipe flow are damped out by viscous action has a value approximately equal to

(*a*) 100 (*b*) 10^5
(*c*) 4000 (*d*) 2100.

176. In laminar flow through a pipe, Fanning friction factor (f) and Reynolds number (N_{Re}) are related by

(*a*) $f = 16/N_{Re}$ (*b*) $f = 64/N_{Re}$
(*c*) $f = 0{\cdot}079/N_{Re}^{0{\cdot}20}$ (*d*) $f = 0{\cdot}316/N_{Re}^{0{\cdot}20}$.

177. The pressure drop in laminar flow through pipes is equal to

(*a*) $\dfrac{8\,\mu\,\bar{V}\,L}{g_c D^2}$ (*b*) $\dfrac{g_c D}{32\,\mu\,\bar{V}\,L}$
(*c*) $\dfrac{32\,\mu\,\bar{V}\,L}{\rho\, g_c D^2}$ (*d*) $\dfrac{32\,\mu\,\bar{V}\,L}{g_c D^2}$.

178. The ratio of the local velocity to the maximum velocity in laminar flow through pipes is given by

(*a*) $\dfrac{u}{u_{max}} = \dfrac{r}{R}$ (*b*) $\dfrac{u}{u_{max}} = 1-\left(\dfrac{r}{R}\right)^2$
(*c*) $\dfrac{u}{u_{max}} = \left(1-\dfrac{r}{R}\right)^2$ (*d*) $\dfrac{u}{u_{max}} = 1-\dfrac{r}{R}$.

where R is the radius of the pipe and r is the distance measured from centre of the pipe in a perpendicular direction to the fluid flow.

179. The value of Fanning friction factor for smooth pipes for $N_{Re} = 10^6$ is approximately

(*a*) 0·0001 (*b*) 0·01
(*c*) 0·1 (*d*) 0·003.

180. For laminar flow in a pipe of circular cross-section, Fanning friction factor (f) is

(*a*) inversely proportional to Reynolds number and independent of pipe wall roughness
(*b*) inversely proportional to Reynolds number and also dependent on pipe wall roughness
(*c*) directly proportional to Reynolds number and independent of pipe wall roughness
(*d*) directly proportional to pipe wall roughness and independent of Reynolds number.

181. In laminar flow through a pipe, the fluid velocity for a given pressure drop, length of pipe and diameter of pipe varies

(*a*) linearly as the viscosity
(*b*) inversely as the viscosity
(*c*) linearly as the square root of the viscosity
(*d*) inversely as the square root of the viscosity.

182. The head loss in turbulent flow in a pipe
(*a*) varies approximately as the square of the velocity of fluid through pipe
(*b*) varies inversely as the square of the velocity of fluid through pipe
(*c*) varies inversely as the velocity of fluid through pipe
(*d*) varies directly as the velocity of fluid through pipe.

183. Total head loss due to sudden contraction is proportional to
(*a*) the square of upstream velocity and a factor which is a fucntion of the ratio of the downstream and upstream velocities
(*b*) the difference of the squares of upstream and downstream velocities
(*c*) the square of the difference in upstream and downstream velocities
(*d*) the square of downstream velocity and to a factor which is a function of the ratio of the upstream and downstream velocities.

184. Total head loss due to suddent enlargement is proportional to
(*a*) the square of the difference in upstream and downstream velocities
(*b*) the difference of the squares of upstream and downstream velocities
(*c*) the square of upstream velocity and to a factor which is a function of the ratio of the downstream and upstream velocities
(*d*) the square of downstream velocity and to a factor which is a function of the ratio of the downstream and upstream velocities.

185. For duct of square cross-section, each side of which is d, the equivalent diameter for pressure drop calculation would be
(*a*) $2d/\sqrt{\pi}$ (*b*) $\sqrt{2d}$
(*c*) $(1 + \sqrt{2})\, d/2$ (*d*) d.

186. If C_V is flow-coefficient, Q, the liquid flow rate in U.S. gpm at line conditions, S, the liquids specific gravity and ΔP, the pressure drop across the valve in psi, the equation for flow of liquids through control valves is written as
(*a*) $\Delta P = C_V \sqrt{S/Q}$ (*b*) $Q = C_V \sqrt{S/\Delta P}$
(*c*) $\Delta P = C_V \sqrt{Q/S}$ (*d*) $Q = C_V \sqrt{\Delta P/S}$.

187. In sudden enlargement in a horizontal pipe, the velocity head is converted into
(*a*) velocity head (*b*) pressure head

(*c*) elevation head (*d*) all of these answers.

188. In sudden contraction in a horizontal pipe, the pressure head is converted into
(*a*) velocity head (*b*) pressure head
(*c*) elevation head (*d*) all of these answers.

189. The ratio of Reynolds number for water flow through 4″ ID pipe at 150 litre/min to Reynolds number for water flow through 6″ ID pipe at 100 litre/min is
(*a*) less than one (*b*) equal to one
(*c*) greater than one (*d*) none of the above.

190. If f is the Fanning friction factor, the Blausius or Darcy friction factor is
(*a*) $f/4$ (*b*) $4f$
(*c*) f (*d*) $f/2$.

191. For laminar flow of Newtonian fluid in a pipe of circular cross-section, the ratio of the maximum velocity to the average velocity is
(*a*) 2 (*b*) 0·8
(*c*) 0·5 (*d*) 1·2.

192. Fanning's equation, $\Delta P = 4fL\rho\, \overline{V}^2/2g_cD$, is used in
(*a*) laminar flow only (*b*) both laminar and turbulent flow
(*c*) turbulent flow only (*d*) transition region only.

193. The transition length or entrance length is
(*a*) the length of pipe in which the boundary layer remains uniform
(*b*) the length of the entrance region of pipe in which flow develops fully such that the velocity profile does not change downstream
(*c*) the length of entrance region of pipe in which the flow is irrotational
(*d*) more for turbulent flow than that for laminar flow for all Reynolds number.

194. For turbulent flow in smooth pipe of diameter D, the transition length is taken as
(*a*) 0·05 D (*b*) 50 D
(*c*) 150 D (*d*) 0·5 D.

195. The transition length (x_t) for laminar flow in a pipe of diameter D is given by
(*a*) $x_t = 0{\cdot}05\, N_{Re}$ (*b*) $x_t = 0{\cdot}05\, D$
(*c*) $x_t/D = 0{\cdot}05\, N_{Re}$ (*d*) $x_t/D = 50$.

196. For a 2″ ID pipe and a Reynolds number of 1500, the transition length is

(*a*) 12·5 ft (*b*) 150 ft
(*c*) 12·5 in (*d*) 100 in.

197. The velocity of a fluid in a pipe flow is maximum
(*a*) at the wall (*b*) in the centre
(*c*) in between centre and wall.

198. Hagen-Poiseuille equation is applicable for
(*a*) laminar flow of non-Newtonian fluids
(*b*) laminar flow of Newtonian fluids
(*c*) turbulent flow
(*d*) the flow of Newtonian and non-Newtonian fluid.

199. Navier-Stokes equation is useful in the analysis of
(*a*) viscous flows
(*b*) non-viscous flows
(*c*) turbulent flows
(*d*) both viscous and turbulent flows.

200. The ratio of average velocity to the maximum velocity for turbulent flow of Newtonian fluid in circular pipes is
(*a*) less than 0·1
(*b*) less than 0·3
(*c*) more than 0·5 but less than 1·0
(*d*) 1·0.

201. The tube is said to be hydraulically smooth
(*a*) if the friction factor is zero for all values of Reynolds number
(*b*) if the friction factor for a given Reynolds number does not change by further smoothing of pipe
(*c*) if the friction factor for a given Reynolds number changes by further smoothing of pipe
(*d*) if the friction factor is independent of Reynolds number.

202. The shear stress (τ) distribution in pipe flow depends on the pressure gradient (dP/dx) and the radius (r) and is given by

(*a*) $\tau = -\frac{r}{2}\frac{dP}{dx}$ (*b*) $\tau = \frac{r}{2}\frac{dP}{dx}$

(*c*) $\tau = -r\frac{dP}{dx}$ (*d*) $\tau = -\frac{2}{r}\frac{dP}{dx}$.

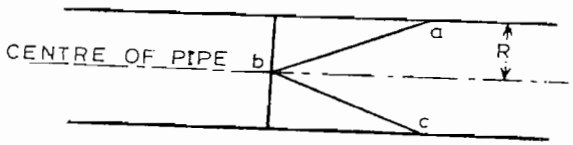

Fig. 1·7.

203. In Fig. 1·7, curve *abc* shows
(*a*) the variation of shear stress in pipe
(*b*) the velocity distribution for laminar flow in pipe
(*c*) the velocity distribution for turbulent flow in pipe
(*d*) the pressure distribution for turbulent flow in pipe.

204. In steady flow, either laminar or turbulent, the shear stress (τ) at any given cross-section of the conduit
(*a*) varies linearly as the radial distance
(*b*) varies as the square of the radial distance
(*c*) varies inversely as the square of the radial distance
(*d*) varies inversely as the radial distance.

205. Intensity of turbulence
(*a*) measures the size of the eddies
(*b*) is the frequency of turbulent fluctuations
(*c*) is the average kinetic energy of turbulence
(*d*) refers to the speed of rotation of the eddies and the energy contained in an eddy of a specified size.

206. The turbulent shear stress (Reynolds stress) is represented by the term
(*a*) $-\rho\overline{u'v'}$ (*b*) $-\rho\overline{u'w'}$
(*c*) $-\rho\overline{(u')^2}$ (*d*) $-\rho\overline{(v')^2}$
where u', v', and w' are deviating velocities in x, y, and z directions respectively.

207. The turbulence is said to be isotropic if
(*a*) $\overline{(u')^2} \neq \overline{(v')^2} \neq \overline{(w')^2}$ (*b*) $\overline{u'v'} = \overline{u'w'} = \overline{v'w'} \neq 0$
(*c*) $\overline{(u')^2} = \overline{(v')^2} = \overline{(w')^2}$ (*d*) $\overline{(u')^2} = \overline{(v')^2} \neq \overline{(w')^2}$
where u', v', and w' are deviating velocities in x, y, and z directions respectively.

208. The turbulence is said to be anisotropic where
(*a*) $\overline{(u')^2} = \overline{(v')^2} = \overline{(w')^2}$ (*b*) $\overline{(u')^2} \neq \overline{(v')^2} \neq \overline{(w')^2}$
(*c*) $\overline{(u')^2} = \overline{(v')^2} \neq \overline{(w')^2}$ (*d*) $\overline{u'v'} = \overline{u'w'} \neq \overline{v'w'}$
where u', v' and w' are deviating velocities in x, y, and z directions respectively

209. For one dimensional flow if $\frac{du}{dy} = 0$, where y is distance in a direction perpendicular to fluid flow in pipe, the turbulence is isotropic. This situation is found
(*a*) at the centreline of a pipe

(*b*) at the outer edge of a boundary layer
(*c*) both *a* and *b*
(*d*) neither *a* nor *b*.

210. In laminar flow

(*a*) there are no eddies
(*b*) the deviating velocities do not exist
(*c*) pressure fluctuations do not exist
(*d*) all of these answers.

211. Select the incorrect relation for turbulent flow

(*a*) $\frac{1}{t_0}\int_0^{t_0} u'\,dt \neq 0$ (*b*) $\frac{1}{t_0}\int_0^{t_0} v'\,dt = 0$

(*c*) $\frac{1}{t_0}\int_0^{t_0} w'\,dt = 0$ (*d*) $\frac{1}{t_0}\int_0^{t_0} P'\,dt = 0$

where u', v', w' = deviating velocities in x, y, and z directions respectively
P' = fluctuating part of pressure due to eddies
t_0 = time period of the order of a few seconds.

212. The eddy viscocity is

(*a*) greater for laminar flow than for turbulent flow
(*b*) a constant if the temperature remains the same
(*c*) mainly a function of the type of turbulence involved
(*d*) a fluid property.

213. The total shear stress in a turbulent fluid is the sum of the viscous stress and turbulent stress, or

$$\tau g_c = (\nu + \varepsilon_M)\frac{d(\rho u)}{dy}$$

where ε_M is called the eddy diffusivity of momentum which is defined as the
(*a*) ratio of the absolute viscosity to mass density
(*b*) ratio of the eddy viscosity to mass density
(*c*) product of the eddy viscosity and mass density
(*d*) product of the absolute viscosity and mass density.

214. The velocity distribution in turbulent flow in a pipe is given approximately by Prandtl by

(*a*) $\frac{u}{u_{max}} = \left(\frac{y}{R}\right)^{1/3}$ (*b*) $\frac{u}{u_{max}} = \left(\frac{y}{R}\right)^{1/5}$

(*c*) $\frac{u}{u_{max}} = \left(\frac{y}{R}\right)^{1/7}$ (*d*) $\frac{u}{u_{max}} = 1 - \left(\frac{y}{R}\right)^{1/7}$

where y is the distance measured from the pipe wall and R is the pipe radius.

215. The ratio of the average velocity to the maximum velocity in turbulent flow of Newtonian fluid in a pipe as given by Prandtl's one-seventh power law, is

(*a*) 0·5 (*b*) 49/60
(*c*) 60/49 (*d*) 0·99.

216. What is the value of the kinetic energy factor α for turbulent flow of Newtonian fluid in a pipe if the velocity distribution is approximated by Prandtl's one-seventh power law ?

(*a*) 1·01 (*b*) 1·02
(*c*) 1·06 (*d*) 1·10.

217. An important parameter, especially in the study of turbulent flow, is the Fanning friction factor (f) and defined as

(*a*) $\frac{(\rho\overline{V}^2/2g_c)}{\tau_w}$ (*b*) $\frac{\tau_w}{(\rho\overline{V}^2/2g_c)}$

(*c*) $\frac{\tau_w}{(\overline{V}^2/2g_c)}$ (*d*) $\frac{\tau_w}{(\rho\overline{V}^2)}$.

218. For turbulent flow of Newtonian fluid in a pipe, pressure drop can be calculated by

(*a*) $-\Delta P = \frac{4f L\rho\overline{V}^2}{2g_c D}$ (*b*) $-\Delta P = \frac{f L\rho\overline{V}^2}{2g_c D}$

(*c*) $-\Delta P = \frac{4f L\overline{V}^2}{2g_c D}$ (*d*) $-\Delta P = \frac{f L\rho\overline{V}^2}{2g_c D}$

where f = Fanning friction factor.

219. The velocity distribution in laminar flow in a pipe is a function of the distance r measured from the centreline of the pipe and follows a

(*a*) linear law (*b*) logarithmic law
(*c*) parabolic law (*d*) hyperbolic law.

220. For laminar flow in a pipe, the value of momentum correction factor (β) is

(*a*) 3/4 (*b*) 4/3
(*c*) 0 (*d*) 1.

221. The momentum correction factor (β) is defined by the relation

(*a*) $\beta = \frac{1}{A}\int_A \left(\frac{u}{\overline{V}}\right)^{1/3} dA$ (*b*) $\beta = \frac{1}{A}\int_A \left(\frac{u}{\overline{V}}\right)^{2} dA$

(*c*) $\beta = \frac{1}{A}\int_A \left(\frac{u}{\overline{V}}\right)^{3} dA$ (*d*) $\beta = \frac{1}{A}\int_A \left(\frac{u}{\overline{V}}\right)^{1/2} dA$.

222. The kinetic energy correction factor (α) is defined by the relation

(*a*) $\alpha = \frac{1}{A}\int_A \left(\frac{u}{\bar{V}}\right)^2 dA$ (*b*) $\alpha = \frac{1}{A}\int_A \left(\frac{u}{\bar{V}}\right)^{1/2} dA$

(*c*) $\alpha = \frac{1}{A}\int_A \left(\frac{u}{\bar{V}}\right)^{1/3} dA$ (*d*) $\alpha = \frac{1}{A}\int_A \left(\frac{u}{\bar{V}}\right)^3 dA.$

223. For laminar flow in a pipe, the value of kinetic energy correction factor (α) is

(*a*) 1 (*b*) 1·01
(*c*) 1·33 (*d*) 2.

224. For turbulent flow in a pipe, the value of kinetic energy correction factor (α)

(*a*) is 0·75
(*b*) is 2
(*c*) varies from about 1·01 to 1·10
(*d*) is more than 2.

225. The momentum correction factor (β) is used in fluid flow problems to account for

(*a*) change in pressure
(*b*) change in total energy
(*c*) change in direction of flow
(*d*) non-uniform direction of velocities at inlet and outlet sections.

226. The wall shear stress (τ_w) for laminar flow in a pipe is given by

(*a*) $\tau_w = \frac{8\bar{V}\mu}{g_c D}$ (*b*) $\tau_w = \frac{32\bar{V}\mu}{g_c D}$

(*c*) $\tau_w = \frac{2\bar{V}\mu}{g_c D}$ (*d*) $\tau_w = \frac{\bar{V}\mu}{g_c D}$.

227. Select the correct statement for turbulent flow of a Newtonian fluid in a smooth pipe

(*a*) At the centreline the turbulence is anisotropic
(*b*) In all other areas of the turbulence flow-regime except the centreline, the turbulence is isotropic
(*c*) At centreline, the turbulence is isotropic
(*d*) The velocity gradient is not zero at the centreline.

228. The velocity distribution in turbulent flow of a Newtonian fluid in a smooth pipe is a function of the distance y measured from wall of pipe and the friction velocity u^* and follows a

(*a*) linear law (*b*) parabolic law
(*c*) logarithmic law (*d*) hyperbolic law.

229. The friction velocity (u^*), used in the analysis of turbulent flow of a Newtonian fluid in a pipe, is related with the average velocity ($\bar{V}$) by

(*a*) $u^* = \bar{V}$ (*b*) $u^* = \bar{V}\sqrt{f/2}$
(*c*) $u^* = f\sqrt{\bar{V}/2}$ (*d*) $u^* = \bar{V}\sqrt{f}$

where f = Fanning friction factor.

230. The average velocity ($\bar{V}$) over a cross-section is given by

(*a*) $\bar{V} = \frac{1}{A}\sqrt{\int_A u^2 dA}$ (*b*) $\bar{V} = \frac{1}{A}\left(\int_A u^3 dA\right)^{1/3}$

(*c*) $\bar{V} = \frac{1}{A}\int_A u\, dA$ (*d*) $\bar{V} = \int_A u\, dA$

where A = flow cross-section.

231. A pipeline carries water at 8 ft/s through 1 ft ID pipe. At another section the inside diameter is 2 ft. What is the velocity at this section ?

(*a*) 2 ft/s (*b*) 16 ft/s
(*c*) 4 ft/s (*d*) 32 ft/s.

232. The velocity distribution in turbulent flow in a pipe is given by

$$\frac{u}{u_{max}} = \left(\frac{y}{R}\right)^{1/n}$$

where y is the distance from wall and R the pipe radius. The ratio of the average velocity to maximum velocity is

(*a*) $\frac{2n(n+2)}{(n+1)(2n+1)}$ (*b*) $\frac{2n^2}{(n+1)(2n+1)}$

(*c*) $\frac{(n+1)(2n+1)}{2n^2}$ (*d*) $\frac{(n+1)(2n+1)}{2n(n+2)}$.

233. The kinetic energy factor (*a*) for the velocity distribution given by

$$\frac{u}{u_{max}} = (y/R)^{1/n},$$

y = distance from wall
R = pipe radius

is

(*a*) $\frac{(n+1)^3(2n+1)^3}{4n^4(n+3)(2n+3)}$ (*b*) $\frac{(n+1)^3(2n+1)^3(n+6)}{4n^5(n+3)(2n+3)}$

(*c*) $\frac{(n+1)(2n+1)^2}{4n^2(n+2)}$ (*d*) $\frac{(n+1)(n+4)(2n+1)^2}{4n^3(n+2)}$

234. The momentum correction factor (β) for the velocity distribution given by

$$\frac{u}{u_{max}} = (y/R)^{1/n},$$

Y = distance from wall
R = pipe radius is

(a) $\dfrac{(n+1)^3(2n+1)^3}{4n^4(n+3)(2n+3)}$ (b) $\dfrac{(n+1)^3(2n+1)^3(n+6)}{4n^5(n+3)(2n+3)}$

(c) $\dfrac{(n+1)(2n+1)^2}{4n^2(n+2)}$ (d) $\dfrac{(n+1)(n+4)(2n+1)^2}{4n^3(n+2)}$

235. The fluid is bounded between two very large, flat, parallel plates separated by distance d. The lower plate is stationary, and the upper plate is moving to the right at a constant velocity u_0. For a Newtonian fluid the velocity profile follows

(a) linear law (b) logarithmic law
(c) parabolic law (d) hyperbolic law.

236. The friction factor in turbulent flow in rough pipes depends upon the following

(a) V, L, N, μ, ρ (b) $V, \mu, \rho, D, \varepsilon$
(c) V, L, D, μ, ρ, P (d) V, μ, D, ρ.

where V= velocity ; D = diameter ; μ = viscosity ;
L = length of pipe ; ρ = density ; P = pressure ;
ε = size of roughness projections

237. In the steady laminar flow of a Newtonian fluid at constant pressure through a cylindrical pipe, the velocity varies as

(a) the pipe diameter
(b) the square of the pipe diameter
(c) the cube of the pipe diameter
(d) the three-halves power of the pipe diameter.

238. In the steady laminar flow of a dilatent fluid at constant pressure drop through a cylindrical pipe, the velocity varies as

(a) the pipe diameter
(b) the square root of the pipe diameter
(c) the square of the pipe diameter
(d) the cube of the pipe diameter.

239. For what kind of non-Newtonian fluid would the velocity in steady laminar flow at constant pressure drop through a cylindrical pipe, vary as the cube of the pipe diameter ?

(a) Bingham plastics (b) Pseudoplastic fluid
(c) Dilatent fluid (d) All of the above.

240. The friction factor

(a) is dimensionless
(b) has the units of energy per unit weight of fluid
(c) appears in pressure drop relation for laminar flow through pipes
(d) is inversely proportional to Reynolds number.

241. The loss of energy in commerical pipe fittings, is generally expressed by

$$h_f = K_f V^2/2gc$$

in which K_f is called loss factor for fitting. Which of the following pipe fitting has the maximum value of K_f ?

(a) Globe value, wide open (b) Gate value, wide open
(c) Tee (d) Elbow, 90°.

242. Friction resulting from the formation of wakes is called

(a) skin friction (b) form friction
(c) disk friction (d) none of the above.

243. As the fluid flows along the solid boundary, the fluid in the vicinity of boundary gets retarded. The deceleration of the fluid is due to

(a) high velocity gradients which exist at and near the boundary
(b) high viscosity of the fluid
(c) high flow velocity outside the boundary layer
(d) the assumption of fluid being ideal at and near the boundary.

244. The boundary layer is defined as that part of a moving fluid in which

(a) the fluid motion is affected by the presence of a solid boundary
(b) the fluid velocity is constant
(c) the fluid velocity is more than the bulk fluid velocity
(d) the fluid velocity is affected by the flow pressure.

245. The boundary layer exists in

(a) pipe flow only (b) flow over flat surfaces only
(c) flow of ideal fluids (d) flow of real fluids.

246. The boundary layer exists on account of

(a) fluid viscosity (b) fluid density
(c) gravitational effect (d) surface tension.

247. Varies definitions of boundary-layer thickness have been suggested. One of them is called the displacement thickness which is defined as

(a) the distance to the point where $u/u_\infty = 0{\cdot}99$
(b) the distance the main flow must be shifted
(c) one-half the actual thickness of boundary layer
(d) the actual thickness of boundary layer.

248. The nominal thickness of the boundary-layer is expressed mathematically as

(a) $\delta_n = \int_0^\delta \left(1 - \frac{u}{u_\infty}\right) dy$ (b) $\delta_n = \int_0^\delta \frac{u}{u_\infty}\left(1 - \frac{u}{u_\infty}\right) dy$

(c) $\delta_n = \int_0^{\delta} \frac{u}{u_\infty}\left[1-\left(\frac{u}{u_\infty}\right)^2\right] dy$ (d) $y = \delta_n$ for $u = 0{\cdot}99\ u_\infty$

where u_∞ is the free-stream velocity.

249. The displacement thickness of the boundary layer is expressed mathematically as

(a) $\delta_d = \int_0^{\delta}\left(1-\frac{u}{u_\infty}\right) dy$ (b) $\delta_d = \int_0^{\delta} \frac{u}{u_\infty}\left(1-\frac{u}{u_\infty}\right) dy$

(c) $\delta_d = \int_0^{\delta} \frac{u}{u_\infty}\left[1-\left(\frac{u}{u_\infty}\right)^2\right] dy$ (d) $y = \delta_d$ for $u = 0{\cdot}99\ u_\infty$.

250. The momentum thickness of the boundary layer is expressed mathematically as

(a) $\delta_m = \int_0^{\delta}\left(1-\frac{u}{u_\infty}\right) dy$ (b) $\delta_m = \int_0^{\delta} \frac{u}{u_\infty}\left(1-\frac{u}{u_\infty}\right) dy$

(c) $\delta_m = \int_0^{\delta} \frac{u}{u_\infty}\left[\left(1-\frac{u}{u_\infty}\right)^2\right] dy$ (d) $y = \delta_m$ for $u = 0{\cdot}99\ u_\infty$.

251. The energy thickness of the boundary layer is expressed mathematically as

(a) $\delta_e = \int_0^{\delta}\left(1-\frac{u}{u_\infty}\right) dy$ (b) $\delta_e = \int_0^{\delta} \frac{u}{u_\infty}\left(1-\frac{u}{u_\infty}\right) dy$

(c) $\delta_e = \int_0^{\delta} \frac{u}{u_\infty}\ 1-\left(\frac{u}{u_\infty}\right)^2 dy$ (d) $y = \delta_e$ for $y = 0{\cdot}99\ u_\infty$.

252. The boundary-layer thickness in laminar flow over a flat plate

(a) increases as the square root of the distance from the leading edge
(b) increases as the three-halves power of the distance from the leading edge
(c) increases as the five-halves power of the distance from the leading edge
(d) increases as $x^{4/5}$, where x is the distance from the leading edge.

253. The boundary-layer thickness in turbulent flow over a flat plate

(a) increases as $x^{1/5}$ (b) increases as $x^{1/2}$
(c) increases as $x^{4/5}$ (d) increases as $x^{5/4}$.

where x is the distance from the leading edge.

254. The shear stress at the boundary of a flat plate is

(a) $\mu \left.\frac{\partial u}{dy}\right|_{y=0}$ (b) $\nu \left.\frac{\partial u}{\partial y}\right|_{y=0}$

(c) $\rho \left.\frac{\partial u}{\partial y}\right|_{y=0}$ (d) $\nu \left.\frac{\partial u}{\partial y}\right|_{y=6}$

255. The laminar-boundary-layer over a long flat plate becomes unstable and changes flow characteristics from laminar to turbulent when the plate Reynolds number approaches a value between

(a) 2100–4000 (b) 3×10^4–6×10^4
(c) 3×10^5–6×10^5 (d) 3×10^6–6×10^6.

256. The boundary layer separation

(a) cannot occur in laminar flow
(b) occurs at points of abrupt change in the direction of the flow
(c) is not very important in hydraulic design problems
(d) does not occur in the case of boundaries experiencing form drag.

257. A fluid is said to be compressible

(a) if the density is little affected by moderate change in temperature and pressure
(b) if the density is sensitive to changes in temperature only
(c) if the density is sensitive to changes in pressure only
(d) if the density is sensitive to changes in both temperature and pressure.

258. A fluid can be considered incompressible for Mach number upto

(a) 0·1 (b) 0·3
(c) 1 (d) 0·75.

259. For air flow at room temperature to be incompressible, the air velocity must not exceed

(a) 10 m/s (b) 20 m/s
(c) 70 m/s (d) 200 m/s.

260. A measure of the effect of compressibility in fluid flow is the magnitude of a dimensionless parameter known as

(a) Reynolds number (b) Weber number
(c) Euler number (d) Mach number.

261. Specific volume, pressure, and temperature in a gas flow are related by the

(a) Newton's first law of motion
(b) equation of state
(c) Newton's law of viscosity
(d) Newton's second law of motion.

262. The magnitude of the accoustical velocity in any medium is given by

(*a*) $\sqrt{g_c\left(\frac{dP}{d\rho}\right)}$ (*b*) $\sqrt{g_c\left(\frac{d\rho}{dP}\right)}$

(*c*) $\sqrt{g_c\left(\frac{dT}{d\rho}\right)}$ (*d*) $\sqrt{g_c\left(\frac{d\rho}{dT}\right)}$.

263. For an isentropic flow, the speed of sound in an ideal gas is given by

(*a*) $\sqrt{g_c \gamma P/\rho}$ (*b*) $\sqrt{g_c \gamma RT/M}$

(*c*) $\sqrt{g_c\, K/\rho}$ (*d*) any of the above.

where K = bulk modulus of elasticity
γ = specific heats ratio
M = molecular weight.

264. In an isothermal flow, the speed of sound in an ideal gas

(*a*) changes from section to section
(*b*) remains constant and is given by

$$C = \sqrt{g_c \gamma\, RT/M}$$

(*c*) is always zero
(*d*) is always infinity.

265. In an incompressible fluid, the Mach number is always

(*a*) 0 (*b*) ∞
(*c*) 1 (*d*) 100.

266. Select the correct relation for ideal gases when the compression is isentropic.

(*a*) $K = P/\gamma$ (*b*) $K = \gamma P$
(*c*) $K = \gamma/P$ (*d*) $K = \gamma P/\rho$.

267. For an isentropic flow, the speed of sound wave in an ideal gas varies

(*a*) inversely as the square root of absolute temperature
(*b*) inversely as the absolute temperature
(*c*) directly as the absolute temperature
(*d*) directly as the square root of absolute temperature

268. The compressibility is minimum for

(*a*) water (*b*) air at 1 atm pressure
(*c*) air at 0·5 atm pressure (*d*) oxygen gas at 5 atm.

269. A stagnation point is a point

(*a*) where the total energy is zero
(*b*) where the pressure is zero
(*c*) where the temperature is zero

(*d*) where the velocity of flow reduces to zero.

270. A stagnation pressure is the sum of

(*a*) static pressure and dynamic pressure
(*b*) absolute pressure and dynamic pressure
(*c*) static pressure and vacuum pressure
(*d*) dynamic pressure and vacuum pressure.

271. The critical pressure ratio at which air flow through converging-diverging ducts becomes sonic is about

(*a*) 5·3 (*b*) 0·53
(*c*) 53·0 (*d*) 0·053.

272. The critical temperature ratio at which air flow through converging-diverging ducts becomes sonic is

(*a*) $\left(\frac{2}{\gamma+1}\right)^{\gamma/(\gamma-1)}$ (*b*) $\left(\frac{2}{\gamma+1}\right)^{1/(\gamma-1)}$

(*c*) $\left(\frac{2}{\gamma+1}\right)$ (*d*) $\left(\frac{2}{\gamma+1}\right)^{\gamma}$.

273. The critical density ratio at which air flow through converging-diverging duct becomes sonic is

(*a*) $\left(\frac{2}{\gamma+1}\right)^{\gamma}$ (*b*) $\left(\frac{2}{\gamma+1}\right)$

(*c*) $\left(\frac{2}{\gamma+1}\right)^{\gamma/(\gamma-1)}$ (*d*) $\left(\frac{2}{\gamma+1}\right)^{1/(\gamma-1)}$

274. The speed of sound wave in an ideal gas is a function of

(*a*) its pressure only (*b*) its temperature only
(*c*) its specific volume only (*d*) all of the above.

275. The Fanno line is applicable in the analysis of

(*a*) steady isothermal flow of an ideal gas through long ducts
(*b*) steady adiabatic flow of an ideal gas through pipes
(*c*) frictionless flow of an ideal gas through pipes
(*d*) all of the above.

276. The Rayleigh line applies to

(*a*) steady isothermal flow of an ideal gas through pipes
(*b*) frictionless flow of an ideal gas through pipes
(*c*) steady adiabatic flow of an ideal gas through pipes
(*d*) all of the above.

277. The Mach number is defined as the ratio of

(*a*) the speed of the fluid to the speed of sound in the air at atmospheric conditions
(*b*) the speed of the fluid to the speed of sound in the fluid under conditions of flow
(*c*) the speed of sound in the fluid under conditions of flow to the speed of the fluid
(*d*) the speed of sound in the air at atmospheric conditions to the speed of the fluid.

278. The flow of the fluid through a pipeline is called supersonic if the Mach number is

(*a*) less than 1 (*b*) equal to 1
(*c*) greater than 1 (*d*) equal to 0.

279. For an isentropic flow, the speed of sound wave in an ideal gas

(*a*) varies inversely as the molecular weight of gas
(*b*) varies inversely as the square root of the molecular weight of gas
(*c*) is independent of the molecular weight of gas
(*d*) is directly proportional to the square root of the molecular weight of gas.

280. If 200 cubic feet of rock contains many tiny pores and spaces which together have a volume of 20 cubic feet, the porosity of the rock is

(*a*) 20% (*b*) 10%
(*c*) 9·09% (*d*) 11·11%.

281. The porosity of a bed

(*a*) is the ratio of the total volume of the bed to the volume of voids in the bed
(*b*) is the ratio of the volume of voids in bed to the total volume of the bed
(*c*) has a dimension of volume
(*d*) is equal to the volume of voids.

282. Which of the following equations is applicable for the flow of fluid through a packed bed ?

(*a*) Hagen-Poiseuille equation
(*b*) Kremser equation
(*c*) Nikuradse equation
(*d*) Ergun equation.

283. In laminar flow of fluid through a packed bed,

(*a*) viscous forces are unimportant
(*b*) Kozeny-Carman equation is applicable
(*c*) the flow rate is inversely proportional to the pressure drop
(*d*) Hagen-Poiseuilie equation is applicable.

284. Which of the following equations is applicable for the flow of fluid through a packed bed for large Reynolds number ?

(*a*) Fanning equation (*b*) Kozeny-Carman equation
(*c*) Blake-Plummer equation (*d*) Kremser equation.

285. Body *A* has thrice the submerged weight, thrice the projected area, and thrice the drag coefficient of body *B*. The ratio of the terminal velocities of the two bodies *A* and *B* in the air would be

(*a*) $\sqrt{3}$ (*b*) $1/\sqrt{3}$
(*c*) 3 (*d*) 1/3.

286. The forces acting on a particle moving through a stationary fluid are

(*a*) gravity and buoyant (*b*) gravity, buoyant, and drag
(*c*) buoyant and drag (*d*) gravity and drag.

287. The buoyant force is, by Archimede's principle, the product of the mass of the fluid displaced by the particle and the acceleration from the external force. For a particle of mass m, density ρ_p, moving through a stationary fluid of density ρ, the buoyant force is

(*a*) mg/g_c (*b*) $(m\rho_p g)/(\rho g_c)$
(*c*) $(m\rho g)/(\rho_p g_c)$ (*d*) $(\rho_p \rho g)/(mg_c)$.

288. The acceleration of a particle from a centrifugal force from circular motion is

(*a*) r^2w^2 (*b*) r^2w
(*c*) rw (*d*) rw^2.

where r = radius of path of particle
w = angular velocity.

289. The drag coefficient (C_D) used for immersed solid is defined by

(*a*) $\dfrac{(F_D/A_P)}{(\rho u_0^2/2g_c)}$ (*b*) $F_D/(\rho u_0^2/2g_c)$

(*c*) $\dfrac{(F_D/A_P)}{(u_0^2/2g_c)}$ (*d*) $\dfrac{(F_D/A_P)}{(\rho u_0^2)}$.

where F_D = total drag ; A_P = projected area of the solid body ;
ρ = density of the fluid ; u_0 = velocity of the approaching stream.

290. The projected area of a cylinder whose axis is perpendicular to the flow, is

(*a*) L^2 (*b*) $\pi D_p L$
(*c*) $L\,D_p$ (*d*) $\frac{\pi}{4} D_p^2$.

where L = length of the cylinder
D_p = diameter of the cylinder.

291. The projected area of a cylinder whose axis is parallel to the direction of flow, is

(*a*) D_p^2 (*b*) $\frac{\pi}{4} D_p^2$

(*c*) $L\,D_p$ (*d*) $\pi\,D_p L$

where L and D_p are the length and diameter of the cylinder, respectively.

292. The projected area of a sphere of diameter D_p is

(*a*) $\frac{\pi}{4} D_p^2$ (*b*) D_p^2

(*c*) $\pi\,D_p^2$ (*d*) $4\pi\,D_p^2$.

293. Very slow motion of a sphere in a viscous fluid was first analysed by Sir George G. Stokes on the assumption that the inertia forces are negligibly small as compared to the viscous ones. The drag force resisting the motion of the sphere of diameter D_p is given by

(*a*) $(6\pi\mu u\,D_p)/g_c$ (*b*) $(3\pi\mu u\,D_p)/g_c$

(*c*) $(3\pi\mu u\,D_p)/2g_c$ (*d*) $(3\pi\mu u\,D_p^2)/g_c$.

294. For motion of spherical particle in a stationary fluid, the drag coefficient in the Stokes's law range is given by

(*a*) $16/N_{Re,\,P}$ (*b*) $24/N_{Re,\,P}$

(*c*) $64/N_{Re,\,P}$ (*d*) $6/N_{Re,\,P}$

where $N_{Re,\,P} = u_0 \rho\, D_p/\mu$.

295. For motion of spherical particle in a stationary fluid, the drag coefficient in the Newton's law range is

(*a*) 44 (*b*) 0·44

(*c*) 4·4 (*d*) 0·044.

296. For motion of spherical particle in a stationary fluid, a plot of ln C_D versus ln $N_{Re,\,P}$ gives a straight line of slope

(*a*) 24 (*b*) −24

(*c*) −1 (*d*) 1.

297. Stokes' law is valid only when $N_{Re,\,P}$ is less than or equal to

(*a*) 500 (*b*) 2100

(*c*) 200 (*d*) 2.

298. In the Stokes' law raw range, the terminal velocity of a solid spherical particle falling through a stationary fluid mass is

(*a*) directly proportional to the square of the particle size
(*b*) inversely proportional to the viscosity of the fluid medium
(*c*) directly proportional to the difference in the densities of the particle and fluid medium
(*d*) all of the above.

299. In the Newton's law range, the terminal velocity of a solid spherical particle falling through a stationary fluid mass varies as

(*a*) the first power of its diameter
(*b*) the second power of its diameter
(*c*) the square root of its diameter
(*d*) the inverse of its diameter.

300. In the Newton's law range, the terminal velocity of a solid spherical particle falling through a stationary fluid mass is

(*a*) directly proportional to the fluid viscosity
(*b*) inversely proportional to the fluid viscosity
(*c*) inversely proportional to the square root of the fluid viscosity
(*d*) independent of the fluid viscosity.

301. For motion of spherical particles in a stationary fluid, the drag coefficient in hindered settling is

(*a*) always equal to that in free settling
(*b*) always less than in free settling
(*c*) always greater than in free settling
(*d*) equal to or less than in free settling.

302. For motion of spherical particle in a stationary fluid, the ratio of wall drag to form drag in the Stoke's law range is

(*a*) $\frac{1}{3}$ (*b*) $\frac{2}{3}$

(*c*) 2 (*d*) $\frac{1}{2}$.

303. For motion of spherical particle in a stationary fluid, the ratio of wall drag to the total drag in the Stoke's law range is

(*a*) $\frac{1}{2}$ (*b*) $\frac{1}{6}$

(*c*) $\frac{1}{3}$ (*d*) $\frac{2}{3}$.

304. The wall drag is primarily due to

(*a*) separation of boundary layer
(*b*) pressure distribution over the body surface
(*c*) shear stresses generated due to viscous action
(*d*) development of stagnation point.

305. The form drag depends on

(*a*) the occurrence of a wake
(*b*) the shear stresses generated due to viscous action
(*c*) the development of stagnation point
(*d*) the boundary layer formation.

306. Current meters, such as cup or vane anemometers,
- (*a*) make use of an element which rotates at a speed determined by the velocity of the fluid in which the meter is immersed
- (*b*) depend on the creation of an electrical potential by the motion of a conducting fluid through an externally generated uniform magnetic field
- (*c*) include metering pumps of various kinds
- (*d*) are examples of variable-head meters.

307. Magnetic flow meters
- (*a*) are examples of area meters
- (*b*) are examples of variable-head meters
- (*c*) depend on the creation of an electrical potential by the motion of a conducting fluid through an externally generated uniform field.
- (*d*) are used to measure the velocity of petroleum products.

308. By Faraday's law of electromagnetic induction the voltage created is
- (*a*) inversely proportional to the velocity of the flowing fluid
- (*b*) directly and linearly proportional to the velocity of the flowing fluid
- (*c*) directly proportional to the square root of the velocity of the flowing fluid
- (*d*) directly proportional to the square of the velocity of the flowing fluid.

309. Which of the following does not fall in the category of variable-head meters ?

(*a*) Venturi meter (*b*) Orifice meter
(*c*) Pitot tube (*d*) Rotameter.

310. Which of the following falls in the category of area meters ?

(*a*) Orifice meter (*b*) Venturi meter
(*c*) Pitot tube (*d*) Rotameter.

311. The piezometric head is the sum of
- (*a*) elevation head and pressure head
- (*b*) pressure head and velocity head
- (*c*) elevation head and velocity head
- (*d*) elevation head, pressure head, and velocity head.

312. A piezometric opening is used to measure
- (*a*) the static pressure
- (*b*) the dynamic pressure
- (*c*) the total pressure
- (*d*) the point velocity in a flowing stream.

313. The static tube measures

(*a*) the static pressure (*b*) the total pressure

(*c*) the dynamic pressure (*d*) the density.

314. The simple pitot-tube measures

(*a*) the density (*b*) the static pressure
(*c*) the dynamic pressure (*d*) the total pressure.

315. Pitot-tube is a device for measuring
- (*a*) viscosity of a fluid
- (*b*) average flow rate of fluid
- (*c*) point velocity of the flow of fluid along a streamline
- (*d*) pressure of fluid.

316. While using the Pitot-tube, it must be ensured that its alignment is such that
- (*a*) its opening is facing upstream and the horizontal leg is perfectly aligned with the direction of flow
- (*b*) its opening is facing downward direction
- (*c*) its horizontal leg is perpendicular to the flow direction
- (*d*) its horizontal leg is at an angle of 60° to the flow direction.

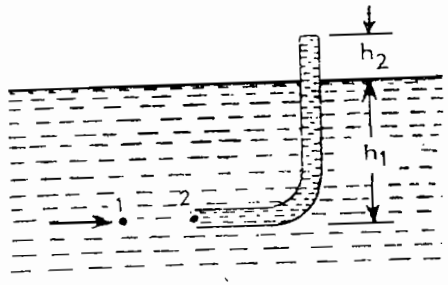

Fig. 1·8.

317. A simple pitot-tube, sometimes called an impact tube, may be used to measure the velocity in a flowing stream as shown in Fig. 1·8. The velocity at point 1 is given by

(*a*) $\sqrt{2g\,(h_1 + h_2)}$ (*b*) $\sqrt{2g\,h_2}$

(*c*) $\sqrt{2g\,h_1}$ (*d*) $\sqrt{2\gamma\,h_2}$.

318. A pitot-static tube (Fig. 1·9) is used with a mercury manometer to measure the flow rate of water. The velocity at point 1 is given by

(*a*) $\sqrt{2g\,h_2(S_{Hg} - 1)}$ (*b*) $\sqrt{2g\,h_1(S_{Hg} - 1)}$

(*c*) $\sqrt{2g\,(h_1 + h_2)(S_{Hg} - 1)}$ (*d*) $\sqrt{2g\,h_2(S_{Hg} + 1)}$.

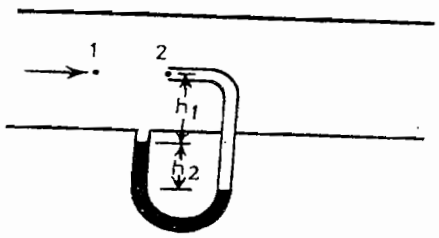

Fig. 1·9.

319. For well designed venturimeters, the discharge coefficient is about

(*a*) 0·61 (*b*) 0·98
(*c*) 0·89 (*d*) 0·39.

320. Select the correct statement.

(*a*) The venturi meter requires larger power consumption than the orifice meter
(*b*) The ratio of throat diameter to pipe diameter in the venturi meter can be changed
(*c*) The venturi meter is less expensive than the orifice meter
(*d*) The venturi meter occupies more space than the orifice meter.

321. In a properly designed venturi meter, the permanent loss is about

(*a*) 50% of the pressure drop in the upstream cone
(*b*) 10% of the pressure drop in the upstream cone
(*c*) 1% of the pressure drop in the upstream cone
(*d*) 30% of the pressure drop in the upstream cone.

322. A venturi meter is used to measure

(*a*) total energy (*b*) pressure
(*c*) flow rate (*d*) velocity head.

323. For the flow of incompressible fluid through venturi meter

(*a*) the discharge depends upon the gage difference regardless of the orientation of venturi meter
(*b*) the velocity coefficient which is the ratio of the actual velocity to the theoretical velocity is always unity.
(*c*) the coefficient of discharge which is the ratio of the actual discharge to the theoretical discharge is always unity.
(*d*) the coefficient of contraction which is the ratio of jet area at vena contracta to the area of throat is always unity.

324. For incompressible flow the losses per unit weight of fluid between the upstream section and throat of a venturi meter can be expressed as $K V_{2t}^2/2g$ if

(*a*) $K = (C_v^2-1)(1-\beta^2)$ (*b*) $K = C_v^2\,(1-\beta^4)$

(*c*) $K = \left(\frac{1}{C_v^2}-1\right)(1-\beta^4)$ (*d*) $K = \frac{1}{C_v^2}(1-\beta^4)$

where C_v = velocity coefficient
β = ratio of throat diameter to pipe diameter
V_{2t} = theoretical velocity at throat of the venturi meter.

325. A venturi meter is to be used to measure the flow of water in a given pipeline. What will be the power required to operate the venturimeter at full load if the maximum water flow rate is expected to be 45 ft^3/min ? The pressure drop in the upstream cone is 3300 lbf/ft^2. Assume that the permanent loss is 10% of the pressure drop in the upstream cone.

(*a*) 4·5 hp (*b*) 0·45 hp
(*c*) 40·5 hp (*d*) 27 hp.

326. If the flow of incompressible fluids through the venturi meter were frictionless, the pressure of the fluid leaving the meter

(*a*) would be exactly equal to that of the fluid entering the meter
(*b*) would be about 90% of the fluid entering the meter
(*c*) would be about 10% of the fluid entering the meter
(*d*) would depend upon the ratio of the throat diameter and pipe diameter.

327. If the ratio of the upstream to downstream pressure (both absolute) in a flow nozzle or orifice meter is below 50%, then

(*a*) flow becomes independent of upstream pressure
(*b*) flow is directly proportional to the downstream pressure
(*c*) flow is inversely proportional to upstream pressure
(*d*) flow becomes independent of downstream pressure and directly proportional to upstream pressure.

328. If the ratio of orifice diameter (D_0) to pipe diameter (D) is less than 0·25 and Reynolds number at orifice ($N_{Re,0} = D_0 u_0 \rho/\mu$) is greater than about 20000, the velocity through orifice, u_0, is given by

(*a*) $u_0 = 0{\cdot}98\sqrt{\frac{2g_c(P_a-P_b)}{\rho}}$ (*b*) $u_0 = 0{\cdot}61\sqrt{\frac{2g_c(P_a-P_b)}{\rho}}$

(*c*) $u_0 = 0{\cdot}39\sqrt{\frac{2g_c(P_a-P_b)}{\rho}}$ (*d*) $u_0 = \sqrt{\frac{2g_c(P_a-P_b)}{\rho}}$.

329. The disadvantage of the orifice meter is the poor pressure recovery. The fraction of the orifice differential that is permanently lost

(*a*) increases exponentially with increase in β
(*b*) decreases with increase in β
(*c*) is independent of β
(*d*) increases linearly with increase in β.
where β = ratio of orifice diameter to pipe diameter.

330. The mass flow rate of air (m) through orifice meter can be calculated by

$$m = 0{\cdot}61\, Y\, A_0 \sqrt{2 g_c (P_a - P_b)\, \rho_a}$$

where Y = dimensionless expansion factor
A_0 = cross-sectional area of orifice
P_a, P_b = pressures at stations a (upstream section) and b (vena contracta)
ρ_a = density of air under upstream conditions

The dimensionless expansion factor, Y, depends on

(*a*) k, P_b/P_a, and β (*b*) k, β, and γ
(*c*) k, P_b/P_a, and γ (*d*) β, γ, and P_b/P_a.

where β = ratio of orifice diameter to pipe diameter
γ = specific weight
k = ratio of specific heats.

331. For an orifice meter, flow rate is

(*a*) proportional to the square root of the meter reading
(*b*) proportional to the square of the meter reading
(*c*) approximately proportional to the meter reading
(*d*) inversely proportional to the square root of the meter reading.

332. Orifice meters and venturi meters measure

(*a*) the point velocity of the flow of fluid
(*b*) the average velocity of the entire stream of fluid
(*c*) the maximum velocity of the flow of fluid
(*d*) the pressure of fluid.

333. The ratio of theoretical discharge to actual discharge through an orifice is

(*a*) $C_v C_c$ (*b*) $\dfrac{1}{C_v C_c}$
(*c*) C_v/C_c (*d*) C_c/C_v

where C_v = ratio of actual velocity to theoretical velocity
C_c = ratio of jet area at vena contracta to area of orifice.

334. A liquid discharges through an orifice in a large tank which is kept full. The theoretical velocity at vena contracta is expressed by

(*a*) $\sqrt{2gH}$ (*b*) $\sqrt{2\rho H}$
(*c*) $\sqrt{2\rho H/\gamma}$ (*d*) $\sqrt{2\gamma H}$.

where H = head of liquid measured from centre of orifice to the free surface.

335. The head loss per unit weight of fluid flow through an orifice in a large tank is expressed by

(*a*) $H(1 + C_v^2)$ (*b*) $H(C_v^2 - 1)$
(*c*) $H(1 - C_v^2)$ (*d*) $H\,(1 - C_v^{1/2})$.

where H = head of liquid measured from centre of orifice to the free surface
C_v = ratio of actual velocity to theoretical velocity.

336. An orifice under a head of 10 ft discharges water at a rate of 1 cfs. Calculate the horsepower loss if the ratio of actual velocity to theoretical velocity is 0·98.

(*a*) 0·396 hp (*b*) 0·045 hp.
(*c*) 2·7 hp (*d*) 0·008 hp.

337. Area meters consist of devices in which

(*a*) the pressure drop is constant, or nearly so
(*b*) the area through which the fluid flows does not vary with flow rate
(*c*) the pressure drop varies as the square root of flow rate
(*d*) the pressure drop varies linearly with flow rate.

338. For a rotameter, the flow rate is

(*a*) proportional to the square root of the meter reading
(*b*) proportional to the square of the meter reading
(*c*) approximately directly proportional to meter reading
(*d*) inversely proportional to the meter reading.

339. For a given flow rate, the equilibrium position of the float in a rotameter is established by a balance of three forces

(1) the weight of the float (F_g)
(2) the buoyant force of the fluid on the float (F_b)
(3) the drag force on the float (F_d)

For equilibrium

(*a*) $F_d + F_g + F_b = 0$ (*b*) $F_d + F_b = F_g$
(*c*) $F_d + F_g = F_b$ (*d*) $F_d = F_b + F_g$.

340. For a given rotameter operating on a definite fluid, the drag force on the float, F_d,

(*a*) is constant
(*b*) varies linearly with the flow rate

(*c*) varies as the square of the flow rate
(*d*) varies as the square root of the flow rate.

341. Which of the following is preferred for measurement of flow of gases ?

(*a*) Rotameter (*b*) Orifice meter
(*c*) Venturi meter (*d*) Flow nozzle.

342. Hot wire anemometer is used to measure

(*a*) temperature of gases (*b*) velocity of liquids
(*c*) velocity of gases (*d*) pressure of gases.

343. The pressure loss is maximum in

(*a*) venturi meter (*b*) orifice meter
(*c*) rotameter (*d*) flow nozzle.

344. Installation cost is maximum in the case of

(*a*) venturi meter (*b*) orifice meter
(*c*) rotameter (*d*) flow nozzle.

345. Viscosity may be measured by

(*a*) use of Newton's law of viscosity
(*b*) use of the Hagen-Poiseuille equation
(*c*) methods that require calibration with fluids of known viscosity
(*d*) any of the above.

346. Cavitation in fluid flow occurs when

(*a*) the pressure of flow reaches to a value close to its vapour pressure at the prevailing temperature
(*b*) the total energy increases suddenly
(*c*) the total energy decreases suddenly
(*d*) the fluid velocity decreases to zero.

347. Arrange the following flow measuring devices in the increasing order of head loss caused by them

(1) Flow nozzle (2) Venturimeter
(3) Orifice meter
(*a*) 1, 2, 3 (*b*) 3, 1, 2
(*c*) 2, 3, 1 (*d*) 1, 3, 2.

348. Arrange the hydraulic coefficients of orifice in decreasing order of magnitude

(1) C_v (2) C_c (3) C_d
(*a*) 1, 2, 3 (*b*) 3, 2, 1
(*c*) 1, 3, 2 (*d*) 3, 1, 2.

349. The coefficient of discharge of an orifice meter

(*a*) remains constant at a value of 0·61
(*b*) is a function of the ratio of orifice diameter to pipe diameter only
(*c*) is a function of Reynolds number at the orifice only

(*d*) is a function of the ratio of orifice diameter to pipe diameter as well as Reynolds number at the orifice.

350. Overall pressure loss in orifice meters

(*a*) remains constant with change in β
(*b*) increases with increase in β
(*c*) decreases with increase in β
(*d*) decreases linearly with increase in β
where β = ratio of orifice diameter to pipe diameter.

351. The discharge through a sharp-crested rectangular weir is proportional to

(*a*) H (*b*) $H^{5/2}$
(*c*) $H^{3/2}$ (*d*) $H^{1/2}$.

352. The discharge through a sharp-crested triangular weir is proportional to

(*a*) $H^{1/2}$ (*b*) H
(*c*) $H^{3/2}$ (*d*) $H^{5/2}$.

353. A fluid jet discharging from a 50 mm diameter has a diameter of 40 mm at its vena contracta. The coefficient of contraction is

(*a*) 0·8 (*b*) 1·25
(*c*) 1·56 (*d*) 0·64.

354. Which of the flow measuring devices is used to measure flow rates in an open channel ?

(*a*) Rotameter (*b*) Pilot tube
(*c*) Weir (*d*) None of the above.

355. Vessels *A* and *B* shown in Fig. 1·10 have the same base area but their shapes are different. Both are filled to a depth *h* with liquid of density ρ. The thrust of the liquid on the base is

(*a*) the same in both vessels
(*b*) greater in *A* than in *B*
(*c*) greater in *B* than in *A*
(*d*) greater in *B* than in *A* only if $\rho < 1$.

Fig. 1·10.

356. All pipes of a given nominal size

(*a*) have the same outside diameter
(*b*) have the same inside diameter
(*c*) have the same outside and inside diameters
(*d*) none of the above.

357. For a pipe of a given nominal size the wall thickness is maximum for schedule number

(*a*) 40 (*b*) 80
(*c*) 120 (*d*) 160.

358. The designation "2-in. nickel IPS pipe" means nickel pipe having the same

(*a*) inside diameter as standard 2-in. steel pipe
(*b*) outside diameter as standard 2-in. steel pipe
(*c*) wall thickness as standard 2-in. steel pipe
(*d*) none of the above.

359. The normal range of velocity of water in pipes is

(*a*) 30-50 ft/s (*b*) 50-100 ft/s
(*c*) 4-8 ft/s (*d*) 0·15-0·30 ft/s.

360. The normal range of velocity of steam in pipes is

(*a*) 3-8 ft/s (*b*) 0·15-0·8 ft/s
(*c*) 30-50 ft/s (*d*) 250-300 ft/s.

361. The schedule number is an indication of

(*a*) material density (*b*) pipe wall thickness
(*c*) pipe size (*d*) pipe roughness.

362. The schedule number which is an indication of the wall thickness of pipe, is given by the approximate equation

(*a*) schedule number = 100 P′/S
(*b*) schedule number = 1000 P′/S
(*c*) schedule number = 1000 S/P′
(*d*) schedule number = 100 S/P′

363. Most centrifugal pumps used in chemical industries are

(*a*) electric motor driven
(*b*) steam or gas turbine driven
(*c*) diesel engine driven
(*d*) gasoline engine driven.

364. 'Shut-off' pressure in connection with centrifugal pumps is the pressure which will build up if

(*a*) pump discharge valve is fully closed
(*b*) pump discharge valve is fully opened
(*c*) pump suction valve is fully closed
(*d*) pump suction valve is fully opened.

365. The purpose of providing check valve in the discharge line of a centrifugal pump is

(*a*) to control the flow of fluid when pump is running
(*b*) to prevent backflow of fluid when pump is stopped
(*c*) to control the discharge pressure
(*d*) to control the discharge temperature.

366. The theoretical head developed by a centrifugal pump depends on

(*a*) the impeller diameter
(*b*) the impeller speed
(*c*) the velocity of the fluid leaving the impeller
(*d*) all of the above.

367. If a centrifugal pump develops a head of 100 ft, and if the pump is full of water at 20°C, the increase in pressure is about

(*a*) 43 psi (*b*) 4·3 psi
(*c*) 6230 psi (*d*) 0·7 psi.

368. If a centrifugal pump develops a head of 100 ft, and if the pump is full of air of density 1·29 kg/m^3, the increase in pressure is about

(*a*) 129 psi (*b*) 14·7 psi
(*c*) 2·9 psi (*d*) 0·1 psi.

369. The specific speed of a centrifugal pump is defined as the speed of a unit

(*a*) of such a size that it delivers unit discharge at unit head
(*b*) of such a size that it delivers unit discharge at unit power
(*c*) of unit size with unit discharge at unit head
(*d*) of unit size with unit discharge at unit power.

370. Brake horse power (BHP) is the horsepower required at the pump shaft and is calculated by the formula

(*a*) $\text{BHP} = \dfrac{Q\ (\text{gpm}) \times H\ (\text{ft}) \times \text{sp gr of liquid}}{3960}$

(*b*) $\text{BHP} = \dfrac{Q\ (\text{gpm}) \times H\ (\text{ft}) \times \text{sp gr of liquid}}{3960 \times \text{pump efficiency (\% fraction)}}$

(*c*) $\text{BHP} = \dfrac{Q\ (\text{gpm}) \times H\ (\text{ft}) \times \text{pump efficiency (\% fraction)}}{3960 \times \text{sp gr of liquid}}$

(*d*) $\text{BHP} = \dfrac{Q\ (\text{gpm}) \times H\ (\text{ft})}{3960 \times \text{pump efficiency (\% fraction)}}$

where Q = capacity in gpm
H = head in ft.

371. The specific speed (N_S) of a centrifugal pump is given by

(*a*) $N_S = (\text{rpm}) \cdot Q^{0.5}/H$ (*b*) $N_S = (\text{rpm}) \cdot Q/H^{0.75}$
(*c*) $N_S = (\text{rpm}) \cdot Q/H$ (*d*) $N_S = (\text{rpm}) \cdot Q^{0.5}/H^{0.75}$.

where Q is in gpm and H is the head per stage in feet of liquid.

372. Which of the following relationships is true for two geometrically similar centrifugal pumps ?

(*a*) $Q_1/\{(\text{rpm})_1 \cdot D_1^2\} = Q_2/\{(\text{rpm})_2 \cdot D_2^2\}$
(*b*) $Q_1/\{(\text{rpm})_1 \cdot D_1^3\} = Q_2/\{(\text{rpm})_2 \cdot D_2^3\}$
(*c*) $Q_1 \cdot D_1^3/(\text{rpm})_1 = Q_2 \cdot D_2^3/(\text{rpm})_2$
(*d*) $Q_1^{0.5} \cdot (\text{rpm})_1/D_1^3 = Q_2^{0.5} \cdot (\text{rpm})_2/Q_2^3$.

373. Select the correct relation for centrifugal pumps at equal efficiencies

(*a*) $\dfrac{D_2}{D_1} = \left(\dfrac{Q_2}{Q_1}\right)^{1/2} = \left(\dfrac{H_2}{H_1}\right)^{1/3} = \left[\dfrac{(\text{BHP})_2}{(\text{BHP})_1}\right]^{1/2}$

(*b*) $\dfrac{D_2}{D_1} = \dfrac{Q_2}{Q_1} = \left(\dfrac{H_2}{H_1}\right)^{1/2} = \left[\dfrac{(\text{BHP})_2}{(\text{BHP})_1}\right]^{1/3}$

(*c*) $\left(\dfrac{D_2}{D_1}\right)^{1/2} = \left(\dfrac{Q_2}{Q_1}\right)^{1/3} = \dfrac{H_2}{H_1} = \dfrac{(\text{BHP})_2}{(\text{BHP})_1}$

(*d*) $\left(\dfrac{D_2}{D_1}\right)^{1/3} = \left(\dfrac{Q_2}{Q_1}\right)^{1/2} = \dfrac{H_2}{H_1} = \dfrac{(\text{BHP})_2}{(\text{BHP})_1}$.

where D is the impeller diameter, Q the capacity, H the head and BHP, the Brake horse power.

374. Select the correct relation for centrifugal pumps at equal efficiencies

(*a*) $\dfrac{N_2}{N_1} = \dfrac{Q_2}{Q_1} = \left(\dfrac{H_2}{H_1}\right)^{1/2} = \left[\dfrac{(\text{BHP})_2}{(\text{BHP})_1}\right]^{1/3}$

(*b*) $\dfrac{N_2}{N_1} = \left(\dfrac{Q_2}{Q_1}\right)^{1/2} = \left(\dfrac{H_2}{H_1}\right)^{1/3} = \left[\dfrac{(\text{BHP})_2}{(\text{BHP})_1}\right]^{1/2}$

(*c*) $\left(\dfrac{N_2}{N_1}\right)^{1/2} = \left(\dfrac{Q_2}{Q_1}\right)^{1/3} = \dfrac{H_2}{H_1} = \dfrac{(\text{BHP})_2}{(\text{BHP})_1}$

(*d*) $\left(\dfrac{N_2}{N_1}\right)^{1/3} = \left(\dfrac{Q_2}{Q_1}\right)^{1/2} = \dfrac{H_2}{H_1} = \dfrac{(\text{BHP})_2}{(\text{BHP})_1}$.

375. What is the relationship among the impeller diameter, D (inches), the head developed, H (in ft of liquid pumped), and speed of the centrifugal pump (rpm) ?

(*a*) $D = 1840\ (\text{rpm})/H^{0.5}$ (*b*) $D = 1840\ H^2/(\text{rpm})$
(*c*) $H = 1840\ D^{0.5}/(\text{rpm})$ (*d*) $D = 1840\ H^{0.5}/(\text{rpm})$.

376. With 3500 rpm, the discharge pressure of a centrifugal pump indicated by the gauge is 160 psig. The suction pressure, also indicated by the gauge, amounts to 5 psig. Neglecting the differential between the velocity heads on the suction and discharge sides, what is the diameter of the pump in operation ?

(*a*) 6 inch (*b*) 15 inch
(*c*) 10 inch (*d*) 20 inch.

377. The BHP required by a centrifugal pump at zero flow (shut-off) is

(*a*) always zero
(*b*) not zero
(*c*) always infinity
(*d*) zero for propeller type only.

378. Operating a centrifugal pump with a closed discharge valve is allowed, but for only very short intervals. In this situation

(*a*) the capacity output is zero
(*b*) the head developed is zero
(*c*) the BHP required is zero
(*d*) all of the above.

379. For a specific impeller diameter, fixed impeller speed and constant density of the liquid, the BHP required by a centrifugal pump

(*a*) remains constant with change in the capacity
(*b*) increases with decrease in the capacity
(*c*) decreases with decrease in the capacity
(*d*) increases linearly with decrease in the capacity.

380. For a specific impeller diameter, fixed impeller speed and constant density of the liquid, the head in feet of liquid pumped by a centrifugal pump

(*a*) remains constant with change in the capacity
(*b*) increases with decrease in the capacity
(*c*) decreases with decrease in the capacity
(*d*) increases linearly with decrease in the capacity.

381. The capacity of a centrifugal pump can be increased by
(*a*) increasing the impeller diameter
(*b*) increasing the impeller speed
(*c*) adding a second pump in parallel or in series
(*d*) all of the above.

382. The net positive suction head of a centrifugal pump is defined as
(*a*) the sum of the velocity and pressure heads at the suction
(*b*) the sum of the velocity and pressure heads at the discharge
(*c*) the sum of the velocity and pressure heads at the discharge minus vapour pressure of the liquid at the discharge temperature
(*d*) the sum of the velocity and pressure heads at the suction minus vapour pressure of the liquid at the suction temperature.

383. For a specific impeller diameter, fixed impeller speed of a centrifugal pump, and constant density
(*a*) NPSH required decreases with increase in the capacity
(*b*) NPSH available increases with increase in the capacity
(*c*) NPSH required increases with increase in the capacity
(*d*) NPSH required and NPSH available both increase with increase in the capacity.

384. For a centrifugal pump to operate properly, the NPSH available
(*a*) must be less than NPSH required
(*b*) must be larger than NPSH required
(*c*) must be equal to or less than NPSH required
(*d*) does not change with change in the capacity.

385. Cavitation in centrifugal pumps is caused by
(*a*) high fluid velocity at the suction
(*b*) low barometric pressure
(*c*) low suction pressure
(*d*) high suction pressure.

386. Cavitation in centrifugal pumps may be eliminated by maintaining
(*a*) suction pressure higher than vapour pressure of the liquid at the suction temperature
(*b*) suction pressure sufficiently lower than vapour pressure of the liquid at the suction temperature
(*c*) liquid velocity at the suction less than 0·3 ft/s
(*d*) suction pressure less than 1 atm.

387. Propeller type centrifugal pumps are used
(*a*) for low capacities at high heads
(*b*) for high capacities at low heads
(*c*) for low capacities at low heads
(*d*) for high capacities at high heads.

388. Piston pump is suitable for heads upto
(*a*) 200 ft (*b*) 1000 ft
(*c*) 2000 ft (*d*) 100 ft.

389. Which of the following pumps is preferred for pumping slurries ?
(*a*) Gear pump (*b*) Lobe pump
(*c*) Screw pump (*d*) Centrifugal pump.

390. Positive-displacement pumps
(*a*) are usually self-priming
(*b*) deliver fluid at a uniform pressure without pulsations
(*c*) run at higher speeds than centrifugal pumps
(*d*) can be operated with a closed discharge valve for a longer time.

391. Centrifugal pumps
(*a*) deliver fluid at a uniform pressure without pulsations
(*b*) can be operated with a closed discharge line for a short intervals
(*c*) run at higher speeds than positive-displacement pumps
(*d*) all of the above.

392. One horse power is equivalent to
(*a*) 550 ft. lbf/hr (*b*) 550 ft. lbf/min
(*c*) 550 ft. lbf/sec (*d*) 550 m kgf/sec.

393. What is the horse power developed in a simple steam pump cylinder of 8-in. diameter and 12-in. stroke, with pump making 50 working strokes per minute, and with steam pressure 100 psi gauge ?
(*a*) 0·76 hp (*b*) 76 hp
(*c*) 7·6 hp (*d*) 5·0 hp.

394. The piston speed in a duplex pump having a 6-in. stroke and making a total of 100 strokes per minute is
(*a*) 25 ft/min (*b*) 100 ft/min
(*c*) 50 ft/min (*d*) 300 ft/min.

395. The total piston travel in a duplex pump having a 6-in stroke and making a total of 100 strokes per minute is
(*a*) 50 ft/min (*b*) 25 ft/min
(*c*) 100 ft/min (*d*) 300 ft/min.

396. An $8 \times 4\frac{1}{2} \times 10$-in. duplex pump makes a total of 80 strokes per minute. How many U.S. gallons per minute does it discharge if slip is 10 per cent ?
(*a*) 86,400 (*b*) 0·62
(*c*) 61·8 (*d*) 49·55.

397. The reason(s) other than the head, and capacity requirements for preferential use of centrifugal compressors over reciprocating ones is/are

(*a*) low space requirement
(*b*) quiter operation
(*c*) lower initial investment and operating costs
(*d*) all of the above.

398. Regardless of any other change in centrifugal compressor, at a given inlet volumetric flow rate of gas, an increase in horse power would always mean

(*a*) increase in discharge pressure
(*b*) decrease in discharge pressure
(*c*) no change in discharge pressure

399. For a given head, number of stages required for chlorine compression will be

(*a*) equal to the number of stages required for ammonia compression
(*b*) less than the number of stages required for ammonia compression
(*c*) more than the number of stages required for ammonia compression.

400. Given other parameters, head devloped by a centrifugal compressor will

(*a*) increase with increase in molecular weight of gas
(*b*) decrease with increase in molecular weight of gas
(*c*) remain unchanged with increase in molecular weight of gas.

401. Given other parameters, head developed by a centrifugal compressor will

(*a*) remain unchanged with increase in specific heats ratio of gas
(*b*) decrease with increase in specific heats ratio of gas
(*c*) increase with increase in specific heats ratio of gas.

402. *For compressing and moving gases the pressure difference produced is maximum for*

(*a*) fans (*b*) blowers
(*c*) compressors (*d*) vacuum pumps.

403. The compression ratio is maximum for

(*a*) fans (*b*) blowers
(*c*) compressors (*d*) vacuum pumps.

404. Two geometrically similar units are homologous if they have

(*a*) the same Reynolds number
(*b*) the same efficiency

(*c*) similar stream line
(*d*) all of the above.

405. Select the correct relationships necessary for homologous units

(*a*) Q/N^2D^2 = constant ; H/N^3D = constant
(*b*) Q/ND^3 = constant ; H/N^2D^2 = constant
(*c*) $N\sqrt{Q/H^{5/4}}$ = constant ; $N\sqrt{P/H^{3/4}}$ = constant
(*d*) $N\sqrt{Q/H^{1/2}}$ = constant ; $N\sqrt{P/H^{3/5}}$ = constant.

406. Vane pumps

(*a*) are suitable for large discharges with pressures upto 1000 psi
(*b*) do not depend upon centrifugal force for their operation
(*c*) cannot be constructed with variable displacement
(*d*) have efficiencies less than 50 per cent.

407. Foot valve is

(*a*) a back-pressure valve (*b*) a relief valve
(*c*) a direction control valve (*d*) a pressure-reducing valve.

408. A relief valve provided in a positive-displacement pump

(*a*) is manually controlled three-or four-way valve
(*b*) protects a pump from excessive pressure
(*c*) is a back-pressure valve
(*d*) is used to control discharge rate.

409. The flow number, N_Q, is defined by

(*a*) nD_a^3/q (*b*) $q/n\,D_a^3$
(*c*) $Pg_c/n^3D_a^5\rho$ (*d*) $n^3D_a^5\rho/Pg_c$.

where q = volumetric flow rate through the impeller
n = rotational speed of impeller
D_a = diameter of impeller
ρ = density of fluid
P = power.

410. The power number, N_p, is defined by

(*a*) $\dfrac{n^3D_a^5\rho}{Pg_c}$ (*b*) $\dfrac{q}{nD_a^3}$

(*c*) $\dfrac{Pg_c}{n^3D_a^5\rho}$ (*d*) $\dfrac{nD_a^3}{q}$.

411. The power number (N_p), flow number (N_Q), and k are related as

(*a*) $N_p = \pi kN_Q$ (*b*) $N_p = \pi^2kN_Q$
(*c*) $N_Q = \pi^2kN_p$ (*d*) $N_p = kN_Q$

where k = ratio of tangential liquid velocity at blade tips to blade-tip velocity.

412. Which of the following is an example of axial-flow impellers ?

(*a*) Paddle
(*b*) Turbine
(*c*) Propeller
(*d*) None of the above.

413. For a given impeller, k and β_2 are related by the equation

(*a*) $\tan \beta_2 = \sqrt{\frac{2k}{1+k}}$ (*b*) $\tan \beta_2 = \sqrt{\frac{k}{1+k}}$

(*c*) $\tan \beta_2 = \sqrt{\frac{1-k}{2k}}$ (*d*) $\tan \beta_2 = \sqrt{\frac{2k}{1-k}}$

where β_2 = the angle at which liquid leaves the impeller
k = ratio of the tangential liquid velocity at blade tips to blade-tip velocity.

414. For marine impeller, the flow number may be considered constant and is equal to

(*a*) 2100
(*b*) 3×10^5
(*c*) 0·5
(*d*) 500.

415. The power number depends on

(*a*) the angle at which liquid leaves the impeller
(*b*) the ratio of the tangential liquid velocity at blade tips to blade-tip velocity
(*c*) the ratio of width of blades to impeller diameter
(*d*) all of the above.

416. The power number is proportional to

(*a*) the ratio of the drag force acting on a unit area of the impeller to the inertial stress
(*b*) the ratio of the inertial stress to the gravitational force per unit area acting on the fluid
(*c*) the ratio of the pressure force acting on a unit area of the impeller to the gravitational force per unit area acting on the fluid
(*d*) the ratio of the drag force acting on a unit area of the impeller to the surface tension forces per unit area acting on the fluid.

417. The equivalent diameter of a non-spherical particle is defined as the diameter of a sphere having the same

(*a*) surface area as the particle
(*b*) volume as the particle
(*c*) surface area to volume ratio as the particle
(*d*) volume-to-surface ratio as the particle.

418. The sphericity of a non-spherical particle

(*a*) has a dimension of length
(*b*) is the ratio of surface area of a sphere having the same volume as the particle to the actual surface area of the particle
(*c*) is always greater than 1
(*d*) is the ratio of volume of a sphere having the same surface area as the particle to the actual volume of the particle.

419. The equivalent diameter for channels of constant non-circular cross-section is given by

(*a*) S/L_p
(*b*) $4S/L_p$
(*c*) $4L_p/S$
(*d*) $\sqrt{S}$

where S = cross-sectional area of channel
L_p = perimeter of channel in contact with fluid.

420. The equivalent diameter of a 6 by 12 cm cross-section is, in centimetres,

(*a*) 8
(*b*) 2
(*c*) 6
(*d*) 12.

421. For a non-spherical particle, the sphericity (ϕ_s) is defined by the relation

(*a*) $\phi_s = \frac{v_p}{D_p S_p}$ (*b*) $\phi_s = \frac{D_p S_p}{v_p}$

(*c*) $\phi_s = \frac{6 v_p}{D_p S_p}$ (*d*) $\phi_s = \frac{v_p}{6 D_p S_p}$.

where D_p = equivalent diameter of particle
S_p = surface area of one particle
v_p = volume of one particle.

422. For a cylindrical particle whose length equals the diameter, the sphericity is

(*a*) < 1
(*b*) $\sqrt{2}$
(*c*) 2
(*d*) 1.

423. If the equivalent diameter of a cubical particle is taken as the height of cube, the sphericity is

(*a*) 1
(*b*) < 1
(*c*) $\sqrt{3}$
(*d*) $\sqrt{2}$.

424. For crushed coal particles, the sphericity is

(*a*) less than 1
(*b*) equal to 1
(*c*) greater than 1
(*d*) infinity.

425. Select the wrong statement.

(*a*) Standard screens are used to measure the size (and size distribution) of particles in the size range between 3 and 0·0015 inches

(*b*) Each standard screen is identified in meshes per inch
(*c*) The openings of standard screen are square
(*d*) The openings of standard screen are circular.

426. The Tyler standard screen series is based on the opening of the 200-mesh screen, which is established at

(*a*) 0·074 mm (*b*) 0·74 mm
(*c*) 0·0074 mm (*d*) 7·4 mm.

427. The sphericity for rasching rings is

(*a*) < 1 (*b*) 1
(*c*) $\sqrt{2}$ (*d*) 1·189.

428. In the Tyler standard screen series, the ratio of the actual mesh dimension of any screen to that of the next smaller screen is

(*a*) 1 (*b*) 1·41
(*c*) 1·73 (*d*) 2.

429. In the Tyler standard screen series, the ratio of the area of the openings in any screen to that of the next smaller screen is

(*a*) 1·189 (*b*) 1·41
(*c*) 2 (*d*) 1·73.

430. 20-mesh screen means

(*a*) 20 openings per linear inch
(*b*) 20 openings per linear cm
(*c*) 20 openings per square inch
(*d*) 20 openings per square cm.

431. In screen analysis, the notation 60/72 means

(*a*) passing through 60-mesh and retained on 72-mesh
(*b*) passing through 72-mesh and retained on 60-mesh
(*c*) 60 gm fines and 72 gm coarse
(*d*) 72 gm fines and 60 gm coarse.

432. The capacity of vibrating screens, in tons/ft^2-h-mm mesh size, normally ranges between

(*a*) 100 and 200 (*b*) 200 and 800
(*c*) 0·2 and 0·8 (*d*) 10 and 100.

433. The critical speed of rotation of a trommel is

(*a*) directly proportional to the diameter of trommel
(*b*) inversely proportional to the diameter of trommel
(*c*) directly proportional to the square root of the diameter of trommel
(*d*) inversely proportional to the square root of the diameter of trommel.

434. The best operating speed of a trommel is usually about

(*a*) 1·33 to 1·45 times the critical speed
(*b*) 0·33 to 0·45 times the critical speed
(*c*) 0·03 to 0·04 times the critical speed
(*d*) 1 to 2 times the critical speed.

435. The screen effectiveness

(*a*) remains unaffected with change in the capacity of the screen
(*b*) decreases with increase in the capacity of the screen
(*c*) increases with increase in the capacity of the screen
(*d*) increases linearly with increase in the capacity of the screen.

436. If the differential analysis is used to calculate specific surface of a mixture, the assumption is made that all particles in a single fraction are equal in size and that the size is

(*a*) the geometrical mean of the mesh dimensions of the two screens that define the fraction
(*b*) the arithmetical mean of the mesh dimensions of the two screens that define the fraction
(*c*) the harmonical mean of the mesh dimensions of the two screens that define the fraction
(*d*) the mesh dimension of the screen on which the fraction is retained.

437. The specific surface of spherical particles of diameter (D_p) and density (ρ_p) is

(*a*) $\dfrac{3}{\rho_p D_p}$ (*b*) $\dfrac{4}{\rho_p D_p}$

(*c*) $\dfrac{6}{\rho_p D_p}$ (*d*) $\dfrac{12}{\rho_p D_p}$.

438. The specific surface of spherical particles is

(*a*) independent of the diameter of the particles
(*b*) directly proportional to the square of the diameter of the particles
(*c*) directly proportional to the diameter of the particles
(*d*) inversely proportional to the diameter of the particles.

439. Which of the following is a cohesive solid ?

(a) Grain (b) Sand
(c) Plastic chips (d) Wet clay.

440. The mass flow rate of granular solids through a circular opening varies approximately as

(*a*) the square of the opening diameter
(*b*) the cube of the opening diameter

(*c*) the square root of the opening diameter
(*d*) the fourth power of the opening diameter.

441. For the storage of granular materials in a bin made of concrete or smooth metal, the coefficient of friction at the bin wall ranges from
(*a*) 0·35 to 0·55 (*b*) 1·35 to 1·55
(*c*) 0·03 to 0·05 (*d*) 1 to 2.

442. The crushing efficiency of a machine is
(*a*) the ratio of the surface energy created by crushing to the energy absorbed by the solid
(*b*) the ratio of the energy absorbed by the solid to the energy supplied to the machine
(*c*) the ratio of the surface energy created by crushing to the energy supplied to the machine
(*d*) the ratio of the energy supplied to the machine to the surface energy created by crushing.

443. The mechanical efficiency of a crushing machine is
(*a*) the ratio of the energy supplied to the machine to the surface energy created by crushing
(*b*) the ratio of the surface energy created by crushing to the energy supplied to the machine
(*c*) the ratio of the energy absorbed by the solid to the energy supplied to the machine
(*d*) the ratio of the surface energy created by crushing to the energy absorbed by the solid.

444. The crushing efficiencies of a machine range between
(*a*) 0·1 to 2 per cent (*b*) 10 to 20 per cent
(*c*) 20 to 30 per cent (*d*) 30 to 50 per cent.

445. The crushing energy required to create new surface is given by
(*a*) Fick's law (*b*) Rittinger's law
(*c*) Fourier's law (*d*) Kopp's rule.

446. Rittinger's law states that the work required in crushing is proportional to
(*a*) the number of particles obtained
(*b*) the new surface created
(*c*) the surface area of the feed particles
(*d*) the number of particles crushed.

447. Bond crushing law states that the work required to form particles of size D_p from very large feed is proportional to
(*a*) the surface-to-volume ratio of the product

(*b*) the square root of the surface-to-volume ratio of the product
(*c*) the square of the surface-to-volume ratio of the product
(*d*) the square of the surface-to-volume ratio of the feed.

448. Which of the following minerals has maximum Rittinger's number ?
(*a*) Quartz (*b*) Pyrite
(*c*) Calcite (*d*) Galena.

449. Which of the following minerals has minimum Rittinger's number ?
(*a*) Galena (*b*) Pyrite
(*c*) Quartz (*d*) Calcite.

450. Jaw crushers operate by
(*a*) compression (*b*) attrition
(*c*) impact (*d*) cutting.

451. Which of the following size reduction equipments can accept feed sizes of 10 inches and up ?
(*a*) Fluid-energy mill (*b*) Jaw crusher
(*c*) Ball mill (*d*) Rod mill.

452. The crushing of coal for sale is done by
(*a*) hammer mills (*b*) fluid-energy mill
(*c*) jaw crushers (*d*) ball mill.

453. According to Taggart's empirical rule a jaw crusher is used if the hourly tonnage to crushed divided by the square of the gap in inches is less than
(*a*) 115 (*b*) 11·5
(*c*) 1·15 (*d*) 0·115.

454. A relationship between the diameter of the crushing rolls (D_r), the diameter of the feed particles (D_f), and the gap between the rolls (D_p) is given by

(*a*) $\tan\alpha = \dfrac{D_r + D_p}{D_r + D_f}$ (*b*) $\tan\alpha = \dfrac{D_r + D_f}{D_r + D_p}$

(*c*) $\cos\alpha = \dfrac{D_r + D_p}{D_r + D_f}$ (*d*) $\cos\alpha = \dfrac{D_r + D_f}{D_r + D_p}$.

where the angle α is half the angle of nip

455. If the radii of the ball mill and of the ball are R and r, respectively, the critical speed (n_c) of the mill is given by

(*a*) $n_c = \dfrac{1}{2}\sqrt{\dfrac{g}{(R-r)}}$ (*b*) $n_c = \dfrac{1}{2\pi}\sqrt{\dfrac{g}{(R-r)}}$

(*c*) $n_c = \dfrac{1}{\pi}\sqrt{\dfrac{g}{(R-r)}}$ (*d*) $n_c = \dfrac{1}{2\pi}\sqrt{\dfrac{(R-r)}{g}}$.

456. What is the critical speed in rpm, of a ball mill of 1290 mm *ID* charged with 64 mm balls ?

(*a*) $\frac{180}{\pi}$ (*b*) $\frac{90}{\pi}$

(*c*) $\frac{240}{\pi}$ (*c*) $\frac{120}{\pi}$.

457. In a ball mill most of the reduction is done by

(*a*) slow compression (*b*) cutting
(*c*) attrition (*d*) impact.

458. The operating speed of a ball mill must be

(*a*) less than the critical speed
(*b*) equal to the critical speed
(*c*) higher than the critical speed
(*d*) equal to or higher than the critical speed.

459. Ultrafine grinders operate principally by

(*a*) slow compression (*b*) impact
(*c*) attrition (*d*) cutting.

460. The reduction ratio for fine grinders, defined as the ratio of the average diameter of the feed to the average diameter of the product, is

(*a*) about 3 to 7 (*b*) about 10 to 20
(*b*) about 20 to 25 (*c*) as high as 100.

461. Fluid-energy mill is an example of

(*a*) crusher (*b*) grinder
(*c*) ultrafine grinder (*d*) cutting machine.

462. In fluid-energy mill most of the reduction is caused by

(*a*) interparticle attrition (*b*) compression
(*c*) impact (*d*) cutting.

463. During grinding of the solid particles, the temperature of the solid particles

(*a*) remains constant (*b*) increases
(*c*) decreases.

464. Which of the following is a continuous filter ?

(*a*) Plate and frame filter press
(*b*) Shell-and-leaf filter press
(*c*) Cartridge filter
(*d*) Rotary-drum filter.

465. In a rotary-drum filter, the fractional submergence of the drum in the slurry is about

(*a*) 0·03 (*b*) 0·30
(*c*) 0·90 (*d*) 0·15.

466. Which of the following is used as a filter aid ?

(*a*) Diatomaceous earth (*b*) Canvas cloth
(*c*) Lime (*d*) Hydrated lime.

467. A filter aid is added to the slurry before filtration to

(*a*) decrease the porosity of the cake
(*b*) increase the porosity of the cake
(*c*) increase the compressibility coefficient of the cake
(*d*) decrease the compressibility coefficient of the cake.

468. During filtration, the filtrate passes through

(*a*) resistance of the cake
(*b*) resistance of the filter medium
(*c*) resistances of the channels conducting the slurry to the upstream face of the cake and filtrate away from the filter medium
(*d*) all of the above.

469. In a constant pressure filtration, the flow rate of the filtrate

(*a*) remains constant (*b*) increases continuously
(*c*) decreases continuously (*d*) none of the above.

470. For compressible sludges, the specific cake resistance

(*a*) remains unaffected with change in the pressure drop across the cake
(*b*) increases with increase in the pressure drop across the cake
(*c*) decreases with increase in the pressure drop across the cake
(*d*) increases linearly with increase in the pressure drop across the cake.

471. In a plate-and-frame filter press, the cake resistance increases steadily with the time of filtration. This is valid for

(*a*) constant pressure filtration method
(*b*) constant rate filtration method
(*c*) both *a* and *b*
(*d*) neither *a* nor *b*.

472. The rate of filtration through a filter cake is

(*a*) directly proportional to the driving surface
(*b*) inversely proportional to the specific cake resistance
(*c*) inversely proportional to the viscosity of the filtrate
(*d*) all of these answers.

473. A plot of the reciprocal of filtration rate versus the volume of filtrate gives a straight line. This is true only for

(*a*) incompressible cakes and turbulent flow of filtrate
(*b*) compressible cakes and turbulent flow of filtrate
(*c*) incompressible cakes and laminar flow of filtrate
(*d*) compressible cakes and laminar flow of filtrate.

474. In a constant rate filtration, the inlet pressure

(*a*) remains constant (*b*) is decreased continuously
(*c*) is increased continuously (*d*) none of the above.

475. The specific cake resistance has the dimensions

(*a*) $M^{-1} L^{-1}$ (*b*) ML^{-1}
(*c*) $M^{-1}L$ (*d*) L^{-1}.

476. The filter medium resistance has the dimensions

(*a*) ML^{-1} (*b*) $M^{-1} L$
(*c*) L^{-1} (*d*) $M^{-1} L^{-1}$

477. The flow of filtrate through cake in a plate-and-frame filter press ensures

(*a*) laminar flow (*b*) turbulent flow
(*c*) plug flow (*d*) none of the above.

478. For incompressible sludges, the specific cake resistance is

(*a*) independent of the pressure drop over cake
(*b*) directly proportional to the pressure drop over cake
(*c*) inversely proportional to the pressure drop over cake
(*d*) directly proportional to the square root of the pressure drop over cake.

479. For compressible sludges, the specific cake resistance is

(*a*) a function of overall pressure drop
(*b*) a function of the pressure drop over cake
(*c*) a function of the pressure drop over medium
(*c*) independent of the pressure drop over cake.

480. The compressibility coefficient of incompressible cakes is

(*a*) 1 (*b*) 0
(*c*) –1 (*d*) ∞.

481. The compressibility coefficient of incompressible cakes is

(*a*) zero (*b*) negative
(*c*) positive (*d*) infinity.

482. For incompressible cakes and negligible resistances of filter medium and piping, the filtrate volume collected in time t and at total pressure drop $(-\Delta P)$ is V_f. The filtrate volume collected in time $t/2$ and at total pressure drop 2 $(-\Delta P)$ would be

(*a*) $4\ V_f$ (*b*) $2\ V_f$
(*c*) V_f (*d*) $V_f/2$.

483. A plot of the filtrate volume versus time for a constant-pressure filtration is a

(*a*) straight line (*b*) parabola
(*c*) hyperbola (*d*) exponential curve.

484. In the rotary-drum filter, the controlling resistance is

(*a*) the filter medium resistance
(*b*) the cake resistance
(*c*) the piping resistance
(*d*) any of the above.

485. If the filter medium resistance is negligible in comparison with the resistance of the cake in a rotary-drum filter, the filtrate flow rate varies

(*a*) directly with the square root of the viscosity and of the cycle time
(*b*) inversely with the square root of the viscosity and of the cycle time
(*c*) inversely with the viscosity and cycle time
(*d*) inversely with the square of the viscosity and of the cycle time.

486. In a rotary-drum filter, the filtration rate

(*a*) remains unaffected with change in drum speed
(*b*) increases with increase in drum speed
(*c*) decreases with increase in drum speed
(*d*) increases linearly with increase in drum speed.

487. If the filter medium resistance is negligible in comparison with the resistance of cake in a constant rate filtration, a plot of ln $(-\Delta P_c)$ versus ln t gives a straight line of slope

(*a*) 1 (*b*) S
(*c*) $1-S$ (*d*) -1

where S is the compressibility coefficient of the cake.

488. The porosity of a compressible cake is

(*a*) maximum at the filter medium
(*b*) maximum at the upstream face
(*c*) same throughout the thickness of cake
(*d*) minimum at the upstream face and maximum at the filter medium.

489. During washing of cake

(*a*) all resistances remain constant
(*b*) all resistances increase
(*c*) all resistances decrease
(*d*) the filter medium resistance is the most important.

490. Which of the following is valid for the flow of filtrate through cake in a plate-and-frame filter press ?

(*a*) Hagen-Poiseuille equation
(*b*) Kremser equation
(*c*) Nikuradse equation
(*d*) Kozeny-Carman equation.

491. The speed, in rpm, of a continuous rotary vacuum filter may be
(*a*) 1 (*b*) 100
(*c*) 1000 (*d*) 10000.

492. Industrially, the process of sedimentation is conducted on a large scale in equipment called
(*a*) sorting classifiers (*b*) cyclones
(*c*) thickners (*d*) filters.

493. Devices which separate particles of differing densities are known as
(*a*) thickners (*b*) sorting classfiers
(*c*) cyclones (*d*) filters.

494. Sorting classifier uses a sink-and-float method to separate particles of differing densities. The separation
(*a*) depends on the particle size
(*b*) depends on the difference in terminal velocities
(*c*) depends on the difference in the densities of the particles
(*d*) depends on the centrifugal force.

495. A sink-and-float method used in sorting classifiers uses a liquid sorting medium, the density of which is
(*a*) less than that of either substance
(*b*) greater than that of either substance
(*c*) intermediate between that of the light material and that of the heavy
(*d*) none of the above.

496. Differential settling methods used in sorting classfiers utilize
(*a*) the difference in the densities
(*b*) the difference in the terminal velocities
(*c*) the difference in the particle size
(*d*) none of the above.

497. Differential settling method used in sorting classifiers uses a liquid medium, the density of which is
(*a*) less than that of either substance
(*b*) greater than that of either substance
(*c*) intermediate between that of the light material and that of the heavy
(*d*) none of the above.

498. The particles of galena (*A*) and quartz (*B*) settle through a medium of density ρ_m in the Stoke's law range. If the terminal velocities of a galena particle of size D_{PA} and of a quartz particle of size D_{PB} are equal, the ratio D_{PA}/D_{PB} is given by

(*a*) $\sqrt{\dfrac{\rho_{PA}-\rho_m}{\rho_{PB}-\rho_m}}$ (*b*) $\sqrt{\dfrac{\rho_{PB}-\rho_m}{\rho_{PA}-\rho_m}}$

(*c*) $\dfrac{\rho_{PA}-\rho_m}{\rho_{PB}-\rho_m}$ (*d*) $\dfrac{\rho_{PB}-\rho_m}{\rho_{PA}-\rho_m}$.

499. Select the correct statement
(*a*) Gear pumps are used mainly for pressure over 2000 psi
(*b*) Efficiencies of gear pumps are more than those for piston pumps
(*c*) Gear pumps normally contain two gears
(*d*) Gear pumps function best with a single gear.

500. Fluids flowing in pipes exhibit a velocity profile. In laminar flow of Newtonian fluids the velocity distribution with respect to radius is ..... with the apex at the ..... of the pipe.

501. Bernoulli equation applies to a ..... , ... fluid which does not exchange shaft work with the surroundings.

502. The flow of gas along a pipe in the direction of decreasing pressure causes ..... in its specific volume.

503. The maximum fluid velocity obtainable in a pipe of constant cross-sectional area is the ..... .

504. For a circular pipe completely filled with a liquid, the hydraulic radius is equal to the diameter of pipe divided by ..... .

505. A nozzle is a device that causes the interchange of internal and kinetic energies of a fluid as a result of changing ..... available for flow.

506. For subsonic flow in a converging nozzle, the velocity increases and pressure decreases as the cross-sectional area ..... .

507. In laminar flow, momentum is transferred as a result of the ..... .

508. The expansion of a gas in a nozzle to produce a high-velocity stream is a process that converts ..... energy into kinetic energy.

509. Turbine converts the internal energy of a high pressure stream into ..... .

510. A throttling process does not change the temperature of ..... .

511. For an ideal fluid flow the Reynolds number is ..... .

512. For pseudoplastic fluids, increase in shear rate ..... the apparent viscosity.

513. A particle attains its terminal settling velocity when sum of the ..... and ..... forces is equal to the gravity force.

514. The velocity of discharge of a liquid from a small orifice in the bottom or a wall of vessel with a constant level H of liquid above the center of orifice in the vessel is proportional to ..... .

515. For a fluidized bed, with the increase in expansion of the bed up to solids carry over from the bed, the pressure drop across the bed ..... .

516. A fluid A of specific gravity 1·0 and viscosity 0·001 N.s/m^2 flows through a horizontal pipe of circular cross section. The fluid B of specific gravity 2 and viscosity 0·002 N.s/m^2 flows through an identical pipe, with the same average velocity as fluid A. The ratio of the pressure drop per unit length of pipe for fluid B to the pressure drop per unit length of pipe for fluid A is ..... .

517. Size reduction in a gyratory crusher is effected primarily by ..... .

518. When a fluid flows in a pipe isothermally, it undergoes a ..... in pressure.

519. A fluid is a substance that can substain no ..... .

520. The viscosity of ..... fluids is a function of temperature only.

521. The viscosity of liquids decreases as the temperature is ..... .

522. For pressure drop calculations, the equivalent diameter for flow through annulus of outer diameter d_0 and inner diameter d_i is ..... .

523. For pressure drop calculations, the equivalent diameter for flow through square of side L is ..... .

524. For pressure drop calculations, the equivalent diameter for flow through rectangle of sides A and B is ..... .

525. The flow of Newtonian liquids through pipes is governed by the ..... equation.

526. The breakdown of laminar flow of Newtonian liquids through pipe-lines takes place at a Reynolds number of about ..... .

527. For isothermal laminar flow, pressure drop is a function of ..... number only.

528. For isothermal turbulent flow, pressure drop is a function of Reynolds number as well as ..... .

529. The ratio of carrying capacities of a pipe of diameter D to the pipe of diameter d is ..... .

530. The time of gravity flow of a fixed volume of fluid is directly proportional to its ..... .

531. For Newtonian fluids shear stress is proportional to the rate of shear in the direction ..... to motion.

532. For laminar flow of Newtonian fluids in a pipe of diameter D and length L with a pressure drop ΔP, shear stress at the pipe wall is ..... .

533. For laminar flow of Newtonian fluids in a pipe of diameter D and length L with an average velocity $\overline{V}$, shear rate at the pipe wall is ..... .

534. In the Stokes law regime, drag coefficient is given by ..... .

535. For $10^3 \leq N_{Re,P} \leq 2 \times 10^5$, drag coefficient is approximately constant at ..... .

536. Colebrook equation for friction factor in turbulent flow reduces to Nikuradse equation for ..... .

537. The fluid velocity at the solid-liquid interface is assumed to be ..... .

538. In a flow system, a pump is used to increase the ..... energy of the flowing fluid.

539. A fluid in equilibrium is ..... from shear stresses.

540. Inclined manometers are used for measuring ..... differences in pressure.

541. In the equation $\tau_v g_c = \mathrm{K}(du/dy)^n$, the value of n is ..... 1 for dilatent fluids.

542. In the equation $\tau_v g_c = \mathrm{K}(du/dy)^n$, the value of n is ..... 1 for pseudoplastic fluids.

543. The set of Tayler standard screens is based on the opening of the ..... screen which is established at 0·074 mm.

544. A generalized relation for crushing is $d\left(\frac{P}{m}\right) = -K\frac{d\overline{D}_s}{\overline{D}_s^n}$. Solution of this equation leads to Kick's law for $n =$ ..... and Rittinger's law for $n =$ ..... .

545. A generalized relation for crushing is $d\left(\frac{P}{m}\right) = -K\frac{d\overline{D}_s}{\overline{D}_s^n}$. Solution of this equation leads to Bond crushing law for $n =$ ..... and feed of ..... size.

546. The kinetic energy correction factor for laminar flow of Newtonian fluids is ..... .

547. The momentum correction factor for laminar flow of Newtonian fluids is ..... .

548. For the flow of ideal gas through nozzles the critical pressure ratio equals ..... .

549. Nozzles are designed to ..... wall friction and to ..... boundary layer separation.

550. Ergun equation assumes that viscous losses and kinetic energy losses are ..... .

551. Forces acting on a particle moving through a fluid are gravity force, ... force and drag force.

552. The acceleration from a ..... from circular motion is $r\omega^2$ where r is radius of the path and ω is the angular velocity, rad/s.

553. For a cohesive solid the ratio of normal pressure to applied pressure approaches ..... .

554. Drag coefficients for compressible fluids ..... with increase in the Mach number greater than about 0·6.

555. In theory Stoke's law is valid only when particle Reynolds number is considerably less than ..... .

556. The surface-volume ratio for spherical particles of diameter D_P is ..... .

557. The drag coefficient in hindered settling is ..... than in free settling.

558. Application of centrifugal force ..... the relative effect of Brownian movement.

559. The terminal velocity of a particle moving through a fluid varies with $D_P{}^n$ where n is ..... in the Stokes law regime and n is ..... in the Newton's law regime.

Match the items in left column with the appropriate item in right column :

560.

(*a*) $\Delta P = \dfrac{32Lu\mu}{D^2}$	(*I*) Terminal settling velocity in Stokes's law regime
(*b*) $u^+ = 2{\cdot}5 \ln y + 5{\cdot}5$	(*II*) Acoustical velocity for an ideal gas
(*c*) $\sqrt{g_c \gamma P/\rho}$	(*III*) Hagen-Poiseuille equation
(*d*) $u_t = \dfrac{gD_p^2(\rho_p - \rho)}{18\mu}$	(*IV*) Prandtl universal velocity distribution for turbulent core

561.

(*a*) $\dfrac{\text{Molecular diffusion of momentum}}{\text{Molecular diffusion of heat}}$	(*I*) Reynolds number
(*b*) $\dfrac{\text{Inertia force}}{\text{Viscous force}}$	(*II*) Schmidt number

(*c*) $\dfrac{\text{Inertia force}}{\text{Gravity force}}$	(*III*) Froude number
(*d*) $\dfrac{\text{Molecular diffusion of momentum}}{\text{Molecular diffusion of mass}}$	(*IV*) Prandtl number

562.

(*a*) $f^{-0.5} = -4{\cdot}0 \log\left[\dfrac{\varepsilon/D}{3{\cdot}70} + \dfrac{1{\cdot}26}{N_{Re} f^{0.5}}\right]$	(*I*) Colebrook formula
(*b*) $f^{-0.5} = 4{\cdot}0 \log\left(N_{Re}\sqrt{f}\right) - 0{\cdot}40$	(*II*) Blasius equation
(*c*) $f^{-0.5} = 4{\cdot}07 \log\left(N_{Re}\sqrt{f}\right) - 0{\cdot}60$	(*III*) von Karman equation
(*d*) $f = 0{\cdot}079 N_{Re}^{-.25}$	(*IV*) Nikuradse equation

563.

(*a*) Euler number	(*I*) N_{Re}^2/N_{Fr}
(*b*) Froude number	(*II*) $\Delta P/\rho \overline{V}^2$
(*c*) Archimedes number	(*III*) $\overline{V}^2/gD$
(*d*) Galileo number	(*IV*) $N_{Re}^2(\rho - \rho_f)/N_{Fr}\rho_f$

564.

(*a*) Sewage sludge	(*I*) Pseudoplastic
(*b*) Rubber latex	(*II*) Dilatent
(*c*) Quicksand	(*III*) Newtonian
(*d*) Water	(*IV*) Bingham plastic

565.

(*a*) $\dfrac{P_b}{P_a} = \exp\left[-\dfrac{gM(z_b - z_a)}{g_c RT}\right]$	(*I*) Friction factor
(*b*) $\tau_v g_c = K(du/dy)^n$	(*II*) Power law
(*c*) $\tau_w/(\rho \overline{V}^2/2g_c)$	(*III*) Barometric equation
(*d*) $u/\sqrt{(g_c \gamma RT/M)}$	(*IV*) Mach number

566.

(*a*) $\dfrac{1}{\sum_i (x_i/\overline{D}_{Pi})}$	(*I*) Mass mean diameter
(*b*) $\dfrac{\sum_i N_i \overline{D}_{Pi}}{\sum_i N_i}$	(*II*) Volume mean diameter
(*c*) $\sum_i x_i \overline{D}_{Pi}$	(*III*) Arithmetic mean diameter

(*d*) $\left[\dfrac{1}{\sum_i \left(x_i/\overline{D}_{Pi}^3\right)}\right]^{1/3}$ — (*IV*) Volume-surface mean diameter

567. (*a*) $\dfrac{P}{m} = K\left(\dfrac{1}{\overline{D}_{sb}} - \dfrac{1}{\overline{D}_{sa}}\right)$ — (*I*) Kick's law

(*b*) $\dfrac{P}{m} = K \ln\left(\dfrac{\overline{D}_{sa}}{\overline{D}_{sb}}\right)$ — (*II*) Bond crushing law

(*c*) $\dfrac{P}{m} = K/\sqrt{D_P}$ — (*III*) Rittinger's law

(*d*) $\ln \alpha = 4V_M \sigma/\nu RTL$ — (*IV*) Kelvin equation

568. (*a*) $\dfrac{\Delta P}{L} = \dfrac{150\overline{V}_0 \mu(1-\varepsilon)^2}{g_c \phi_s^2 D_p^2 \varepsilon^3}$ — (*I*) Ergun equation

(*b*) $\dfrac{\Delta P}{L} = \dfrac{1{\cdot}75\overline{V}_0^2 \rho(1-\varepsilon)}{g_c \phi_s D_p \varepsilon^3}$ — (*II*) Kozney-Carman equation

(*c*) $\dfrac{\Delta P}{L} = \dfrac{150\overline{V}_0 \mu(1-\varepsilon)^2}{g_c \phi_s^2 D_p^2 \varepsilon^3} + \dfrac{1{\cdot}75\overline{V}_0^2 \rho(1-\varepsilon)}{g_c \phi_s D_p \varepsilon^3}$ — (*III*) Blake-Plummer equation

(*d*) $D_v = kT/6\pi r_0 \mu$ — (*IV*) Stokes-Einstein equation

569. (*a*) $\dfrac{N D_a^2 \rho}{\mu}$ — (*I*) Power number

(*b*) $\dfrac{P g_c}{N^3 D_a^5 \rho}$ — (*II*) Froude number

(*c*) $\dfrac{N^2 D_a^3 \rho}{\sigma g_c}$ — (*III*) Reynolds number

(*d*) $\dfrac{N^2 D_a}{g}$ — (*IV*) Weber number

570. (*a*) Wet clay — (*I*) Noncohesive solid

(*b*) Plastic chips — (*II*) Cohesive solid

(*c*) A small vessel with a slopy bottom — (*III*) Silo

(*d*) A tall and relatively small in diameter — (*IV*) Hopper

ANSWERS

1. (*c*)	2. (*b*)	3. (*d*)	4. (*d*)	5. (*b*)
6. (*b*)	7. (*b*)	8. (*c*)	9. (*b*)	10. (*c*)
11. (*a*)	12. (*a*)	13. (*c*)	14. (*d*)	15. (*c*)
16. (*a*)	17. (*d*)	18. (*b*)	19. (*a*)	20. (*a*)
21. (*a*)	22. (*d*)	23. (*b*)	24. (*d*)	25. (*c*)
26. (*b*)	27. (*a*)	28. (*c*)	29. (*d*)	30. (*b*)
31. (*c*)	32. (*c*)	33. (*a*)	34. (*c*)	35. (*c*)
36. (*d*)	37. (*c*)	38. (*c*)	39. (*d*)	40. (*c*)
41. (*c*)	42. (*a*)	43. (*b*)	44. (*c*)	45. (*c*)
46. (*b*)	47. (*b*)	48. (*a*)	49. (*c*)	50. (*a*)
51. (*b*)	52. (*b*)	53. (*c*)	54. (*d*)	55. (*a*)
56. (*b*)	57. (*c*)	58. (*b*)	59. (*d*)	60. (*b*)
61. (*c*)	62. (*b*)	63. (*d*)	64. (*c*)	65. (*d*)
66. (*a*)	67. (*c*)	68. (*d*)	69. (*b*)	70. (*c*)
71. (*c*)	72. (*a*)	73. (*d*)	74. (*c*)	75. (*c*)
76. (*c*)	77. (*c*)	78. (*a*)	79. (*d*)	80. (*b*)
81. (*a*)	82. (*a*)	83. (*c*)	84. (*c*)	85. (*a*)
86. (*a*)	87. (*b*)	88. (*d*)	89. (*c*)	90. (*c*)
91. (*d*)	92. (*d*)	93. (*b*)	94. (*c*)	95. (*c*)
96. (*c*)	97. (*b*)	98. (*b*)	99. (*b*)	100. (*d*)
101. (*c*)	102. (*a*)	103. (*b*)	104. (*a*)	105. (*b*)
106. (*a*)	107. (*b*)	108. (*c*)	109. (*b*)	110. (*b*)
111. (*a*)	112. (*a*)	113. (*b*)	114. (*c*)	115. (*a*)
116. (*b*)	117. (*b*)	118. (*b*)	119. (*d*)	120. (*b*)
121. (*c*)	122. (*a*)	123. (*b*)	124. (*d*)	125. (*d*)
126. (*d*)	127. (*c*)	128. (*d*)	129. (*b*)	130. (*d*)
131. (*c*)	132. (*c*)	133. (*b*)	134. (*b*)	135. (*a*)
136. (*a*)	137. (*d*)	138. (*a*)	139. (*b*)	140. (*b*)
141. (*a*)	142. (*b*)	143. (*b*)	144. (*c*)	145. (*b*)
146. (*b*)	147. (*d*)	148. (*a*)	149. (*b*)	150. (*a*)
151. (*d*)	152. (*c*)	153. (*a*)	154. (*d*)	155. (*d*)
156. (*a*)	157. (*c*)	158. (*d*)	159. (*d*)	160. (*d*)
161. (*a*)	162. (*d*)	163. (*d*)	164. (*c*)	165. (*a*)
166. (*a*)	167. (*b*)	168. (*d*)	169. (*b*)	170. (*b*)
171. (*a*)	172. (*b*)	173. (*b*)	174. (*c*)	175. (*d*)
176. (*a*)	177. (*d*)	178. (*b*)	179. (*d*)	180. (*a*)
181. (*b*)	182. (*a*)	183. (*d*)	184. (*c*)	185. (*d*)
186. (*d*)	187. (*b*)	188. (*a*)	189. (*c*)	190. (*b*)
191. (*a*)	192. (*b*)	193. (*b*)	194. (*b*)	195. (*c*)
196. (*a*)	197. (*b*)	198. (*b*)	199. (*a*)	200. (*d*)
201. (*b*)	202. (*a*)	203. (*a*)	204. (*a*)	205. (*d*)

206. (a) 207. (c) 208. (b) 209. (c) 210. (d)
211. (a) 212. (c) 213. (b) 214. (c) 215. (b)
216. (c) 217. (b) 218. (a) 219. (c) 220. (b)
221. (b) 222. (d) 223. (d) 224. (c) 225. (d)
226. (a) 227. (c) 228. (c) 229. (b) 230. (c)
231. (a) 232. (b) 233. (a) 234. (c) 235. (a)
236. (b) 237. (b) 238. (b) 239. (b) 240. (a)
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276. (b) 277. (b) 278. (c) 279. (b) 280. (b)
281. (b) 282. (d) 283. (b) 284. (c) 285. (b)
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296. (c) 297. (d) 298. (d) 299. (c) 300. (d)
301. (c) 302. (c) 303. (d) 304. (c) 305. (a)
306. (a) 307. (c) 308. (b) 309. (d) 310. (d)
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341. (a) 342. (c) 343. (a) 344. (a) 345. (d)
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351. (c) 352. (d) 353. (d) 354. (c) 355. (a)
356. (a) 357. (d) 358. (b) 359. (c) 360. (c)
361. (b) 362. (b) 363. (a) 364. (a) 365. (b)
366. (d) 367. (a) 368. (d) 369. (a) 370. (b)
371. (d) 372. (b) 373. (b) 374. (a) 375. (d)
376. (c) 377. (b) 378. (a) 379. (c) 380. (b)
381. (d) 382. (d) 383. (c) 384. (b) 385. (c)
386. (a) 387. (b) 388. (c) 389. (d) 390. (a)
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421. (c) 422. (d) 423. (a) 424. (a) 425. (d)
426. (a) 427. (a) 428. (b) 429. (c) 430. (a)
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461. (c) 462. (a) 463. (b) 464. (d) 465. (b)
466. (a) 467. (b) 468. (d) 469. (c) 470. (b)
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476. (c) 477. (a) 478. (a) 479. (b) 480. (b)
481. (c) 482. (c) 483. (b) 484. (b) 485. (b)
486. (b) 487. (c) 488. (b) 489. (a) 490. (d)
491. (a) 492. (c) 493. (b) 494. (c) 495. (c)
496. (b) 497. (a) 498. (b) 499. (c)

500. Parabola, center line
501. Nonviscous, incompressible
502. increase
503. speed of sound
504. four
505. cross-sectional area
506. diminishes
507. velocity gradient
508. internal
509. shaft work
510. ideal gases
511. infinite
512. decreases
513. buoyancy, drag
514. $\sqrt{H}$
515. remains constant
516. 2
517. compression
518. decrease
519. static shear stress
520. Newtonian
521. increased
522. $d_0 - d_i$
523. L
524. $2AB/(A + B)$
525. Hagen-Poiseuille
526. 2100
527. Reynolds
528. Wall roughness
529. $(D/d)^{0.5}$
530. kinematic viscosity
531. perpendicular
532. $D\Delta P/4L$
533. $8\bar{V}/D$
534. $24/N_{Re,P}$
535. 0·44
536. $\varepsilon/D = 0$
537. zero
538. mechanical
539. free
540. small
541. greater than
542. less than
543. 200-mesh
544. 1, 2
545. 1·5, infinite
546. 2
547. 4/3
548. $[2/(\gamma + 1)^{1/(1-1/\gamma)}$
549. minimize, suppress
550. additive
551. buoyancy
552. centrifugal force
553. zero

554. increase
556. $6/D_p$
558. reduces
560. (*a*) – (*III*)
(*b*) – (*IV*)
(*b*) – (*II*)
(*c*) – (*I*)
562. (*a*) – (*I*)
(*b*) – (*IV*)
(*c*) – (*III*)
(*d*) – (*II*)
564. (*a*) – (*IV*)
(*b*) – (*I*)
(*c*) – (*II*)
(*d*) – (*III*)
566. (*a*) – (*IV*)
(*b*) – (*III*)
(*c*) – (*I*)
(*d*) – (*II*)
568. (*a*) – (*II*)
(*b*) – (*III*)
(*c*) – (*I*)
(*d*) – (*IV*)
570. (*a*) – (*II*)
(*b*) – (*I*)
(*c*) – (*IV*)
(*d*) – (*III*).

555. unity
557. greater
559. 2, 1/2
561. (*a*) – (*IV*)
(*b*) – (*I*)
(*c*) – (*III*)
(*d*) – (*II*)
563. (*a*) – (*II*)
(*b*) – (*III*)
(*c*) – (*IV*)
(*d*) – (*I*)
565. (*a*) – (*III*)
(*b*) – (*II*)
(*c*) – (*I*)
(*d*) – (*IV*)
567. (*a*) – (*III*)
(*b*) – (*I*)
(*c*) – (*II*)
(*d*) – (*IV*)
569. (*a*) – (*III*)
(*b*) – (*I*)
(*c*) – (*IV*)
(*d*) – (*II*)

2

Heat Transfer

DEFINITIONS

Absorptivity. Fraction of total incident radiant energy absorbed.

Baffle spacing. The center-to-center distance between baffles. Maximum baffle spacing is taken to be inside diameter of shell and minimum spacing is one-fifth of the inside diameter of shell or 2 inches, whichever is larger.

Barometric condenser. A direct-contact condenser where a vacuum is maintained by a 34-feet head of water.

Black body. A hypothetical "body" or surface that completely absorbs all radiant energy, independent of wavelength and direction. It also emits, at a given temperature, the maximum possible radiation at all wavelengths and in all directions.

Blowdown. To reduce the accumulation of scale forming materials, a small percentage of water fed in the boiler is drained continuously or intermittently as blowdown.

Boiler. A directly fired tubular apparatus which primarily converts chemical energy of fuel into latent heat of vaporization.

Boiling-point elevation. The difference in the boiling points of the solution and the pure water at the same pressure.

Brine. A solution of aqueous chlorides having a freezing point below that of water; sometimes used to describe a nonaqueous liquid cooling medium.

Colburn *J* factor for heat transfer. $J_H = N_{st} N_{Pr}^{2/3}$

Condenser. A heat-transfer device used to liquefy vapours by removing their latent heats.

Conduction. The heat transfer through a body whose molecules, except for vibrations, remain continuously in fixed position.

Configuration factor (view factor). Fraction of radiant energy leaving a surface which reaches a second surface.

Congruent melting point. Melting occurs without change in composition.

Controlling film coefficient. When a significant difference exists, the smaller film coefficient is the controlling film coefficient.

Convection. The transport of heat by fluid flow.

Convection, forced. Convection caused by mechanical forces such as fans.

Convection, natural. Convection of a fluid due to density difference caused by temperature difference.

Critical radius. The ratio of thermal conductivity of the insulation to the surface coefficient of heat transfer.

Duhring rule. The boiling point of a given solution is a linear function of the boiling point of pure water at the same pressure.

Efficiency of heat exchanger. The ratio of the heat transferred by a real heat exchanger to an exchanger with infinite surface.

Emissive power. The total quantity of radiant energy of all wavelengths emitted by a body per unit area and time.

Emissivity. The ratio of the actual emissive power to the black body emissive power under identical conditions.

Equivalent diameter. Four times the hydraulic radius.

Error Function, erf(x). $erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-\beta^2} d\beta$

(Complementary error function, $erfc(x) = 1-erf(x)$).

Eutectic. The mixture of components that has the lowest crystallization temperature.

Evaporator. Employed for the concentration of a solution consisting of a non-volatile solute and a volatile solvent.

Evaporator steam economy. The ratio of the water evaporated to the steam consumed.

Film boiling. The vapourization takes place through a blanketing film of gas covering the heating element.

Fouling factor, R_D (dirt factor). Resistance offered by deposition of dirt and scale. It is defined by

$$R_d = \frac{1}{U_D} - \frac{1}{U_C}$$

where U_D is design or dirty overall coefficient and U_C is clean overall coefficient.

Gray body. A body for which the ratio of the monochromatic emissive power to the monochromatic emissive power of a black body at the same wavelength and temperature is constant for all wavelengths.

Greenhouse effect. The heating effect of a building the outer shell of which is transparent to solar radiation but which is opaque to the thermal re-radiation.

Heat pipe. A device for transferring heat which has a high apparent value of thermal conductance in the direction of heat flow ; usually makes use of vaporization–condensation of a fluid for energy transfer.

Hydraulic radius. For non-circular cross section, it is defined as the ratio of the flow area to the wetted perimeter.

Irradiance. The rate at which radiant energy is incident on a surface per unit area of surface.

Irradiation. The energy incidence on a surface over some specified period of time per unit area of surface.

Kirchhoff's law. At thermal equilibrium the ratio of the total emissive power to the absorptivity for all bodies is the same.

Log mean temperature difference (LMTD) $\Delta T_{lm} = \frac{\Delta T_2 - \Delta T_1}{\ln(\Delta T_2/\Delta T_1)}$

LMTD correction factor. The ratio of the true temperature difference to the LMTD for countercurrent flow.

Long wave radiation. Refers to thermal radiation in the far-red ; emitted by bodies at relatively low temperatures, including temperatures near ambient ; atmospheric radiation ; radiation with a wavelength greater than 3 m.

Nucleate boiling. The boiling action occurring at temperature drops below the critical temperature drop is called nucleate boiling, in reference to the formation of tiny bubbles, or vaporization nuclei, on the heating surface.

Planck's law. Defines the spectral distribution of black-body radiation in terms of the absolute temperature.

Radiant energy. Energy in the form of photons or electromagnetic waves.

Radiation. The transfer of radiant energy from a source to a receiver.

Reboiler. A heat exchanger used to provide a flow of vapour into the bottom of a distillation column.

Reflectivity. Fraction of total incident radiant energy reflected.

Regenerator. An apparatus in which heat is alternately stored and removed. Employed in the blast and open-hearth furnaces of the steel industry.

Stefan-Boltzmann law. States that radiant flux density emitted by a black body is proportional to the fourth power of the absolute temperature ; the proportionality constant is known as the Stefan-Boltzmann constant which is equal to $5{\cdot}6697 \times 10^{-8}$ W/m^{2}K^4.

Tube count. When tubes are laid out with minimum space allowances between partitions and adjoining tubes and within a diameter free of obstruction, the number of tubes in the layout is the tube count.

Tube pitch. The shortest center-to-center distance between adjacent tubes.

Transmissivity. Fraction of total incident radiant energy transmitted.

Ultra-voilet radiation. Electromagnetic radiation having a wavelength less than 0·38 μm.

Visible radiation. Electromagnetic radiation in the wavelength band of 0·38–0·78 μm.

Wien's law. States that the wavelength at which the spectral emissive power (or emissive power per unit wave band) is a maximum is proportional to the reciprocal of the absolute temperature.

1. Select the only wrong statement.
   (*a*) heat can be converted into work
   (*b*) heat can be reflected by a mirror
   (*c*) heat waves cannot pass through vacuum
   (*d*) heat is a form of energy

2. Which of the following is a form of energy ?
   (*a*) pressure (*b*) momentum
   (*c*) light (*d*) power.

3. When heat is transferred by a chain of molecules from the hot area of an object to a colder area, the process of heat transfer is called
   (*a*) natural convection (*b*) forced convection
   (*c*) conduction (*d*) radiation.

4. Heat transfer by conduction is described by
   (*a*) Fourier's law (*b*) Newton's law of cooling
   (*c*) Stefan-Boltzmann law (*d*) Fick's law.

5. Heat transfer by conduction is directly proportional to
   (*a*) (thermal potential difference)/(thermal resistance)
   (*b*) (thermal resistance)/(thermal potential difference)
   (*c*) (thermal potential difference)(thermal resistance)
   (*d*) thermal resistance

6. Whenever there is a temperature difference,
   (*a*) heat will be transferred from hotter object to colder object
   (*b*) heat will be transferred from colder object to hotter object
   (*c*) heat will not be transferred
   (*d*) none of these answers.

7. The units of thermal conductivity in SI unit are
   (*a*) W/(m.K) (*b*) J/(m.K)
   (*c*) W/(m^2.K) (*d*) J/(m^2.K).

8. The thermal conductivity of a gas
   (*a*) decreases with increasing temperature
   (*b*) increases with increasing temperature
   (*c*) is independent of temperature and pressure
   (*d*) is greater than the thermal conductivity of water at the same temperature.

9. The thermal conductivity of water
   (*a*) remains unaffected with change in temperature
   (*b*) decreases with increase in temperature upto about 300°F
   (*c*) increases with increase in temperature upto about 300°F
   (*d*) is less than the thermal conductivity of air at the same temperature.

10. If k_s, k_l, and k_g are the thermal conductivities of aluminium, water, and air at the same temperature, then
    (*a*) $k_s > k_l > k_g$ (*b*) $k_g > k_t > k_s$
    (*c*) $k_s > k_g > k_l$ (*d*) $k_l > k_s > k_g$.

11. Thermal conductivity is maximum for
    (*a*) coke (*b*) gasoline
    (*c*) steel (*d*) air.

12. Thermal conductivity is minimum for
    (*a*) asphalt (*b*) water
    (*c*) petroleum coke (*d*) air.

13. Heat transfer by conduction depends upon
    (*a*) temperature difference and thermal conductivity only
    (*b*) temperature difference and area only
    (*c*) temperature difference and thickness only
    (*d*) temperature difference, thermal conductivity, area, and thickness.

14. Which one of the four factors would cause heat transfer rate by conduction to decrease, if the value of that factor were increased ?
    (*a*) temperature difference (*b*) thermal conductivity
    (*c*) area (*d*) thickness.

15. Two cylindrical rods *A* and *B* are of equal length. Each rod has its ends at temperatures T_1 and T_2. What is the condition that will ensure equal rates of heat flow through the rods *A* and *B* ?

    (*a*) $\frac{r_A}{r_B} = \frac{k_B}{k_A}$ (*b*) $\frac{r_A}{r_B} = \left(\frac{k_B}{k_A}\right)^2$

    (*c*) $\frac{r_A}{r_B} = \left(\frac{k_B}{k_A}\right)^{1/2}$ (*d*) $\frac{r_A}{r_B} = \left(\frac{k_A}{k_B}\right)^{1/2}$

    where r_A = radius of rod *A*
    r_B = radius of rod *B*
    k_A = thermal conductivity of rod *A*.
    k_B = thermal conductivity of rod *B*.

16. A sphere, a cube, and a thin circular plate, all made of the same material and having the same mass are initially heated to a temperature 300°C. Which of these objects will cool slowest when left in air at room temperature ?
    (*a*) sphere (*b*) cube
    (*c*) circular plate (*d*) all will cool at the same rate.

17. The thermal conductivity of copper.
    (*a*) remains unaffected with change in temperature
    (*b*) increases with increase in temperature

(c) decreases with increase in temperature
(d) is less than the thermal conductivity of aluminium at the same temperature.

18. In general, the thermal conductivity of a non-homogeneous material
(a) decreases with increasing temperature
(b) decreases with increasing apparent bulk density
(c) increases both with increasing temperature and increasing apparent bulk density
(d) increases with increasing temperaure but decreases with increasing apparent bulk density.

19. The thermal conductivity of engine oil (unused)
(a) is greater than the thermal conductivity of water at the same temperature
(b) remains unaffected with change in temperature
(c) decreases with increase in temperature
(d) increases with increase in temperature.

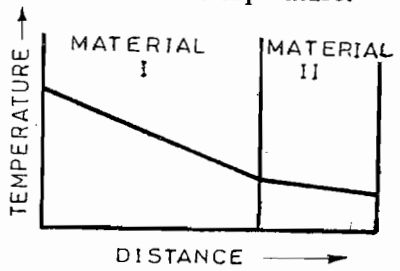


Fig. 2·1.

20. A steady state the temperature profiles in a laminated system is shown in Fig. 2·1. The ratio of the thermal conductivity of material I to the thermal conductivity of material II is
(a) less than 1
(b) greater than I
(c) equal to 1
(d) infinity.

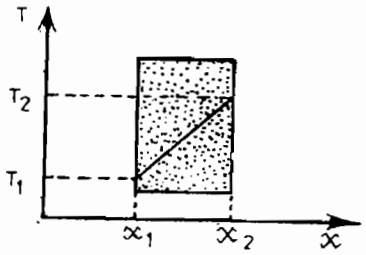


Fig. 2·2.

21. A plane wall 0·4 ft thick of a homogeneous material with $k = 0{\cdot}24$ Btu/(hr ft °F) has steady and uniform temperatures $T_1 = 80°F$ and $T_2 = 170°F$ as shown in Fig. 2·2. What is the heat transfer rate in the positive x-direction per square foot of surface area ?
(a) 54 Btu/(hr.ft^2)
(b) 45 Btu/(hr.ft^2)
(c) –54 Btu/(hr.ft^2)
(d) – 45 Btu/(hr.ft^2)

22. The thermal conductivity of a perfect heat insulator is
(a) zero
(b) infinity
(c) one
(d) between zero and infinity

23. Two flat sheets of thicknesses L_1 and L_2 and thermal conductivities k_1 and k_2 are joined together. If the open face of the first plate is maintained at a temperature T_1 and the open face of second plate at T_2. The temperature (T) at the interface of the plates can be calculated by

(a) $T = \dfrac{(k_1T_1 + k_2T_2)}{(k_1 + k_2)}$

(b) $T = \dfrac{\left(\dfrac{L_1T_1}{k_1} + \dfrac{L_2T_2}{k_2}\right)}{\left(\dfrac{L_1}{k_1} + \dfrac{L_2}{k_2}\right)}$

(c) $T = \dfrac{\left(\dfrac{k_1T_1}{L_1} + \dfrac{k_2T_2}{L_2}\right)}{\left(\dfrac{k_1}{L_1} + \dfrac{k_2}{L_2}\right)}$

(d) $T = \dfrac{\left(\dfrac{T_1}{k_1L_1} + \dfrac{T_2}{k_2L_2}\right)}{\left(\dfrac{1}{k_1L_1} + \dfrac{1}{k_2L_2}\right)}$.

24. Two plates of equal thicknesses and equal heat flow areas with thermal conductivities k_1 and k_2 are joined together to form a single plate of double thickness. What is equivalent thermal conductivity of the composite plate so formed ?

(a) $\dfrac{k_1k_1}{2(k_1 + k_2)}$
(b) $k_1 + k_2$
(c) $\dfrac{k_1k_2}{k_1 + k_2}$
(d) $\dfrac{2k_1k_2}{k_1 + k_2}$

25. The conductance is
(a) directly proportional to the resistance to heat flow
(b) the reciprocal of the resistance to heat flow
(c) directly proportional to the thermal potential difference
(d) the reciprocal of the thermal potential difference.

26. The conductance has the units of
(a) W/m^2
(b) W/K
(c) W/(m.K)
(d) 1/K

27. The conductance is defined as

(a) $L/(kA)$ (b) $(kA)/L$
(c) $k/(AL)$ (d) $A/(kL)$

where k = thermal conductivity of material,
A = heat flow area,
L = thickness.

28. Heat transfer rate through some system has been empirically defined as $Q = 20\ (\Delta T/m)$ where Q is heat transfer rate in Btu/hr, ΔT the temperature difference in °F and m the system mass in lb. What will be its form if the units assigned to Q, ΔT, and m are W, K, and kg respectively ?

(a) $Q = 350\ (\Delta T/m)$ (b) $Q = 270{\cdot}79\ (\Delta T/m)$
(c) $Q = 17{\cdot}23\ (\Delta T/m)$ (c) $Q = 83{\cdot}58\ (\Delta T/m)$

29. The thermal diffusivity of a material is defined as

(a) $k/(\rho C_p)$ (b) $(\rho C_p)/k$
(c) $(kC_p)/\rho$ (d) $(k\rho)/C_p$.

30. The units of the thermal diffusivity of a material are

(a) m^2/K (b) s/m^2
(c) $W/(m^2.K)$ (d) m^2/s.

31. The thermal diffusivity of a material is the ratio of

(a) the thermal conductivity to the thermal capacity of the material
(b) the thermal capacity to the thermal conductivity of the material
(c) the thermal conductivity to the specific heat of the material
(d) the thermal conductivity to the density of the material.

32. The thermal diffusivity of a material is important in the analysis of problems involving heat transfer by

(a) radiation (b) natural convection
(c) condensation (d) conduction.

33. An equation for heat flow in the cube for constant thermal diffusivity is

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

This equation is known as

(a) Laplace equation (b) Poisson equation
(c) Fourier equation (d) Stefan-Boltzmann equation.

34. An equation for heat flow in the cube for constant thermal diffusivity is

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} = 0$$

This equation is known as

(a) Newton equation (b) Laplace equation
(c) Poisson equation (d) Fourier equation.

35. The wall of an oven consists of three layers of firebrick, insulating brick, and building brick. The resistances of the three layers for conduction are R_1, R_2 and R_3 (K/W) respectively. The overall resistance for conduction is

(a) $R_1 + R_2 + R_3$ (b) $(R_1 R_2 R_3)^{1/3}$
(c) $(R_1 + R_2 + R_3)/3$ (d) $\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$.

36. The resistance to heat flow by conduction is

(a) directly proportional to the material thickness
(b) inversely proportional to the material density
(c) inversely proportional to the area normal to the direction of heat transfer
(d) all of these answers.

37. If the thermal conductivity of a wall material varies linearly with temperature, the steady state temperature distribution in the very large thin plane wall having steady, uniform surface temperature follows

(a) linear law (b) parabolic law
(c) logarithmic law (d) hyperbolic law.

38. Logmean heat transfer area for the two heat transfer areas A_1 and A_2 is given by

(a) $\frac{A_1 - A_2}{\ln(A_2/A_1)}$ (b) $\frac{A_1 - A_2}{\ln(A_1/A_2)}$
(c) $(A_1 - A_2)\ln\left(\frac{A_1}{A_2}\right)$ (d) $\frac{\ln(A_1/A_2)}{A_1 - A_2}$.

39. Geometric mean heat transfer area for the two heat transfer area A_1 and A_2 is given by

(a) $(A_1 + A_2)/2$ (b) $(A_1 A_2)^{1/2}$
(c) $(A_1 + A_2)^{1/2}$ (c) $\left(\frac{1}{A_1} + \frac{1}{A_2}\right)^{-1}$.

40. The thicker the insulation the less is the total heat lost. This statement is

(a) always true for flat insulation only
(b) always true for curved insulation only
(c) always true for both flat and curved insulation
(d) not true for both flat and curved insulation.

41. If the thermal conductivity of a wall material is independent of temperature, the steady state temperature distribution in the very large thin plane wall having steady, uniform surface temperatures follows

(*a*) hyperbolic law (*b*) parabolic law
(*c*) linear law (*d*) logarithmic law.

42. The maximum heat loss from pipe occurs when the critical radius equals

(*a*) the ratio of the surface coefficient of heat transfer to the thermal conductivity of the insulation
(*b*) the ratio of the thermal conductivity of the insulation to the surface coefficient of heat transfer
(*c*) the product of the thermal conductivity of the insulation and the surface coefficient of heat transfer
(*d*) the radius of the pipe.

43. If the pipe radius (r) is less than the critical radius (r_c), the heat loss from pipe

(*a*) remains unaffected with addition of insulation
(*b*) decreases with addition of insulation until $r = r_c$, and then increases with further addition of insulation
(*c*) increases with addition of insulation until $r = r_c$, and then decreases with further addition of insulation
(*d*) decreases for any addition of insulation.

44. If the pipe radius (r) is greater than the critical radius (r_c), the heat loss from pipe

(*a*) remains constant for any addition of insulation
(*b*) increases for any addition of insulation
(*c*) decreases for any addition of insulation
(*d*) increases with addition of insulation until $r = r_c$, and then decreases with further addition of insulation.

45. The critical radius for curved insulation

(*a*) remains unaffected with change in the thermal conductivity of insulation
(*b*) decreases with decrease in the thermal conductivity of insulation
(*c*) increases with decrease in the thermal conductivity of insulation
(*d*) increases linearly with decrease in the thermal conductivity of insulation

46. The thermal resistance afforded by a single cylindrical wall of homogeneous material having constant thermal conductivity (k) and uniform inner and outer surface temperatures is

(*a*) $\dfrac{(r_2 - r_1)}{2\pi r_2 k L}$ (*b*) $\dfrac{\ln (r_2/r_1)}{2\pi k L}$

(*c*) $\dfrac{(1/r_1 - 1/r_2)}{4\pi k}$ (*d*) $\dfrac{\ln (r_2/r_1)}{2\pi (r_2 - r_1) k L}$.

where r_1, r_2, and L are inner radius, outer radius, and length of the cylindrical wall respectively.

47. The thermal resistance afforded by a single spherical layer of a homogeneous material having constant thermal conductivity (k) and uniform inner and outer surface temperature is

(*a*) $\dfrac{(1/r_1 - 1/r_2)}{4\pi k}$ (*b*) $\dfrac{(r_2 - r_1)}{4\pi k}$

(*c*) $\dfrac{(r_2 - r_1)}{4\pi \left(r_2^2 - r_1^2\right) k}$ (*d*) $\dfrac{\ln (r_2/r_1)}{2\pi k}$.

where r_1 and r_2 are the inner and outer radius of spherical layer.

48. An industrial furnace wall is constructed of 0·6 ft thick fireclay brick having $k = 0{\cdot}6$ Btu/(hr. ft °F). This is covered on the outer surface with a 0·12 ft thick layer of insulating material having $k = 0{\cdot}04$ Btu/(hr. ft °F). The innermost surface is at 100 °F. The steady state heat transfer per square foot is

(*a*) 450 Btu/(hr. ft^2) (*b*) 533·33 Btu/(hr. ft^2)
(*c*) 400 Btu/(hr. ft^2) (*d*) 800 Btu/(hr. ft^2).

49. If heat is generated inside a plane wall, the steady state temperature distribution in a very large thin plane wall having a constant thermal conductivity and steady, uniform face temperatures follows

(*a*) linear law (*b*) logarithmic law
(*c*) parabolic law (*d*) hyperbolic law.

50. For a steady state current of I passing thorugh a electrical conductor having a resistance of R, the heat generated is given by

(*a*) IR^2 (*b*) IR
(*c*) I^2R (*d*) I^2R^2.

51. The Fourier number (N_{Fo}) is defined as

(*a*) tL^2/α (*b*) $\alpha t/L^2$
(*c*) hL/k (*d*) hk/L.

52. The Fourier number is used in the analysis of problems involving

(*a*) steady state heat conduction
(*b*) transient heat conduction
(*c*) heat transfer by natural convection
(*d*) heat transfer by radiation.

53. The Biot number is defined as

(a) $\alpha t/L^2$ (b) $\alpha t^2/L^2$
(c) hk/L (d) hL/k.

54. The Biot number is important in the problems involving
(a) heat transfer by radiation
(b) heat transfer by natural convection
(c) heat transfer by forced convection
(d) transient heat conduction.

55. For pure metals, the thermal conductivity (k) and the electrical conductivity (k_e) are related approximately as
(a) $L = k\,T/k_e$ (b) $L = k/k_e$
(c) $L = k_e/k$ (d) $L = k/k_eT$.

56. The critical radius for curved insulation
(a) increases with decreasing insulation thickness
(b) decreases with decreasing insulation thickness
(c) is indpendent of insulation thickness
(d) depends on the thermal conductivity of insulating material.

57. Convection is the method of heat transfer in which
(a) the heat is sent out or emitted in waves
(b) the heat is transferred along a chain of molecules
(c) the heat is carried along by a movement of warmed matter
(d) all of the above.

58. Heat transfer by convection is described by
(a) Fick's law (b) Fourier's law
(c) Newton's law of cooling (d) Stefan-Boltzmann law.

59. The unit of heat transfer coefficient is
(a) W/(m.K) (b) W/(m^2.K)
(c) J/(m^2.K) (d) J/(m.K).

60. According to Newton's law of cooling (provided the difference of temperature is small), the rate of heat transfer is proportional to
(a) the excess temperature
(b) the square of the excess temperature
(c) the cube of the excess temperature
(d) the fourth power of the excess temperature.

61. When crude oil is pumped through the furnace, the first heat transfer to the tubes occurs when the hot flue gases rise and heat the tubes. The oil tubes are heated first by the process of
(a) conduction (b) convection
(c) radiation (d) condensation.

62. The Prandtl number (N_{Pr}) is defined as
(a) $C_p\,\mu/\rho$ (b) $k\,C_p/\mu$
(c) $C_p\,\mu/k$ (d) $C_p\,\rho/k$.

63. The Nusselt number (N_{Nu}) is defined as
(a) $C_p\,\mu/k$ (b) $h\,D/k$
(c) $k\,D/h$ (d) $C_p\,\mu/h$.

64. The Stanton number (N_{St}) for heat transfer is given by
(a) $\dfrac{N_{Re}}{N_{Nu}\,N_{Pr}}$ (b) $\dfrac{N_{Pr}}{N_{Nu}\,N_{Re}}$
(c) $\dfrac{N_{Nu}}{N_{Re}\,N_{Pr}}$ (d) $\dfrac{N_{Re}\,N_{Pr}}{N_{Nu}}$.

65. The Peclet number (N_{Pe}) for heat transfer is given by
(a) N_{Re}/N_{Pr} (b) N_{Pr}/N_{Re}
(c) $N_{Re}\,N_{Pr}$ (d) $N_{Nu}/(N_{Re}\,N_{Pr})$.

66. The Grashof number (N_{Gr}) is defined as
(a) $\dfrac{g\beta(T_s - T_\infty)\,L^3}{\mu^2}$ (b) $\dfrac{g\beta(T_s - T_\infty)\,\rho^2 L^3}{\mu^2}$
(c) $\dfrac{g\beta(T_s - T_\infty)\,\rho^2}{\mu^2 L^3}$ (d) $\dfrac{\beta(T_s - T_\infty)\,\rho^2 L^3}{\mu^2}$.

67. The Reyleigh number (N_{Ra}) is given by
(a) $N_{Gr}\,N_{Re}$ (b) $N_{Gr}\,N_{Pr}$
(c) $N_{Gr}\,N_{Pe}$ (d) $N_{Gr}\,N_{St}$.

68. The Graetz number (N_{Gz}) is defined as
(a) $N_{Re}\,N_{Pr}$ (b) $N_{Re}\,N_{Pr}/N_{Nu}$
(c) $(N_{Re}\,N_{Pr})(D/L)$ (d) $(N_{Re})(D/L)$.

69. The Prandtl number is
(a) the ratio of kinematic viscosity to thermal diffusivity
(b) the ratio of thermal diffusivity to kinematic viscosity
(c) the product of thermal diffusivity and kinematic viscosity
(d) the ratio of absolute viscosity to thermal conductivity.

70. The coefficient of volume expansion for an ideal gas is
(a) P/RT (b) R/P
(c) R^2T/P^2 (d) $1/T$.

71. Transition from laminar to turbulent flow in a natural convection on vertical plates occurs when the product of the Prandtl number and the Grashof number equals approximately
(a) 10^5 (b) 2100
(c) 10^9 (d) 4000.

72. In natural convection, fluid moves under the influence of

(*a*) buoyant forces arising from changes in density
(*b*) changes in fluid pressure produced by external work
(*c*) surface tension forces
(*d*) elastic forces.

73. In forced convection, fluid moves under the influence of

(*a*) changes in fluid pressure produced by external work
(*b*) buoyant forces arising from changes in density
(*c*) elastic forces
(*d*) surface tension forces.

74. The Graetz number is associated with

(*a*) heat transfer by radiation
(*b*) heat transfer in laminar flow
(*c*) heat transfer in turbulent flow
(*d*) mass transfer operations.

75. The Grashof number is proportional to

(*a*) the ratio of viscous force to buoyancy force
(*b*) the ratio of buoyancy force to viscous force
(*c*) the ratio of buoyancy force to elastic force
(*d*) the ratio of viscous force to inertial force.

76. The Peclet number is a measure of the ratio of

(*a*) energy transport by conduction to that by convection
(*b*) energy transport by convection to that by conduction
(*c*) buoyancy force to viscous force
(*d*) kinematic viscosity to thermal diffusivity.

77. The hydrodynamic and thermal boundary layers are identical when

(*a*) $N_{pr} = 0{\cdot}7$ (*b*) $N_{Pr} = 1$
(*c*) $N_{Pr} = 1{\cdot}5$ (*d*) $N_{Pr} = 120$.

78. The Reynolds analogy states that

(*a*) $N_{St} = f/8$ (*b*) $N_{St} = f/2$
(*c*) $N_{Pr} = f/4$ (*d*) $N_{St} = f$

where f = Fanning friction factor.

79. Reynolds and Prandtl analogies are exactly same for

(*a*) $N_{Pr} = 0{\cdot}7$ (*b*) $N_{Pr} = 1$
(*c*) $N_{Pr} = 0{\cdot}6$ (*d*) $N_{Pr} > 1$.

80. When the Prandtl number is greater than unity, the thermal boundary layer

(*a*) is thinner than the hydrodynamic boundary layer
(*b*) is thicker than the hydrodynamic boundary layer

(*c*) and the hydrodynamic boundary is identical
(*d*) disappears.

81. The Colburn j factor for heat transfer is defined as

(*a*) $N_{St}\,N_{pr}$ (*b*) $N_{St}\,P_{Pr}^{1/3}$
(*c*) $N_{St}\,N_{Pr}^{2/3}$ (*d*) $N_{St}\,N_{Pr}^{3/2}$

82. The Reynolds analogy

(*a*) applies only to fluids for which the Prandtl number is unity
(*b*) applies over a range of Prandtl numbers from 0·6 to 120
(*c*) can be used for situations where form drag appears
(*d*) cannot be used for situations where wall drag appears.

83. For laminar, fully developed, constant property flow in a pipe at uniform heat flux, the Nusselt number is

(*a*) 3·656 (*b*) 2
(*c*) 4·364 (*d*) 0·7.

84. For laminar, fully developed, constant property flow in a pipe at constant wall temperature, the Nusselt number is

(*a*) 2 (*b*) 4·354
(*c*) 0·7 (*d*) 3·656.

85. The Prandtl number for liquid metals is of the order of

(*a*) 1 (*b*) 10^2
(*c*) 10^{-2} (*d*) 10^3.

86. The Colburn analogy states that

(*a*) $N_{st} = f/2$ (*b*) $N_{st}\,N_{Pr} = f/2$
(*c*) $N_{st}\,N_{Pr}^{2/3} = f/2$ (*d*) $N_{st}\,N_{Pr}^{2/3} = f/8$

where f = Fanning friction factor.

87. Dittus-Boelter equation, $N_{Nu} = 0{\cdot}023\,(N_{Re})^{0{\cdot}8}\,(N_{Pr})^{n}$, where $n = 0{\cdot}4$ for heating the fluid and $n = 0{\cdot}3$ for cooling the fluid, is applicable for

(*a*) $10{,}000 < N_{Re} < 1{\cdot}2 \times 10^5$ (*b*) $0{\cdot}7 < N_{Pr} < 120$
(*c*) $L/D > 60$ (*d*) all the above.

88. For laminar flow over a flat plate the hydrodynamic and thermal boundary layer thicknesses are related by

(*a*) $\delta_t = \delta/N_{Pr}^{1/3}$ (*b*) $\delta_t = \delta$
(*c*) $\delta = \delta_t/N_{Pr}^{1/3}$ (*d*) $\delta_t = \delta/N_{Pr}^{2/3}$.

where δ_t = thermal boundary layer
δ = hydrodynamic boundary layer.

89. The distribution of shear stress in a stream of fluid in a circular tube is

(*a*) linear with radius for laminar flow only
(*b*) linear with radius for turbulent flow only

(c) linear with radius for both laminar and turbulent flow
(d) parabolic with radius for both laminar and turbulent flow.

90. The Colburn analogy applies over a range of Prandtl numbers from
(a) 0·6 to 120 (b) 0·46 to 590
(c) 0·006 to 0·06 (d) 120 to 590.

91. In the absence of adequate data, the Prandtl number for most of the dry gases can be assumed as
(a) 0·1 (b) 120
(c) 10 (d) 0·72.

92. For laminar film condensation, what is the ratio of heat transfer to a horizontal tube of large diameter to that to a vertical tube of the same size for the same temperature difference ?
(a) 0·64 $(L/D)^{1/2}$ (b) 0·64 $(L/D)^{1/3}$
(c) 0·64 $(L/D)^{1/4}$ (d) 0·64 $(L/D)^{1/5}$

93. What L/D ratio will produce the same laminar film condensation controlled heat transfer rate to a tube in both the vertical and horizontal orientations ? Assume the tube diameter is large compared with the condensate thickness.
(a) 5·89 (b) 0·64
(c) 0·023 (d) 1·13.

94. Filmwise condensation
(a) is characterized by a thin liquid film forming over the entire surface
(b) is less common than dropwise condensation
(c) occurs on nonwettable surfaces
(d) is characaterized by high heat transfer coefficients than that for dropwise condensation.

95. For laminar film condensation on vertical surface the local surface conductance
(a) is directly proportional to the film thickness
(b) changes inversely with the film thickness
(c) is independent of the film thickness
(d) varies as the square root of the film thickness.

96. For laminar film condensation on vertical surface, the film thickness
(a) remains constant from top to bottom
(b) cumulatively decreases from top to bottom
(c) cumulatively increases from top to bottom
(d) the surface conductance increase from top to bottom.

97. The presence of small amounts of non-condensing gas in a condensing vapor

(a) greatly increases the rate of condensation
(b) seriously reduces the rate of condensation
(c) does not affect the rate of condensation
(d) increases the condensing film coefficient.

98. For laminar film condensation on vertical surface, the average heat transfer coefficient is inversely proportional to
(a) $(\Delta T)^{1/4}$ (b) $(\Delta T)^4$
(c) $(\Delta T)^{5/4}$ (d) $(\Delta T)^{4/5}$
where ΔT = temperature drop across condensate film.

99. The average heat transfer coefficient for dropwise condensation is
(a) more than that for filmwise condensation
(b) less than that for filmwise condensation
(c) nearly same as that for filmwise condensation
(d) always less than 40 Btu/(hr. ft^2 °F).

100. The heat flux in the free convection regime of pool boiling varies as the
(a) ΔT^3 (b) $\Delta T^{5/4}$
(c) ΔT^2 (d) $\Delta T^{1/4}$.

101. The heat flux in the nucleate boiling regime is proportional
(a) to the square of ΔT (b) to the fourth power of ΔT
(c) to the cube of ΔT (d) to the square root of ΔT
where ΔT = excess temperature.

102. The peak heat flux in a boiling curve is called
(a) the burnout point (b) the Leidenfrost point
(c) the boiling point (d) the Nusselt point.

103. The surface tension of water
(a) is independent of temperature
(b) decreases with increasing temperature
(c) increases with increasing temperature
(d) decreases linearly with increasing temperature.

104. The boiling heat transfer coefficient at atmospheric pressure on a horizontal surface is given by $h_a = 151\ (\Delta T)^{1/3}$, where h_a is the heat transfer coefficient in Btu/(hr ft^2 °F), and ΔT the excess temperature in °F. What will be its form if the units assigned to h_a and ΔT are W/(m^2.K) and K respectively ?
(a) $h_a = 151\ (\Delta T)^{1/3}$ (b) $h_a = 323\ (\Delta T)^{1/3}$
(c) $h_a = 943\ (\Delta T)^{1/3}$ (d) $h_a = 1043\ (\Delta T)^{1/3}$.

105. At atmospheric pressure the critical temperature drop for water is usually between
(a) 70 and 90°F (b) 70 and 90°C
(c) 40 and 50°F (d) 180 and 212°F.

106. The transfer of heat energy from a heated body to a colder body by the emission of heat waves is called

(*a*) conduction (*b*) natural convection
(*c*) forced convection (*d*) radiation.

107. Heat waves

(*a*) travel only in straight lines
(*b*) travel only in circular lines
(*c*) involve some kind of matter to carry the heat energy
(*d*) travel in haphazard manner.

108. Heat transfer by radiation is described by

(*a*) Newton's law of cooling (*b*) Fick's law
(*c*) Fourier's law (*d*) Stefan-Boltzmann law.

109. According to Stefan-Boltzmann law, the radiant heat transfer is proportional to

(*a*) the absolute temperature
(*b*) the second power of the absolute temperature
(*c*) third power of the absolute temperature
(*d*) the fourth power of the absolute temperature.

110. The Stefan-Boltzmann constant (σ) is independent of

(*a*) surface (*b*) medium
(*c*) temperature (*d*) all of the above.

111. The units of the Stefan-Boltzmann constant (σ) are

(*a*) $W/(m^2.K)$ (*b*) $W/(m^2.K^4)$
(*c*) W/m^2 (*d*) $W/(m.K^4)$.

112. The value of the Stefan-Boltzmann constant (σ) is $0{\cdot}1714 \times 10^{-8}$ Btu/(hr. $ft.^2$ $°R^4$). What is its value in $W/(m^2.K^4)$?

(*a*) $0{\cdot}1714 \times 10^{-8}$ (*b*) $5{\cdot}6697 \times 10^{-6}$
(*c*) $5{\cdot}6697 \times 10^{-8}$ (*d*) $0{\cdot}1714 \times 10^{-6}$

113. Heat transfer rate by radiation depends on

(*a*) the distance between the heat source and the object receiving the heat
(*b*) the surface area and temperature of the heat source
(*c*) the type of absorbing surfce
(*d*) all of the above.

114. As the distance between the heat source and the object receiving the heat increases, the rate of heat transfer by radiation

(*a*) remains constant (*b*) increases
(*c*) decreases (*d*) increases linearly.

115. Storage tanks for petroleum products are usually painted. Which paint would be used for a tank used for storage of gasoline ?

(*a*) White lead paint (*b*) Black matte paint
(*c*) Grey paint (*d*) Light cream paint.

116. Which of the tanks below would heat up the most from the radiation from the sun ?

(*a*) A tank painted with light cream paint
(*b*) A tank painted with white lead paint
(*c*) A tank painted with black matte paint
(*d*) A tank painted with grey paint.

117. Absorption coefficient is minimum for

(*a*) white lead paint (*b*) light cream paint
(*c*) grey paint (*d*) black matte paint.

118. Absorption coefficient is minimum for

(*a*) white lead paint (*b*) grey paint
(*c*) light cream paint (*d*) black matte paint.

119. Absorption coefficient is maximum for

(*a*) aluminium plate (*b*) steel
(*c*) furnace refractories (*d*) carbon lamp black.

120. Absorption coefficient is minimum for

(*a*) carbon lampblack (*b*) steel
(*c*) aluminium plate (*d*) furnace refractories.

121. Thermal radiation is defined as the portion of the electromagnetic spectrum between the wavelengths of

(*a*) 0·39 μm and 0·78 μm (*b*) 0·1 μm and 100 μm
(*c*) 10^{-7} μm and 10^{-4} μm (*d*) 100 μm and 10^6 μm.

122. The propagation velocity for all types of electromagnetic radiation in a vacuum is

(*a*) 3×10^{10} m/s (*b*) 3×10^6 m/s
(*c*) 3×10^8 m/s (*d*) 3×10^{12} m/s.

123. The unit(s) of wavelength of radiation is/are

(*a*) micron (*b*) angstrom
(*c*) micrometer (*d*) all of the above.

124. One micron is equal to

(*a*) 10^{-4} m (*b*) 10^{-4} cm
(*c*) 10^{-4} mm (*d*) 10^{-4} ft.

125. Visible light covers a wavelength range of about

(*a*) 0·04 to 0·08 μm (*b*) 1 to 100 μm
(*c*) 0·38 to 0·78 μm (*d*) 10^{-7} to 10^{-4} μm.

126. If the intensity of the radiant energy at any wavelength λ is I_λ, Btu/(hr)$(ft)^2$ (micron), the total emissive power E, Btu/(hr)(ft^2), may be computed by

(a) $E = \int_{0.75}^{400} I_\lambda \, d\lambda$ (b) $E = \int_{-\infty}^{\infty} I_\lambda \, d\lambda$

(c) $E = \int_{0}^{\infty} I_\lambda \, d\lambda$ (d) $E = \int_{0}^{0.75} I_\lambda \, d\lambda$.

127. Which of the following represents the spectral distribution of energy of black body radiation ?

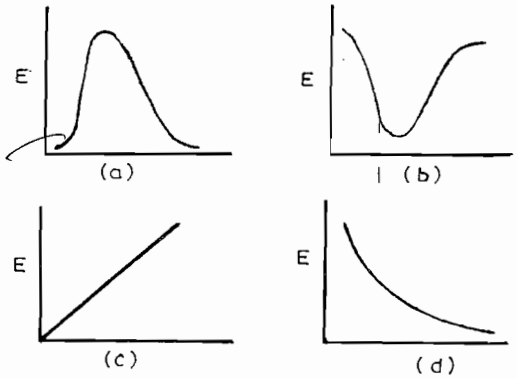


Fig. 2·2.

128. The spectral radiancy (power emitted per unit wavelength) distribution of the radiation from a blackbody at 300 K is shown in Fig. 2·3. If the temperature of the blackbody is increased

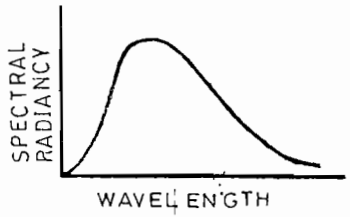


Fig. 2·3.

(a) the peak of the curve becomes higher
(b) the curve no longer passes through origin
(c) the peak value will be shifted to the right
(d) the peak of the curve becomes lower.

129. The shift in location of the maximum value of the monochromatic emissive power to shorter wavelengths with increasing temperature is described by

(a) Stefan-Boltzmann law (b) Kirchhoff's law
(c) Wien's law (d) Planck's law.

130. The total emissivity of a perfect blackbody is

(a) 0 (b) 1
(c) 0·90 (d) ∞

131. The total emissivity of a real surface is

(a) less than zero (b) greater than one
(c) equal to one (d) greater than zero but less than one.

132. Absorptivity of the perfect blackbody is

(a) 1 (b) 0
(c) 0·5 (d) ∞

133. Reflectivity of the perfect blackbody is

(a) 1 (b) 0
(c) ∞ (d) 0·5.

134. Wien's displacement law states that the product of the wavelength of the maximum value of the monochromatic intensity of emission and the absolute temperature is a constant which is equal to

(a) 2897·6 μm.K (b) 2897·6 μm. °R
(c) 2897·6 m.K (d) 2897·6 mm. °R.

135. At thermal equilibrium the ratio of the total emissive power to the absorptivity for all bodies is the same. This statement is known as

(a) Wien's displacement law (b) Stefan-Boltzmann law
(c) Planck's law (d) Kirchhoff's law.

136. The total emissivity of conductors

(a) remains unaffected with change in temperature
(b) decreases with increase in temperature
(c) increases with increase in temperature
(d) decreases linearly with increase in temperature.

137. View factors is important in the analysis of problems involving heat transfer by

(a) conduction (b) natural convection
(c) forced convection (d) radiation.

138. Two very large walls are at the constant temperature of T_1 and T_2 ($< T_1$). Assuming they are black bodies, how much heat must be removed from the colder wall to maintain a constant temperature ?

(a) $\frac{Q}{A} = \sigma\left(T_1^4 + T_2^4\right)$ (b) $\frac{Q}{A} = \sigma\left(T_1^4 - T_2^4\right)$

(c) $\frac{Q}{A} = \sigma T_1^4$ (d) $\frac{Q}{A} = \sigma T_2^4$.

139. The total emissive power (E) of a gray body at a surface temperature of T is given by

(*a*) $E = \sigma T^4$ (*b*) $E = \varepsilon \sigma T^4$
(*c*) $E = \varepsilon \sigma T^2$ (*d*) $E = (1-\varepsilon) \sigma T^4$.

where e = emissivity of gray body at a surface temperature of T.

140. Two very large gray planes are at the constant temperature of T_1 and T_2 ($<T_1$). If the two gray planes have emissivities of ε_1 and ε_2, respectively, what is the net heat exchange rate per unit area ?

(*a*) $\sigma (\varepsilon_1 T_1^4 - \varepsilon_2 T_2^4)$ (*b*) $\varepsilon_1 \varepsilon_2 \sigma (T_1^4 - T_2^4)$

(*c*) $\sigma \left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right)(T_1^4 - T_2^4)$ (*d*) $\frac{\sigma (T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right)}$.

141. The total incident radiant energy upon a body which partially reflects, absorbs and transmits radiant energy is 2200 W/m^2. Of this amount, 300 W/m^2 is reflected and 800 W/m^2 is absorbed by the body. What is the transmissivity ?

(*a*) 0·50 (*b*) 2·0
(*c*) 0·86 (*d*) 0·63.

142. A gray body at a temperature of T_1 has a surface area A_1 and emissivity ε_1. This is completely enclosed by a gray body at a temperature of T_2 ($<T_1$) having a surface area A_2 and emissivity ε_2. The net rate of heat transfer between the two bodies is given by

(*a*) $Q = A_1 \sigma (T_1^4 - T_2^4)$ (*b*) $Q = A_2 \sigma (T_1^4 - T_2^4)$

(*c*) $\frac{A_1 \sigma (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \left(\frac{A_1}{A_2}\right)\left(\frac{1}{\varepsilon_2} - 1\right)}$ (*d*) $Q = \frac{A_1 \sigma (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_2} + \left(\frac{A_1}{A_2}\right)\left(\frac{1}{\varepsilon_1} - 1\right)}$.

143. Two parallel infinite black planes are maintained at 200°C and 300°C. If both temperatures are lowered by 100°C, the net heat-transfer rate by radiation reduces approximately.

(*a*) 53% (*b*) 47%
(*c*) 50% (*d*) 35%.

144. Two parallel infinite gray planes of equal emissivities are maintained at temperatures of T_1 and T_3. If a thin radiation shield is placed between the two planes, the steady state heat-temperature T_2 of the shield is given by

(*a*) $T_2 = (T_1^4 + T_3^4)^{1/4}$ (*b*) $T_2 = \frac{1}{2}(T_1^4 + T_3^4)^{1/4}$
(*c*) $T_2 = \frac{1}{4}(T_1^4 + T_3^4)^{1/4}$ (*d*) $T_2 = 2(T_1^4 + T_3^4)^{1/4}$.

145. Two parallel infinite gray planes of the same emissivities are maintained at temperatures of T_1 and T_2. If n thin radiation shield are placed between the two planes, each having the same emissivities as the initial planes, the ratio Q_n/Q for steady state is

(*a*) $1/n$ (*b*) $1/(n+1)$
(*c*) $1/(n-1)$ (*d*) $1/(2n+1)$.

where Q_n = the net rate of heat transfer if the two planes are separated by n thin radiation shield

Q = the net rate of heat transfer if the two planes were not separated.

146. For a blackbody the wavelength at which the maximum monochromatic emissive power occurs is

(*a*) independent of the absolute temperature of the blackbody
(*b*) directly proportional to absolute temperature of the blackbody
(*c*) inversely proportional to the absolute temperature of the blackbody
(*d*) proportional to the fourth power of the absolute temperature of the blackbody.

147. The monochromatic emissive power for blackbody radiation is given by

(*a*) Stefan-Boltzmann law (*b*) Planck's law
(*c*) Wien's law (*d*) Kirchhoff's law.

148. Which of the following gases do not emit or absorb thermal energy within the temperature ranges encountered in engineering application ?

(*a*) CO_2 (*b*) SO_2
(*c*) NH_3 (*d*) O_2.

149. A body is called gray body if the monochromatic emissivity of the body is

(*a*) zero (*b*) one
(*c*) same for all wavelengths (*d*) different for all wavelengths.

150. Shell and tube type heat exchanger is used for large heat transfer area requirement because

(*a*) it is more economical
(*b*) its space requirement is small
(*c*) it is easy to operate and maintain
(*d*) all of the above.

151. The tube side heat transfer coefficient just at the entrance of tube is

(*a*) infinity
(*b*) zero
(*c*) same as the average value of heat transfer coefficient for tube side
(*d*) none of the above.

152. If the shell side fluid outlet temperature is the same as the tube side fluid outlet temperature in 1–1 cocurrent heat exchanger, the LMTD is

(*a*) infinity
(*b*) zero
(*c*) equal to difference between hot fluid inlet temperature and cold fluid inlet temperature
(*d*) equal to the difference between the hot fluid inlet temperature and cold fluid outlet temperature.

153. Controlling film coefficient means

(*a*) the coefficient which offers the largest resistance
(*b*) the coefficient which offers the least resistance
(*c*) the coefficient which does not offer any resistance
(*d*) the average of the film coefficients.

154. For the same process temperatures, the ratio of the LMTD in parallel flow to the LMTD in counterflow in liquid-liquid heat exchanger is always

(*a*) 1 (*b*) < 1
(*c*) > 1 (*d*) ∞.

155. A cold fluid is heated from 40°C to 130°C by steam at 150°C. The LMTD in parallel flow is

(*a*) lower than the LMTD in counterflow
(*b*) greater than the LMTD in counterflow
(*c*) equal to the LMTD in counterflow
(*d*) zero.

156. Which of the following is/are assumed in deriving the equation $Q = UA$ (LMTD) ?

(*a*) The overall heat transfer coefficient and specific heat are constant over the entire length of path
(*b*) The mass flow rate of fluid is constant
(*c*) There are no partial phase changes in the system and heat losses are negligible
(*d*) All of the above.

157. 1–4 shell and tube heat exchanger means

(*a*) 1 shell side pass and 4 tube side passes
(*b*) 4 shell side passes and 1 tube side pass
(*c*) 4 tubes per pass
(*d*) 4 shell side passes and 4 tube side passes.

158. In a double pipe heat exchanger, one fluid enters at 120°F and leaves at 500°F. The other fluid enters at 900°F and leaves at 520°F. The LMTD for counterflow is

(*a*) ∞ (*b*) 400°F
(*c*) 380°F (*d*) 0°F.

159. For a double pipe heat exchanger in which the overall heat transfer coefficient varies linearly with the temperature difference, the heat transfer rate at steady state is given by

(*a*) $Q = A \dfrac{U_1 \Delta T_1 - U_2 \Delta T_2}{\ln (U_1 \Delta T_1 / U_2 \Delta T_2)}$

(*b*) $Q = A \dfrac{U_1 \Delta T_2 - U_2 \Delta T_1}{\ln (U_1 \Delta T_2 / U_2 \Delta T_1)}$

(*c*) $Q = A \left(\dfrac{U_1 + U_2}{2}\right) \left(\dfrac{\Delta T_2 - \Delta T_1}{\ln (\Delta T_2 / \Delta T_1)}\right)$

(*d*) $Q = A \left(\dfrac{U_1 + U_2}{U_1 U_2}\right) \left(\dfrac{\Delta T_2 - \Delta T_1}{\ln (\Delta T_2 / \Delta T_1)}\right)$.

160. The double pipe heat exchanger is of greatest use where the total required heat transfer surface is in the range

(*a*) 100 to 200 ft^2 (*b*) 100 to 200 m^2
(*c*) 100 to 200 cm^2 (*d*) 100 to 200 mm^2.

161. The temperature difference factor, F_T, is defined as

(*a*) the ratio of the LMTD to the true temperature difference
(*b*) the ratio of the true temperature difference to the LMTD
(*c*) the difference of the true temperature difference and the LMTD
(*d*) the arithmetic mean of the true temperature difference and the LMTD.

162. The value of F_T (LMTD correction factor)

(*a*) increases with increase in number of shell passes
(*b*) decreases with increase in number of shell passes
(*c*) remains unaffected with change in number of shell passes
(*d*) is always unity for multipass exchangers.

163. The LMTD correction factor, F_T, is to be applied

(*a*) in all multipass heat exchangers
(*b*) in heat exchangers having more than one pass on shell side
(*c*) in 1-1 counterflow heat exchanger
(*d*) in unsteady state.

164. Wilson plot is a graph between

(*a*) U *vs* $v^{0.8}$ (*b*) $\dfrac{1}{U}$ *vs* $\dfrac{1}{v^{0.8}}$

(*c*) U *vs* $\dfrac{1}{v^{0.8}}$ (*d*) $\dfrac{1}{U}$ *vs* $v^{0.8}$.

165. The values of film coefficients for gases are generally

(*a*) higher than those obtained for liquids at equal mass velocities
(*b*) lower than those obtained for liquids at equal mass velocities
(*c*) equal to those obtained for liquids at equal mass velocities
(*d*) in the range 1000 to 3000 Btu/(hr ft^2 °F).

166. Fouling factor (R_f) is defined as

(*a*) $R_f = U_{clean} - U_{dirty}$ (*b*) $R_f = \dfrac{1}{U_{dirty}} - \dfrac{1}{U_{clean}}$

(*c*) $R_f = \dfrac{1}{U_{clean}} - \dfrac{1}{U_{dirty}}$ (*d*) $R_f = 1/\sqrt{U_{clean}\, U_{dirty}}$.

167. When new, a heat exchanger transfers 8% more heat than it does after being in service for six months. Assuming that it operates between the same temperature differences and that there is insufficient scale building to change the effective area. What is the effective fouling factor in terms of its clean overall heat transfer coefficient ?

(*a*) $\dfrac{1}{0{\cdot}08\, U_{clean}}$ (*b*) $\dfrac{1{\cdot}08}{U_{clean}}$

(*c*) $\dfrac{0{\cdot}08}{U_{clean}}$ (*d*) $\dfrac{1}{1{\cdot}08\, U_{clean}}$.

168. The tubes in a shell and tube heat exchangers vibrate due to

(*a*) fluid flow on the shell and tube sides
(*b*) oscillations in the flow of shell side or tube side fluid
(*c*) vibrations due to external causes transmitted through piping and/or supports
(*d*) all of the above.

169. The Strouhal number is given by

(*a*) $\dfrac{f\,u}{d}$ (*b*) $N_{Re}\dfrac{d}{L}$

(*c*) $N_{Re}\, N_{Pr}\dfrac{d}{L}$ (*d*) $f\,d/u$.

where f is flow-induced frequency.

170. For a constant Strouhal number, vibration frequency

(*a*) increases with decrease in shell side velocity
(*b*) remains unaffected with change in shell side velocity
(*c*) decreases with decrease in shell side velocity
(*d*) increases linearly with decrease in shell side velocity.

171. Shell side fluid velocity can be changed by changing

(*a*) tube pitch only
(*b*) tube layout only
(*c*) both tube pitch and tube layout.

172. The LMTD correction factor for multipass exchangers is always

(*a*) < 1 (*b*) 1
(*c*) > 1 (*d*) 0.

173. Finned tube used in a heat exchanger

(*a*) increases the effective tube surface area for convective heat transfer
(*b*) decreases the pressure drop
(*c*) decreases the convective heat transfer coefficient
(*d*) decreases the heat transfer rate.

174. Select the correct statement(s)

(*a*) One indication of coke formation in furnace tubes is an abnormally high tube metal temperature
(*b*) The formation of coke inside the tube will cause the heat transfer rate to decrease
(*c*) Scaling of the tubes in a condenser would cause the coefficient of heat transfer to decrease
(*d*) all of the above.

175. If some of the tubes in a heat exchanger are plugged, the effective heat transfer area will

(*a*) remain the same (*b*) increase
(*c*) decrease.

176. If the temperature difference is large and the tube side fluid is dirty, then the best type of heat exchanger to use would be

(*a*) U-tube heat exchanger
(*b*) floating tube sheet heat exchanger
(*c*) single pass fixed tube sheet heat exchanger.

177. Which of the following heat exchangers make allowances for the expansion of the tubes ?

(*a*) U-tube heat exchanger
(*b*) Single pass, fixed tube sheet heat exchanger
(*c*) Multipass, fixed tube sheet heat exchanger.

178. Which of the three heat exchangers would be best to use when the shell side fluid had a temperature much higher than the tube side fluid ?

(*a*) Single pass, fixed tube sheet heat exchanger
(*b*) Three pass, fixed tube sheet heat exchanger
(*c*) U-tube heat exchanger.

179. Which of the following heat exchangers is used for chilling oil to be dewaxed ?

(*a*) U-tube heat exchanger

(*b*) Fixed tube sheet heat exchanger
(*c*) Floating tube sheet heat exchanger
(*d*) Double pipe heat exchanger.

180. Baffles used on shell side of a heat exchanger will
(*a*) decrease heat transfer rate
(*b*) increase heat transfer rate
(*c*) not affect heat transfer rate
(*d*) decrease pressure drop on shell side.

181. When a longitudinal baffle is placed across the shell, the shell side fluid is forced to pass through the heat exchanger
(*a*) once (*b*) twice
(*c*) three times (*d*) four times.

182. Which tube configuration in a heat exchanger would result in the highest heat transfer rate ?
(*a*) Square pitch (*b*) Diagonal square pitch
(*c*) Triangular pitch.

183. If the fluids were clean and non-fouling, the best tube configuration to use would be
(*a*) triangular pitch (*b*) diagonal square pitch
(*c*) square pitch.

184. Both transverse and longitudinal baffles are used to increase
(*a*) the flow velocity (*b*) turbulence of the shell side fluid
(*c*) heat transfer rate (*d*) all of the above.

185. In double pipe heat exchangers, for chilling oil to be dewaxed, there are scrapers inside the pipe to keep the walls of the pipe clean and to increase the mixing of the warmer oil with the cooler oil thus increasing the rate of heat transfer by
(*a*) conduction (*b*) convection
(*c*) radiation.

186. The shell side pressure drop in a shell and tube heat exchanger is maximum for
(*a*) orifice baffle (*b*) disk and ring baffle
(*c*) segmental type baffle.

187. If only thermal conductivity had to be considered in selecting a tube material which metal would be the best ?
(*a*) Carbon steel (*b*) Stainless steel
(*c*) Copper (*d*) Aluminium

188. What value of F_c should be chosen in the absence of data on F_c for computing calorific temperatures for hot and cold hydrocarbons as

$$t_h = t_{h_2} + F_c\left(t_{h_1} - t_{h_2}\right)$$

and $t_c = t_{c_1} + F_c\left(t_{c_2} - t_{c_1}\right)$ respectively ?
(*a*) 0·20 (*b*) 0·30
(*c*) 0·40 (*d*) 0·80.

189. The units of fouling factor are
(*a*) $m^2.K/W$ (*b*) $W/(m^2.K)$
(*c*) m.K/W (*d*) $m^2.K^4/W$.

190. Cooling water fouling factors vary normally in the range
(*a*) 0·001 to 0·003 $[kcal/hr.m^2.\ °C]^{-1}$
(*b*) 0·001 to 0·003 $[Btu/hr.\ ft^2.\ °F]^{-1}$
(*c*) 0·001 to 0·003 $[W/(m^2.K)]^{-1}$
(*d*) 0·001 to 0·003 $[kcal/hr.\ cm^2.\ °C]^{-1}$.

191. Overall heat transfer coefficients for hydrocarbons against water coolant vary normally in the range
(*a*) 50 to 100 $Btu/(hr.\ ft^2\ °F)$ (*b*) 50 to 100 $W/(m^2\ K)$
(*c*) 50 to 100 $kcal/hr.\ m^2\ °C$ (*d*) 50 to 100 $kcal/hr.\ cm^2\ °C$.

192. It is not advisable to design a heat exchanger for LMTD correction factor, F_T, of less than
(*a*) 0·60 (*b*) 0·80
(*c*) 0·90 (*d*) 0·98.

193. The minimum flow of cooling water so as to ensure minimum velocity of 3·5 ft/sec in a shell and tube cooler having 50 tubes (I.d. = 2 cm) per pass will approximately be
(*a*) 17 litres/min. (*b*) 10^6 litres/min
(*c*) 33 litres/min. (*d*) 1000 litres/min.

194. In a given heat exchanger operating at fixed flow rates, $(\Delta t_1/\Delta t_2)$ is proportional to
(*a*) U (*b*) e^{U/K_1}
(*c*) $\ln (U/K_1)$ (*d*) U^{K_1}
where K_1 is a constant.

195. For given tube diameter, pitch and number of passes, the maximum number of tubes that can be accommodated in a shell of tripled inside diameter will be
(*a*) just about nine times
(*b*) considerably less than nine times
(*c*) considerably greater than nine times
(*d*) just about three times.

196. For specified tube outside diameter, higher BWG means
(*a*) higher cross-sectional area (*b*) higher weight per unit length
(*c*) higher tube thickness (*d*) all of the above.

197. Grooves in the tube sheet holes are normally

(*a*) 1/8 cm wide and 1/64 cm deep
(*b*) 1/64 cm wide and 1/8 cm deep
(*c*) 1/8 inch wide and 1/64 inch deep
(*d*) 1/64 inch wide and 1/8 inch deep.

198. Select the correct statement.

(*a*) Compared to inline square pitch, considerably more number of tubes will be accommodated with diamond square pitch
(*b*) Compared to inline square pitch, considerably less number of tubes will be accommodated with diamond square pitch
(*c*) Compared to horizontal apex triangular pitch, about the same number of tubes will be accommodated with diamond square pitch
(*d*) Compared to inline square pitch, about the same number of tubes will be accommodated with diamond square pitch.

199. For one shell and multi-tube pass heat exchanger, the value of limiting efficiency is equal to

(*a*) $1\Big/\left(1 + R + \sqrt{R^2 + 1}\right)$ (*b*) $2\Big/\left(1 + R + \sqrt{R^2 + 1}\right)$

(*c*) $3\Big/\left(1 + R + \sqrt{R^2 + 1}\right)$ (*d*) $4\Big/\left(1 + R + \sqrt{R^2 + 1}\right)$.

200. Total tube lengths for a heat exchanger is given as 450 cm. Maximum allowable unsupported length is 1·5 m. If all baffles are to act as tube supports, the minimum number of baffles required are

(*a*) 2 (*b*) 3
(*c*) 4 (*d*) 5.

201. The minimum water velocity in coolers which is required to be maintained is

(*a*) 3 cm/sec (*b*) 3 m/s
(*c*) 3 ft/sec (*d*) 3 mm/sec.

202. The shell side equivalent diameter (d_e) for square pitch in a shell and tube heat exchanger is given by

(*a*) $d_e = 4P_t^2/\pi d_0$ (*b*) $d_e = \dfrac{P_t^2 - \pi d_0^2/4}{\pi d_0}$

(*c*) $d_e = \dfrac{4\left(P_t^2 - \pi d_0^2/4\right)}{\pi d_0}$ (*d*) $d_e = \dfrac{4\left(P_t^2 - \pi d_0^2\right)}{\pi d_0}$

where P_t is pitch and d_0 is outside diameter of tube.

203. The shell side equivalent (d_e) for triangular pitch in a shell and tube heat exchanger is given by

(*a*) $d_e = \dfrac{4\left(P_t^2 - \pi d_0^2/4\right)}{\pi d_0}$ (*b*) $d_e = \dfrac{4\left(0{\cdot}86\,P_t^2 - \pi d_0^2\right)}{\pi d_0}$

(*c*) $d_e = \dfrac{4\left(1{\cdot}41\,P_t^2 - \pi d_0^2/4\right)}{\pi d_0}$ (*d*) $d_e = \dfrac{4\left(0{\cdot}86\,P_t^2 - \pi d_0^2/4\right)}{\pi d_0}$

where P_t = pitch,
d_0 = outside diameter of tube.

204. For a duct of square cross section, each side of which is d, the equivalent diameter for heat transfer calculation will be

(*a*) $2d/\sqrt{\pi}$ (*b*) $\sqrt{2}\,d$
(*c*) $\left(1 + \sqrt{2}\right)d/2$ (*d*) d.

205. In a double pipe heat exchanger the outer diameter of inner pipe is d_1 and inner diameter of outer pipe is d_2. The equivalent diameter of annulus for heat transfer is

(*a*) $d_2 - d_1$ (*b*) $(d_2 - d_1)/4$
(*c*) $(d_2^2 - d_1^2)/d_1$ (*d*) $(d_2^2 - d_1^2)/4d_1$.

206. In a double pipe heat exchanger the outer diameter of inner pipe is d_1 and inner diameter of outer pipe is d_2. The equivalent diameter of annulus for pressure drop calculation is

(*a*) $(d_2^2 - d_1^2)/d_1$ (*b*) $4(d_2^2 - d_1^2)/d_1$
(*c*) $(d_2 - d_1)$ (*d*) $4(d_2 - d_1)$.

207. The tube pitch is defined as

(*a*) centre-to-centre distance between adjacent tubes
(*b*) the shortest centre-to-centre distance between adjacent tubes
(*c*) the shortest distance between two adjacent tube holes
(*d*) outer diameter of the tube for square pitch.

208. The baffle spacing is usually in the range of

(*a*) $D/5$ or 2 in. (minimum) to $5D$
(*b*) $D/5$ or 2 in. (minimum) to D
(c) D/2 or 5 in. (minimum) to 2D
(*d*) $D/3$ or 2 in. (minimum) to $3D$

where D is the inside diameter of shell.

209. 25 per cent cut segmental baffle means

(*a*) a baffle plate whose height is 25% of the inside diameter of the shell
(*b*) a baffle plate whose height is 75% of the inside diameter of the shell
(*c*) a baffle plate whose height is 25% of the inside diameter of the tube
(*d*) a baffle plate whose height is 25% of the length of tube.

210. The average velocity in the tubes of a 1-4 heat exchanger is ..... times that in a 1-1 heat exchanger having the same number and size of tubes and operated at the same liquid flow rate

(a) 2 (b) 1/4
(c) 1 (d) 4.

211. For turbulent flow of liquid through tubes the tube side heat transfer coefficient is approximately proportional to

(a) $G^{0.2}$ (b) $G^{0.8}$
(c) G^2 (d) $G^{0.5}$.

where G = mass velocity of fluid through tubes.

212. For turbulent flow of fluid through tubes, the tube side pressure drop in a 1-2 heat exchanger is approximately ..... times that in 1-1 heat exchanger having the same number and size of tubes and operated at the same liquid flow rate.

(a) 4 (b) 2
(c) 8 (c) 16.

213. If the steam trap is underdesigned

(a) it will back up condensate
(b) it will waste steam
(c) it will destroy itself of accelerated wear due to rapid recycling.

214. The purpose of steam trap is

(a) to condense steam
(b) to release excess pressure
(c) to remove condensate and inert gases
(d) none of the above.

215. Condensate is a satisfactory water for use as boilder feed water because

(a) it usually contains negligible hardness
(b) it contains low amounts of dissolved solids
(c) it contains low amounts of suspended solids
(d) all of these answers.

216. Steam condensate is highly corrosive mainly due to

(a) presence of CO_2
(b) presence of dissolved O_2
(c) presence of both CO_2 and dissolved O_2
(d) other reasons than the presence of either CO_2 or dissolved O_2.

217. Dowtherm *A* is used as heating medium in chemical industries. It is an eutectic mixture of

(a) 26·5% diphenyl and 73·5% diphenyl oxide

(b) 76·5% diphenyl and 23·5% diphenyl oxide
(c) 50% diphenyl and 50% diphenyl oxide
(d) 2·5% diphenyl and 97·5% diphenyl oxide.

218. Capacity of an evaporator is defined as

(a) the number of kilograms of solvent vaporized per hour
(b) the number of kilograms of solvent vaporized per kilogram of steam fed to the evaporator
(c) the number of kilograms of steam consumed per hour
(d) the number of kilograms of steam consumed per kilogram of solvent vaporized.

219. Economy of an evaporator is defined as

(a) the number of kilograms of steam consumed per hour
(b) the number of kilograms of steam consumed per kilogram of solvent vaporized
(c) the number of kilograms of solvent vaporized per hour
(d) the number of kilograms of solvent vaporized per kilogram of steam fed to the evaporator.

220. Orange juice can be concentrated in

(a) once-through falling film evaporator
(b) long tube evaporator with upward flow
(c) forced circulation evaporator
(d) any of the above.

221. Agitated film evaporators are generally used for

(a) scaling liquors
(b) foamy, frothy liquors
(c) viscous heat sensitive products
(d) all of the above.

222. The type of evaporator generally used for foaming, frothy liquors is

(a) once through falling film evaporator
(b) long tube vertical evaporator
(c) agitated film evaporator
(d) none of the above.

223. Open pan evaporators are preferred

(a) when solution is corrosive
(b) when solution is highly concentrated
(c) when large amount of solution is to be evaporated
(d) because steam economy is more

224. By creating vacuum in an evaporator, the steam economy

(a) remains unaffected (b) increases
(c) decreases.

225. Steam economy of a single evaporator is always

(*a*) 1 (*b*) < 1
(*c*) < 1 (*d*) >> 1.

226. The overall heat transfer coefficient in an agitated film evaporator for Newtonian fluid having viscosity of 100 P is approximately

(*a*) 120 Btu/(hr. ft^2. °F) (*b*) 120 W/(m^2.K)
(*c*) 400 Btu/(hr. ft^2. °F) (*d*) 400 W/(m^2.K).

227. In a multiple effect evaporator with forward feed

(*a*) feed is introduced in the last effect
(*b*) feed flows from higher pressure to lower pressure
(*c*) pumps are required between successive effects
(*d*) feed is introduced in each effect.

228. In a multiple effect evaporator with backward feed

(*a*) feed is introduced in the first effect
(*b*) feed flows in the direction of decreasing pressure
(*c*) transfer between successive effects is done by pumps
(*d*) feed is introduced in each effect.

229. The amount of water vaporized per unit area of surface in an N-effect multiple effect evaporator is approximately

(*a*) $\left(\frac{1}{N}\right)$ th times that in the single effect

(*b*) (N)th times that in the single effect

(*c*) $\left(\sum_{n=1}^{N} \frac{1}{n}\right)$ th times that in the single effect

(*d*) same as that in the single effect.

230. For concentrating cold feed, a multiple effect evaporator with backward feed is desirable because

(*a*) it gives lower economy than forward feed
(*b*) it gives higher economy than forward feed
(*c*) it gives lower capacity than forward feed
(d) it gives lower economy and capacity than forward feed.

231. To evaporate one *lb* of water from a sodium hydroxide solution,

(*a*) about 200 Btu are needed
(*b*) about 589 Btu are needed
(*c*) about 1200 Btu are needed
(*d*) about 80 Btu are needed.

232. The operating pressure of the last effect in a multiple effect evaporator

(*a*) is always 1 atm

(*b*) is determined by the condensing capacity of the condenser following this effect
(*c*) is more than the pressure in the first effect
(*d*) is determined by the pressure of steam fed into first effect.

233. The boiling point of a solution is affected by

(*a*) boiling point elevation only
(*b*) liquid head only
(*c*) both boiling point elevation and liquid head
(*d*) liquid side heat transfer coefficient.

234. Use of multiple effect evaporator results in

(*a*) increase in steam economy only
(*b*) decrease in steam economy only
(*c*) increase in evaporating capacity only
(*d*) increase in both steam economy and evaporating capacity.

235. Steam economy for triple effect evaporator is

(*a*) < 1 (*b*) 1
(*c*) > 1 (*d*) << 1.

236. When the sensible heat effects are negligible for a triple effect evaporator system for which the boiling point elevations are also negligible, the steam economy of the system would be

(*a*) 1 (*b*) 3
(*c*) $^1/_3$ (*d*) 9.

237. Duhring rule is useful in solving problems on

(*a*) distillation (*b*) evaporation
(*c*) crystallization (*d*) drying.

238. Duhring's rule states that the boiling point of a given solution is a linear function of

(*a*) density of water
(*b*) viscosity of water
(*c*) thermal conductivity of water
(*d*) boiling point of pure water at the same pressure.

239. Superheated steam is not preferred in evaporation because

(*a*) metal cannot withstand high temperature
(*b*) metal cannot withstand high pressure
(*c*) it has too low film coefficient
(*d*) all of the above.

240. Select the correct statement

(*a*) The vapor pressure of most aqueous solutions is less than that of water at the same temperature

(*b*) The vapor pressure of most aqueous solutions is more than that of water at the same temperature
(*c*) The vapor pressure of a solution is independent of temperature
(*d*) The vapor pressure of most aqueous solutions increases linearly with increase in temperature.

241. The actual temperature drop across the heating surface of an evaporator depends on

(*a*) the solution being evaporated
(*b*) the difference in pressure between the steam chest and the vapor space above the boiling liquid
(*c*) the depth of liquid over the heating surface
(*d*) all of the above.

242. For design estimates under ordinary conditions, steam side heat transfer coefficient is assumed to be

(*a*) 500 Btu/(hr. ft.^{2}°F) (*b*) 1500 Btu/(hr. ft.^{2}°F)
(*c*) 250 Btu/(hr. ft.^{2}°F) (*d*) 3500 Btu/(hr. ft.^{2}°F).

243. Depending upon the steam conditions, steam side heat transfer coefficient is in the range

(*a*) 10—100 Btu/(hr. ft^2.°F)
(*b*) 100—300 Btu/(hr. ft^2.°F)
(*c*) 300—1000 Btu/(hr. ft^2.°F)
(*d*) 1000—3000 Btu/(hr.ft^2.°F)

244. A aqueous solution containing 100 grams of dissolved $MgSO_4$ is fed to a crystallizer where 80% of the dissolved salt crystallizes out as $MgSO_4.6H_3O$ crystals. How many grams of the hexahydrate salt crystals are obtained from the crystallizer ?

(*a*) 80·0 (*b*) 100·0
(*c*) 151·8 (*d*) 189·8.

245. The formation of crystal can occur in

(*a*) a saturated solution only
(*b*) an undersaturated solution only
(*c*) a supersaturated solution only
(*d*) saturated, undersaturated, and supersaturated solutions.

246. Which of the following solutes shows appreciable increase in the solubility with increase in temperature ?

(*a*) Glauber salt
(*b*) Common salt
(*c*) Anhydrous sodium sulphate
(*d*) Sodium carbonate monohydrate.

247. Ordinarily, crystallization is

(*a*) a slightly endothermic process

(*b*) a highly endothermic process
(*c*) an exothermic process
(*d*) the formation of solid particles within a heterogenous phase.

248. In a U-tube bundle

(*a*) the outermost tube is the longest
(*b*) the innermost tube is the longest
(*c*) all tubes are of same length
(*d*) none of the above.

249. As the temperature cross increases

(*a*) the LMTD correction factor (F_T) reduces very rapidly
(*b*) the LMTD correction factor (F_T) increases very rapidly
(*c*) the LMTD correction factor (F_T) remains constant
(*d*) the LMTD correction factor (F_T) increases linearly.

250. The temperature cross in a shell and tube heat exchanger

(*a*) can be prevented by decreasing the number of shell passes
(*b*) can be prevented by increasing the number of shell passes
(*c*) is desirable
(*d*) increases the LMTD correction factor (F_T).

251. The equivalent diameter for the annulus of a double pipe heat exchanger whose inner pipe has fins on the outside

(*a*) is less than that for the same size pipes without fins
(*b*) is more than that for the same size pipes without fins
(*c*) is same as that for the same size pipes without fins.

252. Air is heated by condensing steam. Controlling resistance is in the ..... film

253. Thermal conductivity of a material has the units of ..... w/m k

254. The reciprocal of the resistance to heat flow is called ..... thermal conductance

255. Thermal conductance has the units of ..... w / k

256. Thermal conductance of a wall of thermal conductivity k, thickness L and heat-flow area A is ..... kA / L

257. Solids which have high thermal conductivities are called conductors and ..... are poor conductor of heat insulators

258. Thermal diffusivity has the dimensions of area divided by ..... time

259. The ..... resistance to heat flow through a composite flat wall consisting of several materials placed together in series is ..... of the resistances of each material.

260. The reciprocal of the total resistance to flow of heat through a composite pipe wall consisting of several materials is equal to the ..... of resistances of each materials.

Sum of Reciprocal

261. When the critical radius equals the ratio of the thermal conductivity of the insulation to the surface coefficient of heat transfer, ... heat loss occurs. Max.

262. It is desirable to keep the critical radius ..... possible so that the application of insulation will result in a reduction and not an increase in the heat loss from a pipe. as small as

263. Insulation of low thermal conductivity is used in a pipe to keep the critical radius less.. than the radius of the pipe.

264. Synonyms for streamline flow are ..... and ..... flow. Viscous Laminar

265. A method for correlating a number of variables into a single equation expressing an effect is known as dimensional analysis

266. If the outlet temperatures of hot and cold fluids are same in parallel flow, the LMTD is ..Zero

267. The LMTD for parallel flow and counterflow are the same when one of the fluids proceeds through the apparatus at constant ..temp.

268. For a fluid flowing in an annulus the wetted perimeter for heat transfer and pressure drop are ..diff..

269. The pressure drop per meter of length of the pipe varies as the ..square.. of the mass velocity. 0.

270. For turbulent flow of liquid in a tube the film coefficient varies nearly as $\overline{V}^n$ where $\overline{V}$ is the velocity of the liquid and n = ...0.8

271. Baffles are employed in shell and tube heat exchangers to induce turbulence outside the tubes.

272. The height of 25 percent cut baffles is equal to ..75%.. of the inside diameter of the shell.

273. 2-4 shell and tube heat exchanger has ...2.... shell passes and ..4..... tube passes.

274. The use of 1-2 shell and tube heat exchanger is not recommended whenever the LMTD correction factor is less than ..0.75

275. The pressure drop through the shell of an exchanger is proportional ..... to the number of times the fluid crosses the bundle between baffles.

276. When a temperature cross occurs in a 1-2 shell and tube heat exchanger, the value of LMTD correction factor drops sharply.

277. For turbulent flow of liquid in the tube side in a 1-2 shell and tube heat exchanger, the inside heat transfer coefficient is increased by ..4..... if the number of tube passes is increased to 8.

278. The frequency of flow induced vibration and the fluid velocity are related by ..... number. Strouhal

279. Emissivity of a black body is ..... . Unity

280. Absorptivity of a black body is ....Unity

281. Emissivities are influenced by the finish or polish of the surface and ..... with its temperature. increase

282. Reynolds and Prandtl analogies are identical for Prandtl number of ..... . Unity

283. Heat can be transmitted by ..... across an absolute vacuum. Radiation

284. Heat transfer by ..... and ..... require the presence of a medium. Cond. Conv

285. Heat transfer by ..... does not require the presence of a medium. Radiation

286. For travel in a vacuum the velocity of propagation of radiation is very nearly ..... miles/sec. 186000

287. The product of the frequency and wavelength is the ..... of the wave. Velocity

288. One micron is equal to ..10^{-6}.. m.

289. For radiant heat transfer in industrial equipment, only waves in the region between the near and far infrared with wavelengths of ..3/4.. to ..400.. microns are of importance.

290. The quantities of heat involved in the vaporization or condensation of a kilogram of fluid are ..identical

291. For a pure fluid component at a given pressure the change from liquid to vapour or vapour to liquid occurs at saturation temperature.

292. A vapour entering a condenser at its saturation pressure condenses because the surface is at a temperature below its dew point or saturation temperature.

293. In the sodium zeolite process of water softening, a complex sodium silicate reacts continuously with the scale forming compounds of the feed water, replacing the positive ions and at the same time retaining the calcium and magnesium compounds as ..Calcium, magnesium Zeolite

294. Vaporizing exchangers are unfired and convert the latent or sensible heat of one fluid into the ..... of another. Latent heat of Vaporization

295. For water evaporating from pools, the film coefficient for vaporization is maximum at the critical temperature difference (the difference between the tube wall and vapour temperature) which occurs at about ..45..... °F.

296. In the multiple-effect evaporator the temperature differences for heat transfer between the vapour from one effect and the boiling liquid of the next, the pressure on each succeeding evaporator must be ..lower.. than its predecessor.

297. In the derivation of the Nusselt equation for a single component the rate at which the vapour enters the condensate film is assumed to be nearly .....0.

298. Compared to black bodies the exchange of radiant energy between two parallel planes of the same emissivity of 0·8 is reduced by a factor of ..... .

299. For surface condensers a plot of 1/U versus ..... on rectangular coordinates yields a straight line.

300. Longitudinal fins are used when the direction of flow of the fluid is ..... to the axis of the tube ; transverse fins are used when the direction of flow of the fluid is ..... the tube.

301. A fin is used for enhancing heat transfer rate from an object to the surrounding fluid with ..... heat-transfer coefficients.

Match the items in the left column with the appropriate item in the right column :

302.

(*a*) Multiple effect evaporator	(*I*) Chilling of milk
(*b*) Barometric leg	(*II*) Heating of gases
(*c*) Extended surface	(*III*) Steam economy
(*d*) Plate heat exchanger	(*IV*) Condensation at reduced pressure

303.

(*a*) Biot number	(*I*) $D^3\rho^2 g\beta\Delta T/\mu^2$
(*b*) Stanton number	(*II*) $\frac{hL}{k}$
(*c*) Graetz number	(*III*) $h/\rho C_P \bar{V}$
(*d*) Grashof number	(*IV*) WC/kL

304.

(*a*) Nusselt number	(*I*) $C_P\mu/k$
(*b*) Peclet number	(*II*) $D\bar{V}\rho/\mu$
(*c*) Prandtl number	(*III*) $D\bar{V}\rho C/k$
(*d*) Reynolds number	(*IV*) hD/k

305.

(*a*) Logarithmic mean difference	(*I*) $(\Delta T_1 \Delta T_2)^{1/2}$
(*b*) Arithmetic mean	(*II*) $(\Delta T_1 + \Delta T_2)/2$
(*c*) Geometric mean	(*III*) $2\Delta T_1 \Delta T_2/(\Delta T_1 + \Delta T_2)$
(*d*) Harmonic mean	(*IV*) $(\Delta T_2 - \Delta T_1)/\ln(\Delta T_2/\Delta T_1)$

306.

(*a*) $I_\lambda = \frac{C_1 \lambda^{-5}}{e^{C_2/\lambda T} - 1}$	(*I*) Wien's law
(*b*) $\lambda T = 2884$	(*II*) Planck's law
(*c*) $E_b = \sigma T^4$	(*III*) Nusselt equation
(*d*) $h = 0{\cdot}943\left(k_f^3 \rho_f^2 \lambda g/\mu_f L \Delta T_f\right)^{1/4}$	(*IV*) Stefan-Boltzmann's law

307.

(*a*) $N_{st} = f/2$	(*I*) Colburn analogy
(*b*) $N_{st} = \frac{f/2}{1 + 5\,(N_{Pr} - 1)\sqrt{f/2}}$	(*II*) Reynolds analogy
(*c*) $N_{st} = \frac{f/2}{1 + 5\left\{N_{Pr} - 1 + \ln\left[1 + \frac{5}{6}(N_{Pr} - 1)\right]\right\}\sqrt{f/2}}$	(*III*) von Karmann analogy
(*d*) $N_{st} N_{Pr}^{2/3} = f/2$	(*IV*) Prandtl analogy

308.

(*a*) Conduction	(*I*) Newton's law of cooling
(*b*) Convection	(*II*) Fourier's law
(*c*) Radiation	(*III*) Stefan Boltzmann's law
(*d*) Law of refraction	(*IV*) Snell's law

ANSWERS

1. (*c*)	2. (*c*)	3. (*c*)	4. (*a*)	5. (*a*)
6. (*a*)	7. (*a*)	8. (*b*)	9. (*c*)	10. (*a*)
11. (*c*)	12. (*d*)	13. (*d*)	14. (*d*)	15. (*c*)
16. (*a*)	17. (*c*)	18. (*c*)	19. (*c*)	20 (*a*)
21. (*c*)	22. (*b*)	23. (*c*)	24. (*d*)	25. (*b*)
26. (*b*)	27. (*b*)	28. (*d*)	29. (*a*)	30. (*d*)
31. (*a*)	32. (*d*)	33. (*c*)	34. (*b*)	35. (*a*)
36. (*d*)	37. (*b*)	38. (*b*)	39. (*b*)	40. (*a*)
41. (*c*)	42. (*b*)	43. (*c*)	44. (*c*)	45. (*b*)
46. (*b*)	47. (*a*)	48. (*c*)	49. (*c*)	50. (*c*)
51. (*b*)	52. (*b*)	53. (*d*)	54. (*d*)	55. (*d*)
56. (*d*)	57. (*c*)	58. (*c*)	59. (*b*)	60. (*a*)
61. (*b*)	62. (*c*)	63. (*b*)	64. (*c*)	65. (*c*)
66. (*b*)	67. (*b*)	68. (*c*)	69. (*a*)	70. (*d*)
71. (*c*)	72. (*a*)	73. (*a*)	74. (*b*)	75. (*b*)
76. (*b*)	77. (*b*)	78. (*b*)	79. (*b*)	80. (*a*)
81. (*c*)	82. (*a*)	83. (*c*)	84. (*d*)	85. (*c*)
86. (*c*)	87. (*d*)	88. (*a*)	89. (*c*)	90. (*a*)
91. (*d*)	92. (*c*)	93. (*a*)	94. (*a*)	95. (*b*)
96. (*c*)	97. (*b*)	98. (*a*)	99. (*a*)	100. (*b*)
101. (*c*)	102. (*a*)	103. (*b*)	104. (*d*)	105. (*a*)
106. (*d*)	107. (*a*)	108. (*d*)	109. (*d*)	110. (*d*)
111. (*b*)	112. (*c*)	113. (*d*)	114. (*c*)	115. (*a*)
116. (*c*)	117. (*d*)	118. (*a*)	119. (*d*)	120. (*c*)
121. (*b*)	122. (*c*)	123. (*d*)	124. (*b*)	125. (*c*)
126. (*c*)	127. (*a*)	128. (*a*)	129. (*c*)	130. (*b*)
131. (*d*)	132. (*a*)	133. (*b*)	134. (*a*)	135. (*d*)
136. (*c*)	137. (*d*)	138. (*b*)	139. (*b*)	140. (*d*)

141. (*a*)	142. (*c*)	143. (*b*)	144. (*b*)	145. (*b*)
146. (*c*)	147. (*b*)	148. (*d*)	149. (*c*)	150. (*d*)
151. (*a*)	152. (*b*)	153. (*a*)	154. (*b*)	155. (*c*)
156. (*d*)	157. (*a*)	158. (*b*)	159. (*b*)	160. (*a*)
161. (*b*)	162. (*a*)	163. (*a*)	164. (*b*)	165. (*b*)
166. (*b*)	167. (*c*)	168. (*d*)	169. (*d*)	170. (*c*)
171. (*c*)	172. (*a*)	173. (*a*)	174. (*d*)	175. (*c*)
176. (*b*)	177. (*a*)	178. (*c*)	179. (*d*)	180. (*b*)
181. (*b*)	182. (*c*)	183. (*a*)	184. (*d*)	185. (*b*)
186. (*a*)	187. (*c*)	188. (*c*)	189. (*a*)	190. (*b*)
191. (*a*)	192. (*b*)	193. (*d*)	194. (*b*)	195. (*c*)
196. (*a*)	197. (*c*)	198. (*d*)	199. (*b*)	200. (*a*)
201. (*c*)	202. (*c*)	203. (*d*)	204. (*d*)	205. (*c*)
206. (*c*)	207. (*b*)	208. (*b*)	209. (*b*)	210. (*d*)
211. (*b*)	212. (*c*)	213. (*a*)	214. (*c*)	215. (*d*)
216. (*c*)	217. (*a*)	218. (*a*)	219. (*d*)	220. (*a*)
221. (*c*)	222. (*b*)	223. (*b*)	224. (*b*)	225. (*b*)
226. (*a*)	227. (*b*)	228. (*c*)	229. (*a*)	230. (*b*)
231. (*c*)	232. (*b*)	233. (*c*)	234. (*a*)	235. (*c*)
236. (*b*)	237. (*b*)	238. (*d*)	239. (*c*)	240. (*a*)
241. (*d*)	242. (*b*)	243. (*d*)	244. (*c*)	245. (*c*)
246. (*a*)	247. (*c*)	248. (*a*)	249. (*a*)	250. (*b*)

251. (*a*)
252. air film
253. W/(m.K)
254. thermal conductance
255. W/K
256. kA/L
257. insulators
258. time
259. total, sum
260. sum of the reciprocal
261. maximum
262. as small as
263. less
264. viscous, laminar
265. dimensional analysis
266. zero
267. temperature
268. different
269. square
270. 0·8
271. turbulence
272. 75 percent
273. 2, 4
274. 0·75
275. proportional
276. drops
277. $4^{0.8}$
278. Strouhal
279. unity
280. unity
281. increase
282. unity
283. radiation
284. conduction, convection
285. radiation
286. 186000
287. velocity
288. 10^{-6}
289. 3/4, 400
290. identical
291. saturation

292. below
293. calcium and magnesium zeolites
294. latent heat of vaporization
295. 45
296. lower
297. infinite
298. 2/3
299. $1/\overline{V}^{0.8}$
300. parallel, across
301. poor
302. (*a*)–(*III*)
(*b*)–(*IV*)
(*c*)–(*II*)
(*d*)–(*I*)
303. (*a*)–(*II*)
(*b*)–(*III*)
(*c*)–(*IV*)
(*d*)–(*I*)
304. (*a*)–(*IV*)
(*b*)–(*III*)
(*c*)–(*I*)
(*d*)–(*II*)
305. (*a*)–(*IV*)
(*b*)–(*II*)
(*c*)–(*I*)
(*d*)–(*III*)
306. (*a*)–(*II*)
(*b*)–(*I*)
(*c*)–(*IV*)
(*d*)–(*III*)
307. (*a*)–(*II*)
(*b*)–(*IV*)
(*c*)–(*III*)
(*d*)–(*I*)
308. (*a*)–(*II*)
(*b*)–(*I*)
(*c*)–(*III*)
(*d*)–(*IV*)

3

Chemical Technology

1. The form of sulphur which is the most stable at ordinary temperature is
   (*a*) monoclinic (*b*) plastic
   (*c*) rhombic (*d*) flowers of sulphur.
2. The allotrope of sulphur which is insoluble in carbon disulphide is
   (*a*) monoclinic sulphur (*b*) rhombic sulphur
   (*c*) milk of sulphur (*d*) plastic sulphur.
3. Oleum is
   (*a*) a mixture of conc. H_2SO_4 and oil
   (*b*) sulphuric acid which gives fumes of sulphur dioxide
   (*c*) sulphuric acid saturated with sulphur trioxide.
   (*d*) a mixture of sulphuric and nitric acids.
4. Oleum may be represented by the formula
   (*a*) H_2SO_4 (*b*) H_2SO_3
   (*c*) $H_2S_2O_6$ (*d*) $H_2S_2O_7$.
5. Oleum gives fumes of
   (*a*) H_2SO_4 (*b*) $H_2O + SO_2$
   (*c*) SO_2 (*d*) SO_3.
6. Which of the following has maximum specific gravity at 18°C ?
   (*a*) 98·5% H_2SO_4 (*b*) 20% oleum
   (*c*) 40% oleum (*d*) 65% oleum.
7. H_2S from petroleum refinery streams is recovered by scrubbing with
   (*a*) ethanol (*b*) ethanol amines
   (*c*) water (*d*) 98·5% H_2SO_4.
8. Sulphur is produced by oxidation-reduction of H_2S. The catalyst used in this process is
   (*a*) V_2O_5 (*b*) Al_2O_3
   (*c*) Pt (*c*) Ni.
9. When sulphur dioxide is passed through a solution of hydrogen sulphide in water

   (*a*) sulphuric acid is formed in solution
   (*b*) sulphurous acid is formed in solution
   (*c*) sulphur is precipitated
   (*d*) no change is observed.
10. Sulphuric acid produced by contact process is
    (*a*) cheaper (*b*) pure and concentrated
    (*c*) of poor quality (*d*) very dilute.
11. Select the wrong statement.
    Compared to platinum catalyst, vanadium pentoxide catalyst used in contact process for the manufacture of H_2SO_4
    (*a*) is relatively immune to poisons
    (*b*) requires low initial investment and 5% replacement per year
    (*c*) requires low O_2/SO_2 to give economic conversion
    (*d*) requires dilute SO_2 input (7-10%).
12. The catalyst used in the manufacture of sulphuric acid by contact process is
    (*a*) iron (*b*) aluminium oxide
    (*c*) nickel (*d*) vanadium pentoxide.
13. In the manufacture of sulphuric acid by contact process platinum catalyst was previously used but suffers from
    (*a*) easy poisoning (*b*) fragility
    (*c*) high initial investment (*d*) all of these answers.
14. Poison for platinum catalyst is
    (*a*) sulphur (*b*) phosphorous
    (*c*) arsenic (*d*) coke.
15. The most favourable conditions of temperature and pressure for the oxidation of sulphur dioxide to sulphur trioxide are
    (*a*) low temperature, high pressure
    (*b*) low temperature, low pressure
    (*c*) high temperature, high pressure
    (*d*) high temperature, low pressure.
16. The equilibrium yield of sulphur trioxide obtained from the oxidation of sulphur dioxide can be increased by
    (*a*) square root of system pressure at a given temperature
    (*b*) cube root of system pressure at a given temperature
    (*c*) square of system pressure at a given temperature
    (*d*) cube of system pressure at a given temperature.
17. Equilibrium constant (K_p) at constant pressure for sulphur dioxide oxidation
    (*a*) increases with increase in temperature
    (*b*) decreases with increase in temperature

(*c*) remains unaffected with change in temperature
(*d*) decreases linearly with increase in temperature.

18. For the production of sulphuric acid, chamber process was developed first but produced acid of concentration
(*a*) less than 80% (*b*) 98%
(*c*) 100% (*d*) 95%.

19. Contact process for the manufacture of sulphuric acid yields
(*a*) 80% H_2SO_4 only (*b*) 98% H_2SO_4 and higher
(*c*) 95% H_2SO_4 only (*d*) 90% H_2SO_4 only.

20. 65% oleum
(*a*) is prepared by distilling 20% oleum
(*b*) is prepared by chamber process
(*c*) does not contain free SO_3
(*d*) contains 0·65% free SO_3.

21. The most efficient agent for the absorption of SO_3 is
(*a*) 80% H_2SO_4 (*b*) 98·5% H_2SO_4
(*c*) 90% H_2SO_4 (*d*) 20% oleum.

22. Which one of the following reactions is not an exothermic ?
(*a*) Absorption of sulphur trioxide by 98·5% sulphuric acid
(*b*) Oxidation of sulphur trioxide
(*c*) Oxidation of sulphur to sulphur dioxide
(*d*) Thermal dissociation of iron pyrites.

23. Producer gas is obtained by
(*a*) thermal cracking of naphtha
(*b*) passing steam and air through red hot coke
(*c*) passing air through red hot coke
(*d*) passing steam through red hot coke.

24. The constituents of water gas are
(*a*) CO and H_2O (*b*) CO_2 and N_2
(*c*) CO and H_2 (*d*) CO and N_2.

25. Coke oven gas is composed of
(*a*) CH_4, CO_2, and H_2O (*b*) CO, CH_4, and N_2
(*c*) CO_2, CO, and H_2 (*d*) H_2, CO, and CH_4.

26. The producer gas is composed of
(*a*) CO and CO_2 (*b*) CH_4 and CO_2
(*c*) CH_4 and C_2H_4 (*d*) CO, N_2 and H_2.

27. The producer gas is mainly used in
(*a*) petroleum refinery (*b*) fertilizer industry
(*c*) steel industry (*d*) pharmaceutical industry.

28. Which of the following reactions is an endothermic reaction ?
(*a*) $C(s) + O_2(g) \longrightarrow CO_2(g)$
(*b*) $2C(s) + O_2(g) \longrightarrow 2CO(g)$
(*c*) $C(s) + H_2O(I) \longrightarrow CO(g) + H_2(g)$
(*d*) $CO(g) + 3H_2(g) \longrightarrow CH_4(g) + H_2O(g)$.

29. Which of following reactions is an exothermic reaction ?
(*a*) $CaO(s) + 3C(s) \longrightarrow CaC_2 + CO(g)$
(*b*) $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$
(*c*) $CaC_2(s) + H_2O(I) \longrightarrow Ca(OH)_2 + C_2H_2(g)$
(*d*) $C(s) + CO_2(g) \longrightarrow 2CO(g)$.

30. Acetylene is manufactured by
(*a*) reacting calcium carbide with liquid water
(*b*) Sachsse process
(*c*) Wulff process
(*d*) all of these ansers.

31. The raw materials for the manufacature of calcium carbide are
(*a*) limestone and coke
(*b*) limestone and slaked lime
(*c*) limestone and sand
(*d*) limestone and caustic soda.

32. The liquefaction of gases in general is favoured at
(*a*) low temperature and low pressure
(*b*) low temperature and high pressure
(*c*) high temperature and high pressure
(*d*) high temperature and low pressure

33. High purity oxygen is used for
(*a*) welding (*b*) cutting of metals
(*c*) medicinal purposes (*d*) all of the above.

34. Nitrogen gas is used
(*a*) as protective atmosphere to prevent oxidation in metal working and food preservation
(*b*) for welding
(*c*) for cutting of metals
(*d*) as refrigerant.

35. The percentage by volume of argon in the air is about
(*a*) 2·97% (*b*) 0·94%
(*c*) 0·01% (*d*) 0·001%.

36. The quantity of electricity required to deposit one gram equivalent of any substance is

(a) one coulomb (b) one faraday
(c) one ampere (d) one microfaraday.

37. When the same quantity of electricity is passed through different solutions, the amounts of different substances produced are proportional to

(a) their atomic weight
(b) their molecular weight
(c) their equivalent weight
(d) the square of their equivalent weight.

38. The degree of ionisation does not depend upon

(a) nature of solvent (b) nature of solute
(c) temperature (d) current strength.

39. The flow of current is actually flow of

(a) α-particles (b) β-particles
(c) γ-particles (d) mesons.

40. Select the correct statement.

(a) Electrolysis cell uses exothermic reactions to produce electrical energy
(b) In the electrolysis cell, the positive current flows from the positive electrode to the negative electrode outside the cell
(c) Electrolysis cell uses electrical energy to produce endothermic chemical changes
(d) In the electrolysis cell, the positive current flows from the negative electrode to the positive electrode inside the cell.

41. Select the wrong statement

(a) Voltaic cell uses exothermic chemical reactions to produce electrical energy
(b) In the voltaic cell, the positive current flows from the positive electrode to the negative electrode outside the cell.
(c) A voltaic cell can become an electrolysis cell by use of an external voltage greater than the voltaic cell voltage and imposed in the opposite directions
(d) Voltaic cell uses electrical energy to produce endothermic chemical changes.

42. Electrolytes, when dissolved in water, dissociate into their constituent ions. The degree of dissociation of an electrolyte increases with

(a) increasing concentration of the electrolyte
(b) decreasing concentration of the electrolyte
(c) decreasing temperature
(d) none of the above.

43. The quantity of an ion discharged during electrolysis is not directly proportional to

(a) time (b) current
(c) resistance (d) chemical equivalent of the ion.

44. A redox reaction is

(a) proton transfer reaction (b) a reaction in gas phase
(c) electron transfer reaction (d) ion combination reaction

45. In electrolysis oxidation takes place at

(a) anode (b) cathode
(c) both the electrodes (d) none of the electrodes.

46. In a fuel cell

(a) electrical energy is converted into chemical energy
(b) chemical energy is converted into electrical energy
(c) electrical energy is converted into mechanical energy
(d) mechanical energy is converted into electrical energy.

47. Diaphragm electrolytic cell produces

(a) 70% NaOH solution (b) 60% NaOH solution
(c) 98·5% NaOH solution (d) 10-12% NaOH solution.

48. Mercury electrolytic cell produces

(a) 10–12% NaOH solution (b) 50·70% NaOH solution
(c) 97–98·5% NaOH solution (d) 20–25% NaOH solution.

49. When a saturated sodium chloride solution is electrolysed using graphite anode and steel cathode, the products are

(a) sodium metal and chlorine
(b) hydrogen and oxygen
(c) hydrogen, chlorine, and sodium hydroxide solution
(d) hydrogen, chlorine, and soda ash.

50. Mercury electrolytic cells are operated at a temperature of

(a) 60–70 °C (b) 130–140 °C
(c) 200–215 °C (d) 100–110 °C.

51. The principal raw material for the production of chlorine gas by mercury electrolytic cell is

(a) saturated NaCl solution only
(b) saturated NaCl solution with solid NaCl make-up
(c) solid NaCl only
(d) 90–92% NaCl solution.

52. Acids are substances that yield H^+ in aqueous solutions while bases yield OH^- ions. In a neutral solution

(*a*) there are no H^+
(*b*) there are no OH^-
(*c*) H^+ and OH^- are present in very small but equal concentration
(*d*) $[H^+] + [OH^-] = 1$.

53. Graphite is
(*a*) an allotropic form of carbon
(*b*) used as moderator in nuclear reactors
(*c*) an electrical conductor
(*d*) all of the above.

54. In an oxidation process
(*a*) oxidation number decreases
(*b*) number of electrons decreases
(*c*) oxygen content decreases
(*d*) number of ions decreases.

55. In a reduction process
(*a*) oxidation number increases
(*b*) number of electrons increases
(*c*) ionisation takes place
(*d*) substance is decomposed.

56. During the electrolysis of sodium chloride, the anodic reaction is
(*a*) oxidation of sodium ions (*b*) reduction of sodium ions
(*c*) oxidation of chloride ions (*d*) reduction of chloride ions.

57. Soda ash is also called
(*a*) sodium carbonate (*b*) sodium hydroxide
(*c*) sodium bicarbonate (*d*) sodium oxide.

58. Washing soda is
(*a*) $Na_2CO_3.10H_2O$ (*b*) Na_2CO_3
(*c*) $Na_2CO_3.H_2O$ (*d*) $Na_2CO_3.2H_2O$

59. Potassium carbonate is not prepared by the Solvy process because
(*a*) potassium bicarbonate is unstable
(*b*) potassium bicarbonate is soluble in water
(*c*) potassium bicarbonate is soluble in ammonium chloride and potassium chloride solutions
(*d*) potassium bicarbonate does not decompose on heating.

60. Grignard reagent is
(*a*) ethyl magnesium chloride (*b*) ethyl chloride
(*c*) sodium sulphate (*d*) sodium cabonate.

61. Compared to mercury electrolytic cells, diaphragm electrolytic cells
(*a*) consume less power per ton of chlorine produced
(*b*) require less initial investment for the same capacity

(*c*) can produce 70% NaOH solution
(*d*) uses saturated NaCl solution with solid NaCl make-up.

62. Solvay process for the manufacture of soda ash
(*a*) can use low-grade brine
(*b*) requires less electric power than the modified Solvay process
(*c*) does not require NH_3 plant investment
(*d*) all of the above.

63. The principal raw materials for the manufacture of soda ash by Solvay process are
(*a*) limestone and potassium chloride
(*b*) dolomite and sodium hydroxide
(*c*) limestone, brine, and coal
(*d*) coal and caustic soda.

64. Glass industry requires soda ash with
(*a*) solids density 1·91 and bulk density 1·0
(*b*) solids density 1·86 and bulk density 0·6
(*c*) solids density 1·80 and bulk density 0·58
(*d*) none of the above.

65. Limestone is predominantly
(*a*) magnesium carbonate (*b*) sodium carbonate
(*c*) calcium carbonate (*d*) potassium carbonate.

66. Portland cement is a finely ground
(*a*) calcium aluminates and silicates of varying compositions
(*b*) calcium aluminates and sodium silicates of varying compositions.
(*c*) calcium aluminates and caustic soda
(*d*) calcium silicates and gypsum of fixed composition.

67. High alumina cement is manufactured by fusing
(*a*) limestone and slaked lime (*b*) limestone and quick lime
(*c*) limestone and bauxite (*d*) limestone and sand.

68. Which of the following reactions is an exothermic reaction ?
(*a*) $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$
(*b*) $CaO(s) + H_2O(I) \longrightarrow Ca(OH)_2(s)$
(*c*) $2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$
(*d*) $C(s) + O_2(g) \longrightarrow CO_2(g)$.

69. The temperature in the calcining zone of a vertical shaft kiln used in the manufacture of quicklime is about
(*a*) 400°C (*b*) 275°C
(*c*) 550°C (*d*) 1000°C

70. Quicklime is

(a) $Ca(OH)_2$ (b) $CaCO_3$
(c) CaO (d) NaOH.

71. Slaked lime is

(a) NaOH (b) KOH
(c) $Ca(OH)_2$ (d) CaO.

72. Slaked lime is produced by

(a) hydrogenation of quicklime
(b) hydration of quicklime
(c) dehydration of quicklime
(d) dehydrogenation of quicklime.

73. Plaster of Paris is

(a) $CaSO_4.2H_2O$ (b) $CaSO_4$
(c) $CaSO_4.\frac{1}{2}H_2O$ (d) $CaSO_4.1\frac{1}{2}H_2O$.

74. Clinker is the mass obtained by heating

(a) powdered limestone and clay
(b) gypsum
(c) dolomite
(d) sand, limestone and washing soda.

75. The process of setting cement under water is essentially

(a) an oxidation process
(b) a reduction process
(c) a double decomposition process
(d) a hydration process.

76. The setting of plaster of Paris takes place with

(a) loss of CO_2 (b) hydrolysis
(c) hydration (d) dehydration.

77. Gypsum is added to clinker during cement manufacture to

(a) decrease the rate of setting of cement
(b) make the cement impervious
(c) bind the particles of calcium silicate
(d) to facilitate the formation of colloidal gel.

78. Plaster of paris is obtained by heating

(a) limestone to 120-130°C (b) soda ash to 120-130°C
(c) dolomite to 120-130°C (d) gypsum to 120-130°C.

79. Sodium bicarbonate is an important constituent of

(a) caustic soda (b) washing soda
(c) baking powder (d) baking soda.

80. Which of the following is not an explosive ?

(a) Calcium ammonium nitrate
(b) Nitroglycerine
(c) Trinitrotoluene
(d) Cellulose nitrate.

81. Hydrogen peroxide is concentrated by

(a) distillation at atmospheric pressure
(b) crystallization
(c) dehydration
(d) vacuum distillation.

82. Dry ice is

(a) solid carbon dioxide
(b) ice kept below 0°C to avoid melting
(c) solid hydrogen
(d) ice kept out of contact of other liquids.

83. Process in which the ions of salt react with water to produce acidity or alkalinity is known as

(a) electrolysis (b) dialysis
(c) hydrolysis (d) none of the above.

84. For blasting purposes TNT is mixed with

(a) NH_4Cl (b) NH_4NO_3
(c) NH_4NO_2 (d) $(NH_4)_2SO_4$.

85. Which of the following glasses does not contain basic oxide ?

(a) Flint glass (b) Crown glass
(c) Quartz glass (d) Pyrex glass.

86. A glass with high refractive index and used in optical instruments is

(a) Pyrex glass (b) Jena glass
(c) Flint glass (d) Crookes glass.

87. Glass is

(a) a crystalline solid
(b) a super cooled liquid
(c) a solid having a definite melting point
(d) a compound of Ca, Na, Si and O.

88. The material used to give blue coloration to glass is

(a) NiO (b) CaO
(c) $FeSO_4$ (d) CdS.

89. The gradual cooling of glass products is called

(a) tempering (b) annealing
(c) quenching (d) galvanising.

90. Pyrex glass is resistant to sudden temperature variations because it has

(a) low coefficient of expansion

(*b*) high softening temperature
(*c*) low density and high melting point
(*d*) high coefficient of expansion.

91. The principal constituent of Pyrex glass is
(*a*) Zn (*b*) B
(*c*) Pb (*d*) Ce.

92. Sodium thiosulphate is used in photography to
(*a*) remove unexposed silver halide
(*b*) reduce the silver halide to silver
(*c*) intensify faint images
(*d*) remove metallic silver.

93. Sodium thiosulphate is used in photography because of its
(*a*) reducing behaviour
(*b*) oxidising behaviour
(*c*) complex forming behaviour
(*d*) reaction with light.

94. The gas which is filled in tungsten lamps is
(*a*) H_2 (*b*) O_2
(*c*) He (*d*) Ar.

95. The gas used in colour discharge tube is
(*a*) Ar (*b*) Ne
(*c*) Kr (*d*) Xe

96. The lightest gas which is non-inflammable is
(*a*) H_2 (*b*) He
(*c*) N_2 (*d*) Ar.

97. The chemical name of bleaching powder is
(*a*) calcium chloro hypochlorite
(*b*) calcium hypochlorite
(*c*) calcium chlorate
(*d*) calcium perchlorate.

98. Bleaching powder may be represented by the formula
(*a*) $Ca(ClO_3)_2$ (*b*) CaCl(OCl)
(*c*) $Ca(OCl)_2$ (*d*) $Ca(ClO_4)_2$.

99. Bleaching properties of bleaching powder are due to its
(*a*) oxidising properties (*b*) reducing properties
(*c*) basic properties (*d*) disinfecting properties.

100. Bleaching powder is manufactured by the action of Cl_2 on
(*a*) quicklime (*b*) slaked lime
(*c*) milk of lime (*d*) soda lime.

101. Which of the following is not used in gun powder ?
(*a*) KNO_3 (*b*) Charcoal
(*b*) Sulphur (*d*) Carbon.

102. Coffee contains
(*a*) nicotine (*b*) caffeine
(*c*) mercaptan (*d*) none of the above

103. Aqua regia is a mixture of concentrated HNO_3 with concentrated
(*a*) H_2SO_4 (*b*) HCl
(*c*) HF (*d*) HBr.

104. The purest form of naturally occurring water is
(*a*) rain water (*b*) river water
(*c*) pond water (*d*) well water.

105. The ultimate source of water is
(*a*) underground and surface (*b*) lakes and rivers
(*c*) rain and snow (*d*) dew and forest.

106. Temporary hardness of water is caused by the presence of
(*a*) chlorides of calcium and magnesium
(*b*) sulphates of calcium and magnesium
(*c*) bicarbonates of calcium and magnesium
(*d*) carbonates of sodium and potassium.

107. Temporary hardness of water may be removed by adding
(*a*) calcium hydroxide (*b*) calcium carbonate
(*c*) calcium chloride (*d*) sodium bicarbonate.

108. When temporary hard water is boiled, one of the substances formed is
(*a*) calcium bicarbonate (*b*) calcium sulphate
(*c*) hydrogen chloride (*d*) carbon dioxide.

109. Permanent hardness of water is caused by the presence of
(*a*) bicarbonates of calcium and magnesium
(*b*) carbonates of sodium and potassium
(*c*) chlorides and sulphates of calcium and magnesium
(*d*) phosphates of sodium and potassium.

110. Both temporary and permanent hardness of water can be removed by
(*a*) boiling (*b*) distillation
(*c*) filtration (*d*) decantation.

111. Both temporary and permanent hardness of water can be removed on boiling water with
(*a*) $Ca(OH)_2$ (*b*) Na_2CO_3
(*c*) CaO (*d*) $CaCO_3$.

112. Permanent hardness of water may be removed by the addition of

(*a*) lime (*b*) soda ash
(*c*) potassium permagnate (*d*) sodium bicarbonate.

113. Permanent hard water may be softened by passing it through

(*a*) sodium silicate
(*b*) sodium bicarbonate
(*c*) sodium hexametaphosphate
(*d*) sodium phosphate.

114. Zeolite softening process removes

(*a*) only temporary hardness of water
(*b*) only permanent hardness of water
(*c*) both temporary and permanent hardness of water
(*d*) the dissolved gases in permanent hard water.

115. Zeolite softening process removes both temporary and permanent hardness of water. In this process the calcium and magnesium present in water are precipitated as

(*a*) insoluble carbonates (*b*) insoluble zeolites
(*c*) insoluble chlorides (*d*) insoluble sulphates.

116. Zeolite used in zeolite softening process for the treatment of hard water gets exhausted after certain time of usage but can be regenerated by flushing it with

(*a*) 10 per cent calcium chloride solution
(*b*) 10 per cent magnesium sulphate solution
(*c*) 10 per cent magnesium chloride solution
(*d*) 10 per cent sodium chloride solution.

117. Which is used as germicidal in modern time for the treatment of drinking water ?

(*a*) Chlorine (*b*) Potassium permagnate
(*c*) Ozone (*d*) Bleaching powder.

118. Hardness of water does not

(*a*) have any bad effect in boiler
(*b*) make cooking of food stuffs difficult
(*c*) make it unfit for drinking
(*d*) cause difficulty in the washing of clothes with soap.

119. Calgon is used for

(*a*) calicoprinting
(*b*) removal of permanent hardness of water
(*c*) removal of temporary hardness of water
(*d*) none of the above.

120. A mineral is called ore if

(*a*) the metal present in the mineral is costly
(*b*) a metal can be extracted from it
(*c*) a metal can be profitably extracted from it
(*d*) a metal cannot be extracted from it.

121. The function of flux during smelting of ores is to

(*a*) make the ore porous (*b*) remove gangue
(*c*) facilitate reduction (*d*) precipitate slag.

122. Which of the following metallurgical processes involves a chemical change ?

(*a*) Froth floatation (*b*) Gravity separation
(*b*) Ore-dressing (*d*) Roasting.

123. Froth floatation process is based on

(*a*) wetting properties of ore particles
(*b*) specific gravity of ore particles
(*c*) magnetic properties of ore particles
(*d*) electrical properties of ore particles.

124. Some ores are roasted in order to

(*a*) dehydrate the ore
(*b*) remove carbon dioxide and water
(*c*) remove sulphur and arsenic
(*d*) fuse the ore.

125. Heating of pyrites in air to remove sulphur is called

(*a*) smelting (*b*) calcination
(*c*) roasting (*d*) cupellation.

126. Iron is extracted from

(*a*) chalcopyrite (*b*) bauxite
(*c*) hematite (*d*) pyrites.

127. Which of the following methods is used for concentration of hematite?

(*a*) forth floatation (*b*) gravity separation
(*c*) magnetic separation (*d*) hand picking.

128. A blast furnace is

(*a*) rectangular (*b*) closed
(*c*) chimney-like (*d*) electrically heated.

129. In blast furnace the highest temperature is in

(*a*) reduction zone (*b*) slag zone
(*c*) combustion zone (*d*) fusion zone.

130. In the extraction of iron from hematite, limestone is used

(a) as gangue (b) as slag
(c) as reducing agent (d) as flux.

131. The flux used in the extraction of iron is

(a) limestone (b) silica
(c) feldspar (d) sand.

132. Iron ores are calcined to remove

(a) water and carbon dioxide (b) sulphur and water
(c) sulphur (d) arsenic.

133. In the extraction of iron from iron oxide ores the reducing agent is

(a) C (b) CO
(c) $CaCO_3$ (d) SiO_2.

134. The impurity of sulphur makes the iron

(a) fibrous (b) red short
(c) cold short (d) malleable.

135. The purest form of iron is

(a) cast iron (b) wrought iron
(c) pig iron (d) steel.

136. If a red hot steel rod is suddenly immersed in water, the steel becomes

(a) soft and malleable (b) hard and brittle
(c) tough and ductile (d) fibrous.

137. Which of the following reactions takes place in the zone of fusion in the manufacture of iron ?

(a) $FeO + SiO_2 \longrightarrow FeSiO_3$
(b) $CaO + SiO_2 \longrightarrow CaSiO_3$
(c) $CaCO_3 \longrightarrow CaO + CO_2$.
(d) $3CaO + 2Al_2O_3 + 6SiO_2 \longrightarrow [3(CaO.SiO_2).2Al_2O_3.3SiO_2]$.

138. Which of the following statements is incorrect for blast furnace ?

(a) The temperature in the furnace increases from top to bottom
(b) The lowest part of the furnace is hearth
(c) The molten metal is taken out from the tap hole in hearth
(d) The furnace has a uniform diameter throughout the length.

139. Which of the following is not a basic flux ?

(a) $CaCO_3$ (b) Lime
(c) SiO_2 (d) CaO.

140. The principal ore of copper is

(a) chalcopyrite (b) siderite
(b) hematite (d) bauxite

141. The flux used in the smelting of copper ores is

(a) limestone (b) silica
(c) magnesia (d) coke.

142. Silica is added to roasted copper ores during smelting in order to remove

(a) cuprous sulphide (b) ferrous oxide
(c) ferrous sulphide (d) cuprous oxide.

143. Auto reduction process is used for the extraction of

(a) Cu and Hg (b) Zn and Hg
(c) Cu and Al (d) Fe and Pb.

144. Copper is extracted from sulphide ores using the method of

(a) carbon reduction (b) carbon monoxide reduction
(b) auto reduction (d) none of these.

145. The matte obtained in the extraction of copper contains

(a) $FeSiO_3$ (b) $SiO_2 + FeS$
(c) $FeS + Cu_2S$ (d) $CuS + SiO_2 + FeO$.

146. The material used for the lining of bessemer converter is

(a) silica (b) lime
(c) iron (d) copper.

147. The function of silica in bessemerisation of smelted copper ores is to

(a) remove acidic impurities (b) remove basic impurities
(c) remove cuprous oxide (d) remove cuprous sulphide.

148. Forth floatation process is used for the concentration of

(a) Al_2O_3 (b) Fe_3O_4
(c) ZnS (d) $Fe_2O_3.3H_2O$.

149. Sulphide ores are usually concentrated by

(a) roasting (b) calcining
(b) gravity separation (d) forth floatation.

150. During the extraction of copper metal, the material obtained after smelting the ore is known as

(a) blister copper (b) matte
(c) impure copper (d) none of the above.

151. Which of the following changes does not occur during the roasting of a mineral ?

(a) Decomposition of carbonates
(b) Formation of slag
(c) Formation of oxide
(d) Oxidation of sulphides.

152. Refractory materials are used for the construction of furnaces because

(*a*) they are light in weight
(*b*) they can withstand high temperature
(*c*) they are leak proof
(*d*) they do not require to be replaced.

153. Alumina is

(a) acidic (b) basic
(*c*) neutral (*d*) amphoteric.

154. The process of converting hydrated alumina into anhydrous alumina is called

(*a*) roasting (*b*) smelting
(*c*) dressing (*d*) calcination

155. Which element is prepared by electrolytic method ?

(*a*) Ag (*b*) Hg
(*c*) Al (*d*) Cu.

156. Electrolytic process is used for the extraction of

(*a*) alkali metals (*b*) alkaline earth metals
(*c*) aluminium (*d*) all of these.

157. The electrolysis of pure alumina is not feasible because

(*a*) alumina is non-conductor
(*b*) fusion temperature of alumina is very high
(*c*) alumina is decomposed when fused
(*d*) alumina is amphoteric.

158. In the extraction of aluminium the function of cryolite is to

(*a*) lower the melting point of alumina
(*b*) increase the melting point of alumina
(*c*) increase the electrical conductivity of alumina
(*d*) make alumina conductor.

159. Cryolite is

(*a*) sodium fluoride
(*b*) aluminium flouride
(*c*) a mixture of sodium and aluminium fluoride
(*d*) none of these.

160. When alumina is electrolysed in presence of cryolite, the gas liberated at graphite anode is

(*a*) F_2 (*b*) O_2
(*d*) CO (*d*) CO_2.

161. Select the correct statement.

(*a*) Fused pure aluminium is lighter than impure aluminium
(*b*) Fused pure aluminium is heavier than impure aluminium

(*c*) The electrolyte used in the refining of aluminium is fused alumina
(*d*) Melting point of aluminium is higher than that of alumina.

162. Which of the following does not contain sulphur ?

(*a*) Iron pyrites (*b*) Zinc blende
(*c*) Galena (*d*) Auriferrous quartz.

163. Which of the following is an ore of lead ?

(*a*) Galena (*b*) Bauxite
(*c*) Hematite (*d*) Chalcopyrite.

164. The chemical formula of Glauber's salt is

(*a*) $Na_2CO_3.10H_2O$ (*b*) $Na_2SO_4.10H_2O$
(*c*) $Na_2CO_3.H_2O$ (*d*) $Na_2SO_4.5H_2O$.

165. The chemical formula of sodium thiosulphate is

(*a*) $Na_2SO_4.10H_2O$ (*b*) $Na_2SO_4.5H_2O$
(*c*) $Na_2S_2O_3.5H_2O$ (*d*) $Na_2S_2O_5.5H_2O$.

166. Sodium silicate is made by fusing

(*a*) sand and limestone at about 1300°C
(*b*) sand and dolomite at about 1300°C
(*c*) sand and quicklime at about 1300°C
(*d*) sand and soda ash at about 1300°C.

167. The fatty materials in the soaps are

(*a*) fatty acids (*b*) fatty alcohols
(*c*) anionic detergents (*d*) cationic detergents.

168. The products of saponification of a fat are

(*a*) glycerol and salts of higher fatty acids
(*b*) glycerol and higher aliphatic alcohols
(*c*) glycerol and organic acids
(*d*) ethylene glycol and organic acids.

169. A detergent

(*a*) is a soap
(*b*) can be used as a catalyst
(*c*) is used as a water-softener
(*d*) is a cleansing agent.

170. Formation of soap involves

(*a*) hydrolysis (*b*) esterification
(*c*) hydrogenation (*d*) all of the above.

171. Tallow refers to

(*a*) oil of animal origin
(*b*) oil derived from soyabean

(c) oil derived from groundnut
(d) a mixture of vegetable oils.

172. Vanaspati is produced by the process of

(a) hydrolysis (b) oxidation
(c) reduction (d) hydrogenation.

173. Hydrogenation of edible oils is carried out in the presence of finely divided

(a) copper (b) nickel
(c) iron (d) silver.

174. Oils and fats merely differ in

(a) composition (b) density
(c) physical state (d) chemical properties.

175. The chemical formula of silicic acid is

(a) H_2SiO_6 (b) H_2SiO_3
(c) C_6H_7COOH (d) $C_{12}H_{25}COOH$.

176. Sodium dodecylbenzene sulphate is

(a) a drug (b) a detergent
(c) an explosive (d) an artificial fibre.

177. Which of the following ingredients used in the manufacture of synthetic detergent acts as anti-redeposition agent ?

(a) Sodium silicate
(b) Sodium sulphate
(c) Sodium carboxymethyl cellulose
(d) Sodium tripolyphosphate.

178. Sulphonation of dodecylbenzene is

(a) a reversible and endothermic reaction
(b) an irreversible and exothermic reaction
(c) a reversible and exothermic reaction
(d) an irreversible and endothermic reaction.

179. Neutralization of dodecylbenzene sulphonic acid by caustic soda is

(a) an endothermic reaction
(b) an exothermic reaction
(c) an autocatalytic reaction
(d) none of the above.

180. An alkali metal salt of palmitic acid is known as

(a) soap (b) alkaloid
(c) explosive (d) detergent.

181. Oils and fats are

(a) higher alcohols (b) esters of higher acids
(c) alkaloids (d) carbohydrates.

182. Hydrogenation of edible oils

(a) increases their melting point
(b) decreases their melting point
(c) does not effect their melting point
(d) is an endothermic reaction.

183. The hydrogenation of edible oils

(a) is an exothermic reaction
(b) is an endothermic reaction
(c) decreases their melting point
(d) is an autocatalytic reaction.

184. The main raw materials for the production of soap are

(a) tallow and 20% oleum
(b) vegetable oils and 98·7% H_2SO_4
(c) vegetable oils and caustic soda
(d) tallow and soda ash.

185. Soap may be prepared by

(a) hydrolysis of tallow
(b) hydrogenation of vegetable oils
(c) boiling the vegetable oils or tallow with caustic soda solution
(d) oxidation of tallow.

186. Which of the following is not an insecticide ?

(a) DDT (b) BHC
(c) TNT (d) 2, 4-D.

187. The condensation reaction of chloral with monochlorobenzene leading to the formation of DDT is

(a) highly endothermic
(b) highly exothermic
(c) a photochemical reaction
(d) a biochemical reaction.

188. The main raw materials for the manufacture of DDT are

(a) chloral, monochlorobenzene, and 20% oleum
(b) monochloracetic acid and benzene
(c) monochloroacetic acid and dichlorophenol
(d) benzene and chlorine

189. The raw materials for the manufacture of 2, 4-D are

(a) benzene and chlorine
(b) monochloroacetic acid and dichlorophenol
(c) chloral and benzene
(d) toluene and chlorine.

190. The catalyst used in the manufacture of DDT is

(*a*) platinum (*b*) aluminium oxide
(*c*) 20% oleum (*d*) sodium hydroxide.

191. The raw materials for the manufacture of BHC are

(*a*) butane and chlorine
(*b*) butylene and chlorine
(*c*) benzene and chlorine
(*d*) chloral and monochlorobenzene.

192. In the manufacture of DDT from chloral and monochlorobenzene, the reaction is carried out at

(*a*) 60—80°C (*b*) 120—130°C
(*c*) 175—185°C (*d*) 15—30°C.

193. BHC is

(*a*) C_6H_5Cl (*b*) $C_6H_6Cl_6$
(*c*) C_6Cl_6 (*d*) $C_6H_3Cl_3$.

194. DDT is

(*a*) dichloro diphenyl trichloroethane
(*b*) dichloro diphenyl trichloromethane
(*c*) dichloro diphenyl trichloropropane
(*d*) dichloro diphenyl trichlorobutane.

195. The saturated fatty acids have the general formula

(*a*) $C_nH_{2n}COOH$ (*b*) $C_nH_{2n+2}COOH$
(*c*) $C_nH_{2n+3}COOH$ (*d*) $C_nH_{2n+1}COOH$.

196. Carbohydrates are the organic compounds of

(*a*) carbon, hydrogen and oxygen only
(*b*) carbon, hydrogen and sulphur only
(*c*) carbon and hydrogen only
(*d*) carbon, hydrogen and nitrogen only.

197. Which of the following is monosaccharide ?

(*a*) Sucrose (*b*) Glucose
(*c*) Maltose (*d*) Lactose.

198. Which of the following is a disaccharide ?

(*a*) Glucose (*b*) Cellulose
(*c*) Starch (*d*) Sucrose.

199. Which of the following is a polysaccharide ?

(*a*) Starch (*b*) Sucrose
(*c*) Glucose (*d*) Fructose.

200. The raw juice extracted from sugar cane contains

(*a*) 75 to 80% sucrose (*b*) 1·5 to 2% sucrose
(*c*) 15 to 20% sucrose (*d*) 60 to 65% sucrose.

201. The chemical formula of sucrose is

(*a*) $C_6H_{12}O_6$ (*b*) $C_6H_{10}O_5$
(*c*) $C_{12}H_{22}O_{11}$ (*d*) $C_{18}H_{32}O_{16}$.

202. Starch has the formula

(*a*) $(C_6H_{12}O_6)_n$ (*b*) $(CH_2O)_n$
(*c*) $(C_6H_{10}O_5)_n$ (*d*) $C_{12}H_{22}O_{11}$.

203. The sugar naturally present in milk is

(*a*) glucose (*b*) sucrose
(*c*) lactose (*d*) fructose.

204. The density of milk is measured by

(*a*) lactometer (*b*) tachometer
(*c*) hydrometer (*d*) hygrometer.

205. Milk sugar is obtained from

(*a*) lactose (*b*) maltose
(*c*) sucrose (*d*) glucose.

206. The state which has the largest sugar mills in India is

(*a*) Bihar (*b*) Uttar Pradesh
(*c*) Tamil Nadu (*d*) None of the above.

207. The product(s) of inversion of sucrose is/are

(*a*) glucose only
(*b*) fructose only
(*c*) both glucose and fructose
(*d*) lactose.

208. The charring of sugar in contact with concentrated sulphuric acid is due to its

(*a*) oxidation (*b*) reduction
(*c*) dehydration (*d*) sulphonation.

209. Maltose is converted into glucose by the enzyme

(*a*) diastase (*b*) invertase
(*c*) maltase (*d*) zymase.

210. Starch is converted into maltose by the enzyme

(*a*) maltase (*b*) zymase
(*c*) invertase (*d*) diastase.

211. The product(s) of the hydrolysis of starch with very dilute sulphuric acid is/are

(*a*) glucose (*b*) fructose
(*c*) glucose and fructose (*d*) sucrose.

212. Enzyme is

(*a*) a living plant
(*b*) a complex sulphur compound
(*c*) a complex nitrogenous compound
(*d*) present in yeast.

213. Yeasts

(*a*) are poisonous
(*b*) are used in brewery and baking industry
(*c*) increase plant diseases
(*d*) increase animal diseases.

214. Pasteurization of milk is a process of

(*a*) cooling the milk to 0°C
(*b*) heating the milk to boiling
(*c*) cooling followed by moderate heating
(*d*) moderate heating followed by cooling.

215. Milk is

(*a*) emulsion (*b*) colloidal solution
(*c*) gel (*d*) colloidal electrolyte.

216. Butter is

(*a*) fat dispersed in water (*b*) fat dispersed in milk
(*c*) fat dispersed in oil (*d*) water dispersed in fat.

217. Which of the following acids is present in vinegar ?

(*a*) Citric acid (*b*) Tartaric acid
(*c*) Lactic acid (*d*) Acetic acid.

218. The reaction between an alcohol and an acid is known as

(*a*) saponification (*b*) esterification
(*c*) *hydrolysis* (*d*) *dehydration.*

219. Esterification is

(*a*) irreversible process
(*b*) reversible process
(*c*) reaction of an acid and an aliphatic base
(*d*) reversible process under some specific conditions.

220. All enzymes are made of

(*a*) carbohydrates (*b*) fats
(*c*) proteins (*d*) all of the above.

221. Haemoglobin is

(*a*) an enzyme (*b*) an amino acid
(*c*) a biological catalyst (*d*) a protein.

222. The general formula for aldehydes is

(*a*) $C_nH_{2n}O_2$ (*b*) $C_nH_{2n+1}O$
(*c*) $C_nH_{2n}O$ (*d*) $C_nH_{2n+2}O$.

223. The factor adversely affecting the fermentation process is

(*a*) low concentration
(*b*) high concentration
(*c*) presence of ammonium salts
(*d*) presence of air.

224. Alcohol fermentations are brought about by the action of

(*a*) yeast
(*b*) carbon dioxide
(*c*) oxygen
(*d*) ammonium salts and phosphates.

225. Yeast cannot be used in the manufacture of

(*a*) loaf of bread in bakeries (*b*) penicillin
(*c*) wine (*d*) all of the above.

226. Nitrogen forms the essential constituent of

(*a*) carbohydrates (*b*) fats
(*c*) proteins (*d*) mineral salts.

227. Formalin is

(*a*) 10% solution of HCHO (*b*) 20% solution of HCHO
(*c*) 37% solution of HCHO (*d*) 50% solution of HCHO.

228. Methyl alcohol from wood is manufactured by

(*a*) fractional distillation (*b*) fermentation
(*c*) dehydration (*d*) destructive distillation.

229. Ethyl alcohol from molasses is manufactured by

(*a*) fractional distillation (*b*) dehydrogenation
(*c*) fermentation (*d*) dehydration.

230. Select the wrong statement.

(*a*) Each enzyme catalyses a specific chemical reaction
(*b*) Enzymes are specific proteins which have biocatalytic activity
(*c*) Enzymes have the general formula $C_nH_{2n+1}COOH$
(*d*) Each enzyme has an optimum temperature.

231. Total fermentable sugar in molasses is about

(*a*) 25% (*b*) 75%
(*c*) 50% (*d*) 95%.

232. Alcohol content in beer is about

(*a*) 8—10% (*b*) 50—55%
(*c*) 96% (*d*) 89·4%.

233. Glucose is converted into ethyl alcohol and carbon dioxide by the enzyme

(*a*) invertase (*b*) zymase
(*c*) maltase (*d*) diastase.

234. For the manufacture of ethanol by fermentation of molasses, the temperature is kept at

(*a*) 120—130°C (*b*) 60—65°C
(*c*) 20—30°C (*d*) 175—180°C.

235. Which of the following drugs is made from vegetables ?

(*a*) Insulin (*b*) Quinine
(*c*) Aspirin (*d*) A.T.S.

236. Antibiotic is

(*a*) any substance which acts against living system
(*b*) any biological material used for protecting plants
(*c*) any biological material produced by organisms and used against animals
(*d*) any biological material that is produced by a living organism and that inhibits or retards the growth of organisms.

237. Who discovered penicillin ?

(*a*) Pfizar (*b*) Alexander Flaming
(*c*) H.G. Khurana (*d*) C.V. Raman.

238. Aerobes are

(*a*) organisms that cannot grow in the presence of air
(*b*) organisms that can grow in the presence of air
(*c*) are chemical substances that inhibit the growth of micro-organism
(*d*) none of the above.

239. Insulin is

(*a*) an antibiotic drug (*b*) an antidiabetic drug
(*c*) an anti-TB drug (*d*) an anaesthetic.

240. Which of the following is an antibiotic drug ?

(*a*) Penicillin (*b*) A.T.S.
(*c*) Insulin (*d*) Chloroform.

241. Cellulose content in a bamboo fibre is about

(*a*) 85% (*b*) 25%
(*c*) 50% (*d*) 15%.

242. In the sulphate (Kraft) pulp process, the essential chemical reagents used in digestor are

(*a*) caustic soda, sodium sulphide, and soda ash

(*b*) slaked lime, salt cake, and mercaptans
(*c*) caustic soda, mercaptans, and ethylene oxide
(*d*) quicklime, baking soda, and dimethyl sulphide.

243. In the sulphate pulp process, the digestor conditions are

(*a*) 120—130°C and 5 atm (*b*) 120—130°C and 1 atm
(*c*) 75—80°C and 15 atm (*d*) 175—180°C and 10 atm.

244. Fourdrinier machine is used

(*a*) in the manufacture of paper
(*b*) in the manufacture of synthetic detergent
(*c*) in the manufacture of sugar
(*d*) in the manufacture of dyes.

245. Bagasse fibre contains

(*a*) cellulose (*b*) lignin
(*c*) pentogens (*d*) all of the above.

246. Methanol is manufactured by

(*a*) catalytic dehydrogenation of isopropanol
(*b*) catalytic dehydrogenation of cumene
(*c*) catalytic hydrogenation of carbon monoxide
(*d*) all of the above.

247. For the manufacture of methanol by catalytic hydrogenation of carbon monoxide, the minimum theoretical mole ratio H_2/CO must be

(*a*) 2 : 1 (*b*) 1 : 2
(*c*) 3 : 1 (*d*) 4 : 1.

248. Formaldehyde is manufactured by

(*a*) catalytic oxidation of carbon monoxide
(*b*) catalytic oxidation—dehydrogenation of methanol
(*c*) catalytic oxidation of ethylene
(*d*) all of the above.

249. Ethylene oxide is manufactured by

(*a*) catalytic oxidation of ethylene
(*b*) catalytic oxidation-dehydrogenation of methanol
(*c*) catalytic dehydrogenation of propylene oxide
(*d*) catalytic dehydrogenation of formaldehyde.

250. The catalyst used in the manufacture of ethylene oxide by oxidation of ethylene is

(*a*) $AlCl_3$ (*b*) ZnO
(*c*) FeO (*d*) AgO.

251. The most favourable conditions for the manufacture of ethylene oxide by the catalytic oxidation of ethylene are

(*a*) 240 atm and 375°C (*b*) 5 atm and 275°C
(*c*) 100 atm and 550°C (*d*) 50 atm and 375°C.

252. The raw materials for the manufacture of ethanol amines are ammonia and

(*a*) ethanol (*b*) ethylene oxide
(*c*) ethane (*d*) ethylene.

253. Vinyl chloride is made by

(*a*) pyrolysis of carbon tetrachloride
(*b*) vapour phase dehydrochlorination of tetrachloro propane, using $BaCl_2$ catalyst
(*c*) thermal pyrolysis of ethylene dichloride
(*d*) none of the above.

254. Trichloroethylene is made by

(*a*) pyrolysis of carbon tetrachloride
(*b*) vapour phase dehydrochlorination of tetrachloroethane, using $BaCl_2$ catalyst
(*c*) thermal pyrolysis of ethylene dichloride
(*d*) all of the above.

255. Pentaerythritol is made

(*a*) from formaldehyde and acetaldehyde in the presence of an alkaline condensing agent
(*b*) by hydrogenation of oils and fats
(*c*) by thermal pyrolysis of acetaldehyde
(*d*) from formaldehyde and phenol in the presence of $AlCl_3$ catalyst.

256. Perchloroethylene is made by pyrolysis of

(*a*) ethylene dichloride (*b*) carbon tetrachloride
(*c*) chlorobenzene (*d*) chlorinated paraffins.

257. The most favourable conditions for the manufacture of vinyl chloride by thermal pyrolysis of ethylene dichloride are

(*a*) 500°C and 4 atm (*b*) 175°C and 100 atm
(*c*) 150°C and 1 atm (*d*) 1750°C and 5 atm.

258. Vinyl chloride has the formula

(*a*) CH_3CH_2Cl (*b*) $ClCH = CHCl$
(*c*) $CH_2 = CCl_2$ (*d*) $CH_2 = CHCl$.

259. Naphthols are derivative of

(*a*) napthalene (*b*) benzene
(*c*) phenol (*d*) oils and fats.

260. Phenol is produced by

(*a*) catalytic oxidation of toluene
(*b*) catalytic hydrogenation of carbon monoxide

(*c*) catalytic oxidation of naphthalene
(*d*) dehydrogenation of ethylbenzene.

261. Styrene is produced by

(*a*) catalytic oxidation of cumene
(*b*) catalytic oxidation of toluene
(*c*) dehydrogenation of ethylbenzene
(*d*) catalytic oxidation of O-xylene.

262. Phthalic anhydride is produced by

(*a*) catalytic oxidation of naphthalene
(*b*) catalytic oxidatioin of benzene
(*c*) dehydrogenation of ethylbenzene
(*d*) catalytic oxidation of toluene.

263. Vinyl acetate is represented by the formula

(*a*) $CH_2 = CHCOOH$ (*b*) $CH_2 = CHOH$
(*c*) $CH_2 = COOCH = CH_2$ (*d*) $CH_3COOCH = CH_2$.

264. Acetone is produced by

(*a*) catalytic dehydrogenation of ethylbenzene
(*b*) catalytic dehydrogenation of phenol
(*c*) catalytic dehydrogenation of isopropanol
(*d*) none of the above.

265. The catalyst used in the manufacture of acetone by dehydrogenation of isopropanol is

(*a*) AgO (*b*) V_2O_3
(*c*) Cu (*d*) Al_2O_3.

266. Cumene is

(*a*) isopropanol (*b*) isopropylbenzene
(*c*) isoprene (*d*) ethylbenzene.

267. Cumene is produced by alkylation of benzene with

(*a*) butylene (*b*) propylene
(*c*) ethylene (*d*) vinyl chloride.

268. Butadiene can be manufactured by

(*a*) dehydrogenation of butane
(*b*) dehydrogenation-dehydration of ethanol
(*c*) steam craking of hydrocarbon gases
(*d*) all of the above.

269. The catalyst used in the manufacture of phthalic anhydride by oxidation of O-xylene is

(*a*) $AlCl_3$ (*b*) V_2O_5
(*c*) Ni (*d*) Fe.

270. Maleic anhydride is produced by

(a) catalytic oxidation of benzene
(b) catalytic oxidation of naphthalene
(c) catalytic oxidation of O-xylene
(d) dehydrogenation of ethylbenzene.

271. Which of the following is used as catalyst in the manufacture of maleic anhydride by oxidation of benzene ?

(a) $AlCl_3$ (b) V_2O_5
(c) AgO (d) Ni.

272. Which of the following is an endothermic process ?

(a) Oxidation of benzene
(b) Oxidation of naphthalene
(c) Dehydrogenation of ethylbenzene
(d) Alkylation of benzene with propylene.

273. Chrome tanning is done for

(a) light leathers only
(b) heavy leathers only
(c) both light and heavy leathers
(d) none of the above.

274. Vegetable tanning is done for

(a) light leathers only
(b) heavy leathers only
(c) both light and heavy leathers
(d) none of the above.

275. Vegetable tanning agents are

(a) chromium salts (b) sulphonated phenols
(c) cresols (d) tannins.

276. Chrome tanned product is

(a) much weaker than vegetable tanned product
(b) much stronger than vegetable tanned product
(c) used as sole leather
(d) none of the above.

277. Which of the following is used for tanning leather for fancy articles like cricket, hockey balls from reptile skins ?

(a) Tannin (b) Chromium sulphate
(c) Alum (d) Cresol.

278. Gelatin is

(a) a nitrogenous organic protein
(b) a carbohydrate

(c) a mixture of fatty acids
(d) none of the above.

279. Gelatin is obtained by hydrolysis of

(a) calgon (b) tannin
(c) collagen (d) none of the above.

280. Chrome tanning agent is

(a) alum (b) tannin
(c) sodium dichromate (d) none of the above.

281. *Which of the following varieties of coal has the highest carbon content ?*

(a) Peat (b) Lignite
(c) Bituminous (d) Anthracite.

282. The high temperature carbonization of coal is carried out at

(a) 600°C to 800°C (b) 175°C to 275°C
(c) 1250°C to 1500°C (d) 900°C to 1150°C.

283. The low temperature carbonization of coal is carried out at

(a) 510°C to 790°C (b) 900°C to 1150°C
(c) 125°C to 175°C (d) 275°C to 300°C.

284. Coal tar produced by high temperature carbonizatioin of coal is the main source of

(a) aliphatic compounds (b) aromatic compounds
(c) paraffins (d) cycloalkane.

285. The cotton fibres consist mainly of

(a) starch (b) cellulose
(c) lignin (d) none of the above.

286. Which of the following is a thermosetting plastic ?

(a) Polyethylene (b) Teflon
(c) Polypropylene (d) Bakelite.

287. Tetrafluoroethylene is known as

(a) perspex (b) Nylon-66
(c) polyester (d) Teflon.

288. The average molecular weight of plastics varies from

(a) 10,000 to 20,000 (b) 15,000 to 20,000
(c) 20,000 to 250,000 (d) 250,000 to 25×10^9.

289. Neoprene is a

(a) polyester (b) rubber product
(c) Nylon (d) polythene.

290. Bakelite is a polymer product of the reaction of formaldehyde and
(a) benzene (b) phenol
(c) ethyl alcohol (d) ammonia.

291. The main raw material(s) for the manufacture of Nylon-6 is/are
(a) caprolactum
(b) adipic acid and hexamethylene diamine
(c) dimethyl terephthalate and ethylene glycol
(d) acrylonitrile.

292. The main raw material for the manufacture of caprolactum is
(a) hexane (b) benzene
(c) methane (d) naphthalene.

293. For the manufacture of Nylon-6 by condensation polymerization of caprolactum, the temperature maintained in the reactor is about
(a) 125—130°C (b) 75—85°C
(c) 245—280°C (d) 550—575°C.

294. In the condensation polymerization of caprolactum at 245° to 280°C, the percentage conversion of caprolactum is about
(a) 10% (b) 70%
(c) 50% (d) 90%.

295. The main raw material(s) for the manufacture of Nylon-66 is/are
(a) caprolactum
(b) acrylonitrile
(c) dimethyl terephthalate and ethylene glycol
(d) adipic acid and hexamethylene diamine.

296. Dimethyl terephthalate and ethylene glycol reacts to form
(a) Nylon-66 (b) Nylon-6
(c) Dacron (d) neoprene,

297. Adipic acid is an intermediate in the manufacture of
(a) bakelite (b) perspex
(c) Nylon-66 (d) Buna-S.

298. Perspex is
(a) polymethyl methacrylate (b) polystyrene
(c) polyethylene (d) polypropylene.

299. Teflon is polymer product of
(a) C_2F_4 (b) CF_4
(c) C_2F_2 (d) $CH_2 = CHF$.

300. Which of the following is a thermoplastic ?
(a) Bakelite (b) Polyester
(c) Polyethylene (d) Silicone.

301. The catalyst used in the low pressure Ziegler process for polyethylene manufacture
(a) is nickel
(b) consists of aluminium triethyl combined with titanium tertrachloride
(c) consists of aluminium chloride combined with titanium dioxide
(d) is vanadium pentaoxide.

302. Which of the following is a thermosetting plastic ?
(a) Polystyrene (b) Polyvinyl chloride
(c) Polyethylene (d) Epoxy polymer.

303. Polyurethane is
(a) a polyester (b) an elastomer
(c) a Nylon-6 (d) none of the above.

304. Neoprene is the trade name of
(a) polyisoprene (b) polychloroprene
(c) polyurethane (d) polybutadiene.

305. Nitrile rubber is a polymer of
(a) acrylonitrile and styrene
(b) butadiene and stryene
(c) butadiene and acrylonitrile
(d) isobutylene and isoprene.

306. Hot SBR is prepared at
(a) 50°C and 3-4 atm gauge (b) 150°C and 1 atm gauge
(c) 200°C and 3 atm gauge (d) 280°C and 3 atm gauge.

307. Cold SBR is prepared at
(a) 25°C and 1 atm gauge (b) 50°C and 3 atm gauge
(c) 50°C and 1 atm gauge (d) 0°C and 1 atm gauge.

308. In the manufacture of silicone rubber, the rate controlling step is
(a) the initial hydrolysis of silicone monomer
(b) the condensation of siloxane to silicone
(c) the polymer termination step
(d) none of the above.

309. Natural rubber is mainly
(a) polybutadiene (b) polychloroprene
(c) polystyrene (d) polyisoprene.

310 Sodium carbonate is manufactured by ammonia-soda process. The process is called
(a) Bosch process (b) Langmuir process
(c) Solvay process (d) Haber's process.

311. Calcium oxide is also called
(a) limestone (b) milk of lime
(c) quicklime (d) slaked lime.

312. On mixing calcium oxide with water, heat is evolved and a hissing sound is produced. The resulting product is
(a) lime mortar (b) plaster of Paris
(c) quicklime (d) slaked lime.

313. Which of the following is a crystalline form of carbon ?
(a) Charcoal (b) Soot
(c) Lampblack (d) Diamond.

314. Carbon monoxide is not used in
(a) the fire extinguishers
(b) the manufacture of phosgene
(c) the manufacture of methanol
(d) none of the above.

315. Which of the following can be directly solidified from the gaseous state ?
(a) Water gas (b) Producer gas
(c) Carbon monoxide (d) Carbon dioxide.

316. Nitric acid is manufactured by catalytic oxidation of ammonia. This process is called
(a) Solvay process (b) Haber's process
(c) Ostwald's process (d) Bosch process.

317. In the manufacture of bromine from sea water, the hot mother liquor containing bromides is treated with
(a) chlorine (b) iodine
(c) sulphur dioxide (d) fluorine.

318. Bessemer converter is used in the manufacture of
(a) pig iron (b) cast iron
(c) wrought iron (d) steel.

319. Near the top of blast furnace used for the extraction of iron, the metal oxides are reduced to spongy iron by
(a) carbon (b) carbon monoxide
(c) limestone (d) carbon dioxide.

320. Molten iron withdrawn from the blast furnace is called
(a) pig iron (b) wrought iron
(c) bessemer iron (d) steel.

321. Blast furnace is used in the metallurgy of

(a) iron (b) aluminium
(c) silver (d) all of the above.

322. The e.m.f. of a Daniell cell

$$Zn \mid Zn^{2+} \mid\mid Cu^{2+} \mid Cu$$

can be increased by
(a) increasing the concentration of zinc sulphate solution
(b) increasing the concentration of copper sulphate solution
(c) increasing the surface area of the electrodes
(d) decreasing the surface area of the electrodes.

323. For synthesis of organic compounds, synthesis gas is generally considered to be a variable mixture of Co and H_2.

324. The catalyst used to manufacture H_2SO_4 is Vanadium Pentaoxide

325. 20% oleum consists of 20% free SO_3.

326. Raw materials for the manufacture of nitric acid are ..... and Ammonia, air

327. A dilute nitric acid can be concentrated from about 60 percent to 95 percent by rectification with 93% H_2SO_4

328. The catalyst used in the manufacture of nitric acid is Platinum - Rhodium

329. The reaction of calcium carbide and water produces calcium hydroxide and Acetylene

330. Croygenics deals with the production and utilization of low temperatures in the region from Absolute zero to 120 K

331. Air is considered to be a mixture of 79% N_2 and 21% by Volume

332. Linde cycle employs refrigeration by Joule thomson cooling

333. Claude cycle employs adiabatic expansion against a piston or in a turbine

334. Electrochemistry deals with chemical changes produced by electric and electrical energy produced by Chemical changes

335. Loss of electrons implies oxidation while gain of electrons implies Reduction

336. In a fuel cell, oxidation takes place at Anode and reduction takes place at Cathode

337. electrolytic cell uses electrical energy to produce endothermic chemical changes.

338. Voltaic cell uses exothermic chemical reactions to produce electrical energy.

339. A voltaic cell can become an electrolysis cell by use of an external voltage greater than the Voltaic cell voltage and imposed in the opposite directions.

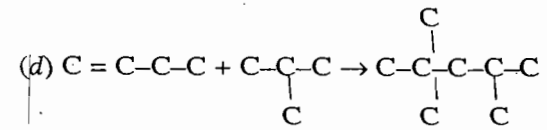
340. Raw materials required for the manufacture of soda ash by Solvay process are Salt , Coke and limestone
341. Diaphragm electrolytic cell produces 10-12% caustic solution.
342. Mercury electrolytic cell produces 70% caustic solution.
343. High alumina cement is manufactured by fusing limestone and bauxite.
344. Portland cement is defined as finely ground calcium ..... and ..... of varying compositions. Silicates
345. Low pressure Ziegler process for the manufacture of high density polyethylene uses a catalyst consisting of Aluminium methyl combined with Titanium tetrachloride .
346. Methanol is manufactured by catalytic hydrogenation of Carbon Monoxide
347. Methanol reactor is lined with copper to avoid the formation of Iron Carbonyl
348. Liquid methanol from the reactor is purified by Potassium permagnate to remove traces of ketones and aldehydes.
349. The starting raw material for production of perchloroethylene is Carbon tetrachloride
350. Trichloroethylene is produced by vapour phase dehydrochlorination of tetrachloroethane using Barium chloride catalyst.
351. Formaldehyde is made by catalytic oxidation-dehydrogenation of Methanol
352. The principal ore used for the production of iron and steel in India is Hemitite
353. In India the prominent copper ore is Chalcopyrite
354. Raw materials for the production of pig iron are ore and Coke .
355. Raw materials for steel manufacture are ..... and .....
356. Raw materials for the manufacture of Nylon-66 are ..... and Pig iron , oxygen .
357. In 66-Nylon, the first number designates the number of carbon atoms in the diamine, the second is for the carbon atoms in the dibasic
358. In 6-Nylon, the number refers to the total number of carbon atoms in the acid ring
359. Butadiene and styrene are copolymerised by emulsion polymerisation in weight ratio of about 3:1
360. Epoxidation is the addition of an oxygen atom across a C:C .
361. Bisphenol A is prepared by condensation of acetone with phenol .
362. Raw materials for DDT manufacture are ethanol and benzene .

363. Raw materials for BHC manufacture are Benzene and chlorine .
364. Raw materials for 2, 4-D manufacture are dichlorophenol and Monochloro acetic acid .
365. Raw materials for parathion manufacture are diethyl phosphorochloridothionate and Sodium p-nitrophenoxide .
366. A dye is a substance imparting colour to any material of which it becomes an integral part.
367. Raw materials for ethanolamines are ethylene oxide and Ammonea
368. 5 kg of methanol and 3 kg of ammonia are reacted to form mono methylamine. The limiting reactant is Methanol if the reaction is equimolar.

Match the items in the left column with the appropriate item in the right column :

369.
(*a*) A part of the product stream is sent back for reprocessing	(I) Purge
(*b*) A part of the reactant stream that does not undergo the processing but joins the product stream	(II) By pass
(*c*) The entire stream or a part it is let out of the processing zone due to build-up of non-reacting components beyond a permissible level in it	(III) Steady state
(*d*) The process parameters do not change with time	(IV) Recycle

370.
(*a*) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	(I) Calcination
(*b*) $CaCO_3 \xrightarrow{heat} CaO + CO_2$	(II) Combustion
(*c*) C-C-C-C-C-C-C $\rightarrow$ C-C-C+C=C-C-C	(III) Esterification
(*d*) $ROH + R'COOH \rightarrow R'COOR + H_2O$	(IV) Pyrolysis

371.
(*a*) $3TiCl_4 + Al \rightarrow 3TiCl_3 + AlCl_3$	(I) Alkylation
(*b*) C-C-C-C-C-C-C $\rightarrow C_6H_6 + H_2$	(II) Reduction
(*c*) $C_6H_5CHO + CH_3CHO \xrightarrow{NaOH} C_6H_5CH{:}CHCHO + H_2O$	(III) Cyclization
(*d*) 	(IV) Condensation

372.
(*a*) Fe_2O_3	(I) Magnetite
(*b*) Fe_2O_3FeO	(II) Hematite
(*c*) $FeCO_3$	(III) Iron pyrite
(*d*) FeS_2	(IV) Siderite

373. (*a*) Sucrose — (I) $C_6H_{12}O_6$
(*b*) d-glucose — (II) $C_6H_{10}O_5$
(*c*) Starch — (III) $C_{12}H_{22}O_{11}$
(*d*) Cellulose — (IV) $(C_6H_{10}O_5)_x$

374. (*a*) Producer gas — (I) C_3H_8, C_4H_{10}
(*b*) Water gas — (II) CO, H_2
(*c*) Coke oven gas — (III) CO, N_2, H_2
(*d*) Liquefied petroleum gas — (IV) H_2, CH_4, CO

375. (*a*) Methylene chloride — (I) $CHCl_3$
(*b*) Chloroform — (II) CH_2Cl_2
(*c*) Cryolite — (III) Al_2Cl_3
(*d*) Alumina — (IV) AlF_3 . 3NaF

376. (*a*) Thermoplastic — (I) Polyamide
(*b*) Thermosetting — (II) Polyisoprene
(*c*) Elastomer — (III) Phenol formaldehyde
(*d*) Fibre — (IV) Polyethylene

377. (*a*) Chemical to electrical conversion — (I) Tetraethyl lead
(*b*) Electroorganic chemical process — (II) Fuel cell
(*c*) Gas phase electric discharge — (III) Chlorine-caustic
(*d*) Aqueous electrolytic — (IV) Ozone

378. (*a*) Grignard reagent — (I) Sodium carbonate
(*b*) Soda ash — (II) Sodium hydroxide
(*c*) Caustic soda — (III) Ethyl magnesium chloride
(*d*) Graphite — (IV) Allotropic form of carbon

379. (*a*) Dolomite — (I) $MgCO_3$
(*b*) Magnesite — (II) $MgSO_4 . 7H_2O$
(*c*) Epsom salt — (III) $KCl. MgCl_2 . 6H_2O$
(*d*) Carnallite — (IV) $MgCO_3 . CaCO_3$

380. (*a*) Quicklime — (I) $Ca(OH)_2$
(*b*) Slaked lime — (II) CaO
(*c*) Limestone — (III) $CaSO_4 . 2H_2O$
(*d*) Gypsum — (IV) $CaCO_3$

381. (*a*) Nylon-66 — (I) Elastomer
(*b*) Dacron — (II) Polyamide
(*c*) Rayon — (III) Polyester
(*d*) Rubber — (IV) Cellulose

382. (*a*) $HOC_6H_4CH_3$ — (I) Chlorhydrin
(*b*) HOCl — (II) Peracetic acid
(*c*) $CH_3COOOCOCH_3$ — (III) Vinyl chloride
(*d*) $CH_2 = CHCl$ — (IV) Cresol

383. (*a*) Polyhexamethylene adipimide — (I) 6-Nylon
(*b*) Polycaprolactum — (II) 6, 6-Nylon
(*c*) Condensation of dimethyl terephthalate and ethylene glycol — (III) Dacron
(*d*) Polyacrylonitrile — (IV) Acrylic fibre

384. (*a*) $HOOC(CH_2)_4COOH$ — (I) Hexamethylene diamine
(*b*) $CH_2 = CHCN$ — (II) Acrylonitrile
(*c*) $NC(CH_2)_4CN$ — (III) Adiponitrile
(*d*) $H_2N(CH_2)_6NH_2$ — (IVI) Adipic acid

385. (*a*) CCl_3CHO — (I) DDT
(*b*) C_6H_5Cl — (II) Chloral
(*c*) $(C_6H_4Cl)_2CHCCl_3$ — (III) Parathion
(*d*) $C_6H_6Cl_6$ — (IV) BHC

386. (*a*) $Cl_2C_6H_3OH$ — (I) 2, 4-dichlorophenoxyacetic acid
(*b*) $ClCH_2COON$ — (II) Diethyl phosphorochloridothionate
(*c*) $Cl_2C_6H_3OCH_2COOH$ — (III) Dichlorophenol
(*d*) $(C_2H_5O)_2PCl$ (S) — (IV) Monochloroacetic acid

387. (*a*) $C_6H_5CH(CH_3)_2$ — (I) Acetonitrile
(*b*) $CH_2 = CHCN$ — (II) Isoprene
(*c*) $CH_2 = CH–C(CH_3) = CH_2$ — (III) Cumene
(*d*) CH_3CN — (IV) Acrylonitrile

388. (*a*) $C_6H_5NH_2$ — (I) Monochlorobenzene
(*b*) C_6H_5Cl — (II) Nitrobenzene
(*c*) $C_6H_5NO_2$ — (III) Trinitrotoluene
(*d*) $C_6H_2(NO_2)_3.CH_3$ — (IV) Aniline

389. (*a*) Oxidation of naphthalene — (I) TNT
(*b*) Oxidation of benzene — (II) Aniline
(*c*) Nitration of toluene — (III) Phthalic anhydride
(*d*) Ammonolysis of Chlorobenzene — (IV) Maleic anhydride

390. (*a*) Dehydrogenation of ethyl benzene — (I) Phenol
(*b*) Cumene peroxidation-hydrolysis — (II) Ethyl benzene

(*c*) Alkylation of benzene	(III)	Styrene
(*d*) Dehydrogenation of butane	(IV)	Butadiene

391.

(*a*) $C_{17}H_{35}COOH$	(I)	Linolenic acid
(*b*) $C_{17}H_{33}COOH$	(II)	Stearic acid
(*c*) $C_{17}H_{31}COOH$	(III)	Linoleic acid
(*d*) $C_{17}H_{29}COOH$	(IV)	Oleic acid

392.

(*a*) $C_{12}H_{25}OH$	(I)	Oleyl alcohol
(*b*) $C_3H_5(OH)_3$	(II)	Allyl alcohol
(*c*) $CH_2OHCH = CH_2$	(III)	Glycerol
(*d*) $C_{18}H_{35}OH$	(IV)	Lauryl alcohol

393.

(*a*) $CH_3CHOHCH_3$	(I)	Acetone
(*b*) $CHOCH = CH_2$	(II)	Isopropanol
(*c*) $C_{17}H_{35}COONa$	(III)	Acrolein
(*d*) CH_3COCH_3	(IV)	Soap

394.

(*a*) $2PbCO_3Pb(OH)_2$	(I)	Prussian blue
(*b*) $ZnSBaSO_4$	(II)	Ilmenite
(*c*) $Fe_4(Fe(CN)_6)_3$	(III)	White lead
(*d*) $FeOTiO_2$	(IV)	Lithopone

ANSWERS

1. (*c*)	2. (*d*)	3. (*c*)	4. (*d*)	5. (*d*)
6. (*d*)	7. (*b*)	8. (*b*)	9. (*c*)	10. (*b*)
11. (*c*)	12. (*d*)	13. (*d*)	14. (*c*)	15. (*a*)
16. (*a*)	17. (*b*)	18. (*a*)	19. (*b*)	20 (*a*)
21. (*b*)	22. (*d*)	23. (*c*)	24. (*c*)	25. (*d*)
26. (*d*)	27. (*c*)	28. (*c*)	29. (*c*)	30. (*d*)
31. (*a*)	32. (*b*)	33. (*d*)	34. (*a*)	35. (*b*)
36. (*b*)	37. (*c*)	38. (*d*)	39. (*b*)	40. (*c*)
41. (*d*)	42. (*b*)	43. (*d*)	44. (*c*)	45. (*a*)
46. (*b*)	47. (*d*)	48. (*b*)	49. (*c*)	50. (*a*)
51. (*b*)	52. (*c*)	53. (*d*)	54. (*b*)	55. (*b*)
56. (*c*)	57. (*a*)	58. (*a*)	59. (*c*)	60. (*a*)
61. (*b*)	62. (*d*)	63. (*c*)	64. (*a*)	65. (*c*)
66. (*a*)	67. (*c*)	68. (*d*)	69. (*d*)	70. (*c*)
71. (*c*)	72. (*b*)	73. (*c*)	74. (*a*)	75. (*d*)
76. (*c*)	77. (*a*)	78. (*d*)	79. (*c*)	80. (*a*)
81. (*d*)	82. (*a*)	83. (*c*)	84. (*b*)	85. (*c*)
86. (*c*)	87. (*b*)	88. (*b*)	89. (*b*)	90. (*a*)
91. (*c*)	92. (*a*)	93. (*c*)	94. (*d*)	95. (*b*)
96. (*b*)	97. (*a*)	98. (*b*)	99. (*a*)	100. (*b*)
101. (*d*)	102. (*b*)	103. (*b*)	104. (*a*)	105. (*c*)

106. (*c*)	107. (*a*)	108. (*d*)	109. (*c*)	110. (*b*)
111. (*b*)	112. (*b*)	113. (*c*)	114. (*c*)	115. (*b*)
116. (*d*)	117. (*c*)	118. (*c*)	119. (*b*)	120. (*c*)
121. (*b*)	122. (*d*)	123. (*a*)	124. (*c*)	125. (*c*)
126. (*c*)	127. (*b*)	128. (*c*)	129. (*c*)	130. (*d*)
131. (*a*)	132. (*a*)	133. (*b*)	134. (*b*)	135. (*b*)
136. (*b*)	137. (*d*)	138. (*d*)	139. (*c*)	140. (*a*)
141. (*b*)	142. (*b*)	143. (*a*)	144. (*c*)	145. (*c*)
146. (*b*)	147. (*b*)	148. (*c*)	149. (*d*)	150. (*b*)
151. (*b*)	152. (*b*)	153. (*d*)	154. (*d*)	155. (*c*)
156. (*d*)	157. (*b*)	158. (*a*)	159. (*d*)	160. (*b*)
161. (*a*)	162. (*d*)	163. (*a*)	164. (*b*)	165. (*c*)
166. (*d*)	167. (*c*)	168. (*a*)	169. (*d*)	170. (*b*)
171. (*a*)	172. (*d*)	173. (*b*)	174. (*c*)	175. (*b*)
176. (*b*)	177. (*c*)	178. (*b*)	179. (*b*)	180. (*a*)
181. (*b*)	182. (*a*)	183. (*a*)	184. (*c*)	185. (*c*)
186. (*c*)	187. (*b*)	188. (*a*)	189. (*b*)	190. (*c*)
191. (*c*)	192. (*d*)	193. (*c*)	194. (*a*)	195. (*d*)
196. (*a*)	197. (*b*)	198. (*d*)	199. (*a*)	200. (*c*)
201. (*c*)	202. (*c*)	203. (*c*)	204. (*a*)	205. (*a*)
206. (*b*)	207. (*c*)	208. (*c*)	209. (*c*)	210. (*d*)
211. (*a*)	212. (*c*)	213. (*b*)	214. (*d*)	215. (*a*)
216. (*a*)	217. (*d*)	218. (*b*)	219. (*b*)	220. (*c*)
221. (*d*)	222. (*c*)	223. (*b*)	224. (*a*)	225. (*b*)
226. (*c*)	227. (*c*)	228. (*d*)	229. (*c*)	230. (*c*)
231. (*c*)	232. (*a*)	233. (*b*)	234. (*c*)	235. (*b*)
236. (*d*)	237. (*b*)	238. (*b*)	239. (*b*)	240. (*a*)
241. (*c*)	242. (*a*)	243. (*d*)	244. (*a*)	245. (*d*)
246. (*c*)	247. (*a*)	248. (*b*)	249. (*a*)	250. (*d*)
251. (*b*)	252. (*b*)	253. (*c*)	254. (*b*)	255. (*a*)
256. (*b*)	257. (*a*)	258. (*d*)	259. (*a*)	260. (*a*)
261. (*c*)	262. (*a*)	263. (*d*)	264. (*c*)	265. (*c*)
266. (*b*)	267. (*b*)	268. (*d*)	269. (*b*)	270. (*a*)
271. (*b*)	272. (*c*)	273. (*a*)	274. (*b*)	275. (*d*)
276. (*b*)	277. (*c*)	278. (*a*)	279. (*c*)	280. (*c*)
281. (*d*)	282. (*d*)	283. (*a*)	284. (*b*)	285. (*b*)
286. (*d*)	287. (*d*)	288. (*c*)	289. (*b*)	290. (*b*)
291. (*a*)	292. (*b*)	293. (*c*)	294. (*d*)	295. (*d*)
296. (*c*)	297. (*c*)	298. (*a*)	299. (*a*)	300. (*c*)
301. (*b*)	302. (*d*)	303. (*b*)	304. (*b*)	305. (*c*)
306. (*a*)	307. (*c*)	308. (*a*)	309. (*d*)	310. (*c*)
311. (*c*)	312. (*d*)	313. (*d*)	314. (*a*)	315. (*d*)
316. (*c*)	317. (*a*)	318. (*d*)	319. (*b*)	320. (*a*)
321. (*a*)	322. (*b*)			

323. CO, H_2
324. Vanadian pentoxide
325. SO_3
326. ammonia, air
327. 93 percent H_2SO_4,
328. platinum-rhodium
329. acetylene
330. absolute zero, 123 K
331. volume
332. Joule-Thomson cooling
333. adiabatic expansion
334. Electric current, chemical changes
335. oxidation, reduction
336. anode, cathode
337. Electrolysis cell
338. Voltaic cell
339. voltaic cell, opposite
340. salt, coke, limestone
341. Diaphragm
342. Mercury
343. limestone, bauxite
344. aluminates, silicates
345. aluminium triethyl, titanium tetrachloride
346. carbon monoxide
347. iron carbonyl
348. potassium permagnate
349. carbon tetrachloride
350. barium chloride
351. methanol
352. hematite
353. chalcopyrite
354. ore, coke, limestone
355. pig iron, oxygen
356. adipic acid, hexamethylene diamine
357. diamine, dibasic acid
358. ring
359. 3 : 1
360. C = C
361. acetone, phenol
362. ethanol, benzene
363. benzene, chlorine
364. dichlorophenol, monochloro-acetic acid
365. Sodium p-nitro phenoxide
366. colour
367. ethylene oxide, ammonia
368. methanol
369. (*a*)–(IV)
(*b*)–(II)
(*c*)–(I)
(*d*)–(III)
370. (*a*)–(II)
(*b*)–(I)
(*c*)–(IV)
(*d*)–(III)
371. (*a*)–(II)
(*b*)–(III)
(*c*)–(IV)
(*d*)–(I)
372. (*a*)–(II)
(*b*)–(I)
(*c*)–(IV)
(*d*)–(III)
373. (*a*)–(III)
(*b*)–(I)
(*c*)–(II)
(*d*)–(IV)
374. (*a*)–(III)
(*b*)–(II)
(*c*)–(IV)
(*d*)–(I)
375. (*a*)–(II)
(*b*)–(I)
(*c*)–(IV)
(*d*)–(III)
376. (*a*)–(IV)
(*b*)–(III)
(*c*)–(II)
(*d*)–(I)

377. (*a*)–(II)
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378. (*a*)–(III)
(*b*)–(I)
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379. (*a*)–(IV)
(*b*)–(I)
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380. (*a*)–(II)
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381. (*a*)–(II)
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382. (*a*)–(IV)
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383. (*a*)–(II)
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384. (*a*)–(IV)
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(*c*)–(III)
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385. (*a*)–(II)
(*b*)–(III)
(*c*)–(I)
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386. (*a*)–(IV)
(*b*)–(III)
(*c*)–(I)
(*d*)–(II)
387. (*a*)–(III)
(*b*)–(IV)
(*c*)–(II)
(*d*)–(I)
388. (*a*)–(IV)
(*b*)–(I)
(*c*)–(II)
(*d*)–(III)
389. (*a*)–(III)
(*b*)–(IV)
(*c*)–(I)
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390. (*a*)–(III)
(*b*)–(I)
(*c*)–(II)
(*d*)–(IV)
391. (*a*)–(II)
(*b*)–(IV)
(*c*)–(III)
(*d*)–(I)
392. (*a*)–(IV)
(*b*)–(III)
(*c*)–(II)
(*d*)–(I)
393. (*a*)–(II)
(*b*)–(III)
(*c*)–(IV)
(*d*)–(I)
394. (*a*)–(III)
(*b*)–(IV)
(*c*)–(I)
(*d*)–(II)

4

Mass Transfer

DEFINITIONS

Absolute humidity. The ratio of the mass of moisture vapour to the mass of moisture-free gas.

Absorption. The selective dissolution of one or more components (solutes) of a gas or vapour stream into a liquid (solvent).

Adsorbate. A component of a gas or liquid that, when in contact with an adsorbent, is retained on the surface of the adsorbent.

Adsorbent. A microporous solid material that preferrentially retains one or more components of a gas or liquid in contact with it.

Adsorption. The accumulation of a substance, usually a gas, on a solid surface.

Azeotrope. A liquid mixture that upon boiling produces a vapour of the same composition; that is, no fractionation occurs between the liquid and the vapour.

Bound moisture. The moisture contained by a substance which exerts an equilibrium vapour pressure less than that of the pure liquid at the same temperature.

Boiling range. The difference between the bubble point and dew point. It exists for any miscible mixture.

Bubble point. The temperature at which the first bubble is forced out of the solution if a mixture is boiled at constant pressure.

Colburn J factor for mass transfer, J_D. $J_D = N_{St} N_{SC}^{2/3}$

Chilton-Colburn analogy. $J_D = J_H = f/2$ where J_H is J factor for heat transfer and f is friction factor.

Constant rate drying period. The period in a drying operation during which the rate of moisture removal per unit of drying surface is constant.

Critical moisture content. The moisture content existing in the material at the termination of the constant rate drying period.

$\Delta_{loading}$. The practical amount of a material that can be adsorbed and then desorbed, per unit weight of adsorbent, per cycle in an adsorption process.

Dew point. The temperature at which a vapour-gas mixture becomes saturated when cooled at constant total pressure out of contact with a liquid.

Dialysis. The separation of solutes of different molecular size in a liquid solution by use of a suitable membrane.

Diffusivity, molecular. The ratio of the diffusive flux to the negative of the concentration gradient in the direction of diffusion.

Displacing agent. A material used to remove one adsorbate from another by adsorbing in its place.

Distillation. A method of separation based on the difference in composition between a liquid mixture and the vapour formed from it. The composition difference is due to the differing effective vapour pressure, or volatilities, of the components of the liquid mixture.

Distribution coefficient. The ratio of the weight fractions (or mole fractions) of a component in two phases in equilibrium with each other.

Dry-bulb temperature. This is the temperature of a vapour-gas mixture as determined by immersion of a thermometer in the mixture.

Drying. The removal of moisture from a substance.

Electrodialysis. The separation of electrolytic crystalline substances from colloids in solution by imposing an electromotive force across the membrane.

Eluate. The effluent stream containing the desorbed solute and eluting solvent.

Elutant. The desorption solvent.

Elution. Desorption of the adsorbed solute by a solvent.

Elution curve. A plot of the solute concentration in the eluate against quantity of eluate.

Equilibrium moisture content. The moisture content to which a material can be dried under specified conditions of temperature and humidity of the surrounding atmosphere.

Extract. The stream of solvent plus components extracted from the feed in a liquid-liquid extraction process.

Falling rate drying period. That period of the drying cycle during which the instantaneous drying rate continuously decreases which commences at the end of the constant rate drying period.

Fick's laws of diffusion. $J_{A,z} = -D_{AB}\frac{\partial C_A}{\partial z}$ (First law)

$$\frac{\partial C_A}{\partial t} = \frac{\partial}{\partial z}\left(D_{AB}\frac{\partial C_A}{\partial z}\right) \quad \text{(Second law)}$$

Free moisture content. The moisture contained by a substance in excess of the equilibrium moisture content. It is removable at a given temperature and may include both bound and unbound moisture.

Freeze drying. A process whereby a material is first frozen and then dried by sublimation in a very high vacuum at a temperature in the range 240-260 K.

Heat of adsorption, differential. The heat liberated at constant temperature when unit quantity of vapour is adsorbed upon a large quantity of solid already containing adsorbate. Such a large quantity of solid is used that the adsorbate concentration is unchanged.

Heat of adsorption, integral. The integral heat of adsorption at any concentration X of the adsorbate upon the solid is defined as the enthalpy of the adsorbate-adsorbent combination minus sum of the enthalpies of unit weight of pure solid adsorbent and sufficient pure adsorbed substance (before adsorption) to provide the required concentration X, all at the same temperature.

Humid heat. The heat required to raise the temperature of 1 kg of dry gas and its associated vapour by 1°C at constant pressure.

Humid volume. The volume of 1 kg of dry gas and its associated vapour at the prevailing temperature and pressure.

Ideal liquid. A liquid mixture in which the components obey Raoult's law, *i.e.* the partial pressure of a component equals its vapour pressure times its mole fraction in the liquid.

Isotherm. An expression giving the equilibrium weight of a material adsorbed per unit weight of adsorbent as a function of the partial pressure of the material (or mole fraction if the material is in a liquid) at constant temperature.

Key component. In a mixture to be separated, a component that appears in both phases and whose concentrations in the phases can be considered to be a criterion of the extent of the separation.

K-value. The ratio of the mole fractions of a component in the vapour phase to the liquid phase.

Leaching. The preferential solution of one or more constituents of a solid mixture by contact with a liquid solvent.

Liquid-liquid extraction. The separation of the components of a liquid solution by contact with another insoluble liquid.

Moisture content, wet basis. The moisture in a material as a percentage of the weight of wet solid.

Moisture content, dry basis. The moisture in a material as a percentage of the weight of bone-dry material. The relationship between wet-and dry-basis moisture contents can be expressed as

$$W_w = \frac{W_d}{1 + W_d}$$

$$W_d = \frac{W_w}{1 - W_w}$$

where W_W is the kilograms of moisture per kilogram of wet material and W_d is the kilograms of moisture per kilogram of bone-dry material.

Overall efficiency. This is equal to the ratio of the number of theoretical plates required for a given separation to the number of actual plates required.

Partial pressure. The pressure that one gas or vapour in a mixture would exert if it were occupying by itself the same volume as the mixture and if it were at the same temperature as the mixture.

Percentage saturation. Defined as $100Y/Y_S$ and $100Y'/Y'_S$, where Y is molal absolute humidity, Y' is mass absolute humidity and the saturated values denoted by subscript S are determined at the dry-bulb temperature of the mixture.

Psychrometry. The study of the properties of mixtures of air and water vapour.

Raffinate. The feed stream minus components extracted by a solvent in a liquid-liquid extraction process.

Raoult's law. States that the partial pressure of a component in the vapour phase above a liquid solution is equal to the product of its vapour pressure and its mole fraction in the liquid solution.

Reboil. The portion of the liquid leaving the lowest plate of a distillation or absorption column that is boiled and returned to the column as vapour.

Reflux. The portion of the vapour stream leaving the top plate of a distillation column returned to the column as a liquid to facilitate separation.

Relative volatility. A measure of the ease of separability of two components in a vapour-liquid separation, defined as $(y_i/y_j)/(x_i/x_j)$ where y_i and y_j are the mole fractions of components i and j in the vapour phase, x_i and x_j are the mole fractions of components i and j in the liquid phase at equilibrium.

Relative saturation. Relative saturation or relative humidity, expressed as percentage is defined as $100p_A/P_A$, where p_A and P_A are the partial and vapour pressures at the dry-bulb temperature of the mixture.

Selectivity. A measure of the ease of separability of two components in a two-phase separation. Defined as $(x_i/x_j)_1/(x_i/x_j)_2$ where x_i and x_j are the mole fractions (or weight fractions) of components i and j in phases 1 and 2 at equilibrium.

Stage (or plate) efficiency. It is a measure of the approach to equilibrium on a plate. The most common definition, called the Murphree efficiency, is $(x_{i,out}-x_{i,in})/(x^*_i-x_{i,in})$, where the subscripts "in" and "out" refer to the compositions in the streams entering and leaving the plate and x^*_i is the composition in equilibrium with the actual composition of the outlet stream of the other phase.

Stripping. The transfer of a component from a liquid phase in which it is dissolved to a gas phase.

Theoretical stage (or plate). A contactor, such as a plate in a distillation column, on which the two leaving streams are in equilibrium with each other.

Thermal diffusion. The formation of a concentration difference within a single liquid or gaseous phase by imposition of a temperature gradient upon the fluid.

Turndown ratio. Turndown ratio $= \dfrac{VAP_{max}}{VAP_{min}}$

where VAP_{max} is vapour rate above which the tray efficiency drops below an acceptable value and VAP_{min} is vapour rate below which the tray efficiency is unacceptable.

Unbound moisture. The moisture contained by a substance which exerts an equilibrium vapour pressure equal to that of the pure liquid at the same temperature. All the moisture content of a non-hygroscopic material is unbound moisture.

Zeolite. A solid, microporous alumina-silicate with uniform pore geometry. It is also called a molecular sieve.

1. Diffusion is a process of
   (*a*) movement of particles from higher concentration to lower concentration.
   (*b*) movement of particles through a semipermeable membrane
   (*c*) rarefaction of particles
   (*d*) accumulation of particles on a solid surface.

2. Fick's first law of diffusion for the z direction is

   (*a*) $J_A = D_{AB}\dfrac{\partial C_A}{\partial z}$ (*b*) $J_A = -D_{AB}\dfrac{\partial C_A}{\partial z}$

   (*c*) $J_A = D_{AB}\dfrac{\partial^2 C_A}{\partial z^2}$ (*d*) $J_A = -D_{AB}\dfrac{\partial^2 C_A}{\partial z^2}$.

3. The diffusivity of a constituent A in solution B has the units.
   (*a*) m/s (*b*) m^2/s
   (*c*) m^3/s (*d*) kmol/(m^2-s).

4. Fick's second law of diffusion is

   (*a*) $\dfrac{\partial C_A}{\partial t} = D_{AB}\left(\dfrac{\partial C_A}{\partial x} + \dfrac{\partial C_A}{\partial y} + \dfrac{\partial C_A}{\partial z}\right)$

   (*b*) $\dfrac{\partial^2 C_A}{\partial t^2} = D_{AB}\left(\dfrac{\partial C_A}{\partial x} + \dfrac{\partial C_A}{\partial y} + \dfrac{\partial C_A}{\partial z}\right)$

   (*c*) $\dfrac{\partial^2 C_A}{\partial t^2} = D_{AB}\left(\dfrac{\partial^2 C_A}{\partial x^2} + \dfrac{\partial^2 C_A}{\partial y^2} + \dfrac{\partial^2 C_A}{\partial z^2}\right)$

   (*d*) $\dfrac{\partial C_A}{\partial t} = D_{AB}\left(\dfrac{\partial^2 C_A}{\partial x^2} + \dfrac{\partial^2 C_A}{\partial y^2} + \dfrac{\partial^2 C_A}{\partial z^2}\right)$.

5. For steady-state molecular diffusion of gas A through non-diffusing B, the ratio $N_A/(N_A + N_B)$ is
   (*a*) 0 (*b*) 1
   (*c*) ∞ (*d*) 1/2.

6. For steady-state equimolal counterdiffusion of two gases A and B, the ratio $N_A/(N_A + N_B)$ is
   (*a*) 0 (*b*) 1
   (*c*) 1/2 (*d*) ∞.

7. Methane is being cracked on a catalyst,
   $$CH_4 \rightarrow C + 2H_2$$
   under circumstances such that CH_4(A) diffuses to the cracking surface and H_2(B) diffuses back. At steady-state the ratio $N_A/(N_A + N_B)$ is
   (*a*) 1/3 (*b*) −1

(c) 2/3 (d) –2.

8. The binary diffusivity in gases is dependent upon

(a) the temperature
(b) the pressure
(c) the nature of the components
(d) all of the above.

9. The binary diffusivity in gases varies almost as

(a) T (b) $T^{1/2}$
(c) $T^{3/2}$ (d) T^2.

where T = absolute temperature of the system.

10. The binary diffusivity in gases varies

(a) directly as the pressure
(b) inversely as the pressure
(c) inversely as the square root of pressure
(d) directly as the square root of pressure.

11. The binary diffusivity in gases at atmospheric conditions is of the order of

(a) 10^{-1} cm^2/sec (b) 10^{-5} cm^2/sec
(c) 10^{5} cm^2/sec (d) 10^{-7} cm^2/sec.

12. The binary diffusivity in liquids is of the order of

(a) 10^{-5} cm^2/sec (b) 10^{-5} m^2/s
(c) 10^{-5} mm^2/sec (d) 10^{-5} ft^2/sec.

13. The partial pressure distribution of both components of a non-reacting binary mixture of ideal gases is linear

(a) in the case of steady-state equimolal counter-diffusion
(b) in the case of steady-state unimolal unidirectional diffusion
(c) both in the case of steady-state equimolal counter-diffusion and steady-state unimolal unidirectional diffusion.

14. The partial pressure distribution of both components of a non-reacting binary mixture of ideal gases is non-linear

(a) in the case of steady-state equimolal counter-diffusion
(b) in the case of steady-state unimolal unidirectional diffusion
(c) both in the case of steady-state equimolal counter-diffusion, and steady-state unimolal unidirectional diffusion.

15. The diffusivity D_{AB} for A diffusing in B is the same as the diffusivity D_{BA} for B diffusing in A for a binary mixture of

(a) ideal gases only (b) real gases only
(c) both ideal and real gases (d) real liquids only.

16. At steady-state the partial pressure distribution of an ideal gas A diffusing through a stagnant ideal gas B follows

(a) linear law (b) hyperbolic law
(c) parabolic law (d) exponential law.

17. Select the wrong statement

(a) Molecular diffusion in solids is much faster than molecular diffusion in gases and liquids
(b) Molecular diffusion in solids is much slower than molecular diffusion in gases and liquids
(c) The diffusion coefficient in a liquid is 10^{-4} to 10^{-5} times the diffusion coefficient in a gas
(d) Molecular diffusion in gases is much faster than molecular diffusion in liquids.

18. The Knudsen diffusivity is proportional to

(a) T (b) $T^{3/2}$
(c) $T^{1/2}$ (d) T^2.

where T = absolute temperature.

19. The partial pressure of component A in the vapour phase is given by

$$p_A = X_A P_A$$

where X_A = the mole fraction of component A in the boiling liquid, and P_A = saturation pressure of pure component A at the temperature of the liquid mixture. This is known as

(a) Dalton's law (b) Henry's law
(c) Raoult's law (d) Lewis and Randall law.

20. Permeability P is defined as

(a) $P = \dfrac{V}{-d\,p/d\,z}$ (b) $P = 1/D_{AB}$

(c) $P = V(-dp/dz)$ (d) $P = D_{AB}$/solubility

where V = the volume of gas (at some specified temperature and pressure) diffusing per unit time (area) under the pressure gradient $-dp/dz$.
D_{AB} = diffusivity of gas through membrane.

21. For flow of gas through a capillary according to Poiseuille's law, the permeability

(a) varies inversely as the gas viscosity
(b) is proportional to the gas viscosity
(c) varies as the square root of gas viscosity
(d) varies as the square of the gas viscosity

22. For flow of a gas through a given capillary according to Poiseuille's law, the permeability

(a) remains unaffected with change in temperature
(b) increases with increase in temperature
(c) decreases with increase in temperature
(d) varies as the square root of temperature.

23. The permeability increases with increase in temperature for the flow of gases through a capillary according to

(*a*) Knudsen law
(*b*) Poiseuille's law
(*c*) both Knudsen law and Poiseuille's law
(*d*) none of the above.

24. The binary diffusivity in liquids varies almost as

(*a*) T (*b*) $T^{3/2}$
(*c*) T^2 (*d*) T^3.

25. The diffusivity has the same dimensions as

(*a*) absolute viscosity (*b*) kinematic viscosity
(*c*) density (*d*) concentration

26. The Schmidt number (N_{Sc}) is the ratio of

(*a*) the momentum diffusivity to the mass diffusivity
(*b*) the mass diffusivity to the momentum diffusivity
(*c*) the thermal diffusivity to the mass diffusivity
(*d*) the momentum diffusivity to the thermal diffusivity.

27. The Schmidt number (N_{Sc}) is defined as

(*a*) μ/D_{AB} (*b*) $\mu/\rho D_{AB}$
(*c*) $\rho\mu/D_{AB}$ (*d*) $\mu D_{AB}/\rho$.

28. For water at 20°C the Prandtl number (N_{Pr}) is

(*a*) 0·702 (*b*) 7·02
(*c*) 70·2 (*d*) 120.

29. The units of mass transfer coefficients could be

(*a*) $\dfrac{\text{Moles transferred}}{\text{Time (area) (pressure)}}$

(*b*) $\dfrac{\text{Moles transferred}}{\text{Times (area) (mole fraction)}}$

(*c*) $\dfrac{\text{Moles transferred}}{\text{Times (area) (concentration)}}$

(*d*) any of these answers.

30. According to the film theory the mass-transfer coefficient is directly proportional to

(*a*) D_{AB} (*b*) $D_{AB}^{0.5}$
(*c*) D_{AB}^2 (*d*) $D_{AB}^{1.5}$.

31. According to the penetration theory the mass-transfer co-efficient is directly proportional to

(*a*) D_{AB} (*b*) D_{AB}^2
(*c*) $D_{AB}^{1.5}$ (*d*) $D_{AB}^{0.5}$.

32. According to the surface-renewal theory the mass transfer coefficient is directly proportional to

(*a*) D_{AB} (*b*) $D_{AB}^{1.5}$.
(*c*) $D_{AB}^{0.5}$. (*d*) D_{AB}^2.

33. Peclet number (N_{Pe}) for mass-transfer is defined as

(*a*) N_{Re}/N_{Sc} (*b*) $N_{Re}\,N_{Sc}$
(*c*) N_{Sc}/N_{Re} (*d*) $N_{Sh}\,N_{Sc}$.

34. Stanton number (N_{St}) for mass-transfer is defined as

(*a*) $N_{Sh}/(N_{Re}\,N_{Sc})$ (*b*) $N_{Pe}\,N_{Sh}$
(*c*) N_{Sh}/N_{Sc} (*d*) $N_{Sh}\,N_{Sc}$.

35. The eddy momentum diffusivity, the thermal diffusivity, and the mass diffusivity will be the same for

(*a*) $N_{Pr} = N_{Sc} = 0{\cdot}7$ (*b*) $N_{Pr} = N_{Sc} = 1$
(*c*) $N_{Pr} = N_{Sc} = 7{\cdot}02$ (*d*) $N_{Pr} = N_{Sc} = 297$.

36. The Sherwood number (N_{Sh}) is defined as

(*a*) $\dfrac{D_{AB}}{k_c\,d}$ (*b*) $\dfrac{k_c}{d\,D_{AB}}$
(*c*) $\dfrac{k_c\,D_{AB}}{d}$ (*d*) $\dfrac{k_c\,d}{D_{AB}}$

where k_c = mass transfer coefficient for equimolar counter-diffusion with concentration as the driving force
d = hydraulic diameter
D_{AB} = diffusivity.

37. For ideal gases the different mass transfer coefficients are related as

(*a*) $k_c = k_g\,RT = k_{ye}\,RT/P$ (*b*) $k_c = k_g/RT = k_{ye}\,P/RT$
(*c*) $k_c = k_g\,RT/P = k_{ye}\,RT$ (*d*) $k_c = k_g = k_{ye}$.

where k_c = mass transfer coefficient for equimolar counter-diffusion with concentration as the driving force
k_g = mass transfer coefficient for diffusion of a gas through a stagnant inert with pressure as the driving force
k_{ye} = mass transfer coefficient for equimolar counter-diffusion with mole fraction as the driving force.

38. The Chilton-Colburn analogy for mass transfer states that

(*a*) $N_{St}\,N_{Sc}^{1/3} = f/8$ (*b*) $N_{St}\,N_{Sc}^{2/3} = f/2$
(*c*) $N_{St}\,N_{Sc}^{3/2} = f/2$ (*d*) $N_{St}\,N_{Sc}^{2/3} = f/8$

where f = Fanning friction factor.

39. The temperature at which a vapour-gas mixture becomes saturated when cooled at constant total pressure out of contact with a liquid is called

(*a*) bubble point (*b*) dew point
(*c*) wet-bulb temperature (*d*) dry-bulb temperature.

40. For a vapour-gas mixture of absolute humidity Y' at t_G °C and P_t atm, the ideal-gas law gives the humid volume (v_H) as

(*a*) $v_H = \left(\frac{1}{M_B} + \frac{Y'}{M_A}\right)(22{\cdot}4)\left(\frac{1}{P_t}\right)\left(\frac{272 + t_G}{273}\right)\text{m}^3$

(*b*) $v_H = \left(\frac{1}{M_B} + \frac{Y'}{M_A}\right)(22{\cdot}4)\left(\frac{1}{P_t}\right)\left(\frac{273}{273 + t_G}\right)\text{m}^3$

(*c*) $v_H = (M_B + Y'M_A)(22{\cdot}4)\left(\frac{1}{P_t}\right)\left(\frac{273 + t_G}{273}\right)\text{m}^3$

(*d*) $v_H = \left(\frac{1}{M_B} + \frac{Y'}{M_A}\right)(359)\left(\frac{1}{P_t}\right)\left(\frac{273 + t_G}{273}\right)\text{m}^3$

where M_A and M_B are molecular weights of vapour and gas respectively.

41. The dew point of an unsaturated mixture of vapour and gas does not depend on

(*a*) the temperature of the mixture
(*b*) the total pressure of the mixture
(*c*) the composition of the mixture
(*d*) all of the above.

42. The relative saturation of an unsaturated mixture of vapour and gas

(*a*) is always equal to its percentage saturation
(*b*) is always lower than its percentage saturation
(*c*) is always greater than its percentage saturation
(*d*) may be smaller or greater than its percentage saturation depending on the composition of the mixture.

43. The relative saturation of an unsaturated mixture of vapour and gas depends on

(*a*) the composition of the mixture
(*b*) the temperature of the mixture
(*c*) the nature of the vapour
(*d*) all of the above.

44. For a vapour-gas mixture the wet and dry-bulb temperature are 20°C and 35°C, respectively. If the mixture is heated to 50°C at constant pressure, the wet-bulb temperature will be

(*a*) 20°C (*b*) > 20°C
(*c*) < 20°C (*d*) ≤ 20°C.

45. At the boiling point of the liquid at the prevailing pressure the saturated absolute humidity becomes

(*a*) one (*b*) zero
(*c*) infinity (*d*) none of the above.

46. The dew point of an unsaturated mixture of water vapour and air at constant temperature and pressure

(*a*) does not change with change in absolute humidity
(*b*) increases with increase in absolute humidity
(*c*) decreases with increase in absolute humidity
(*d*) decreases linearily with increase in absolute humidity.

47. The partial pressure of water vapour p_A, in atm, in a given mixture of water vapour and air of molal absolute humidity Y at t_G °C and P_t atm is given by

(*a*) $p_A = YP_t$ (*b*) $p_A = \frac{YP_t}{1 + Y}$
(*c*) $p_A = \frac{YP_t}{1-Y}$ (*d*) $p_A = (1 + Y)P_t$.

48. The steady-state temperature reached by a small amount of liquid evaporating into a large amount of unsaturated vapour-gas mixture is called

(*a*) dry-bulb temperature (*b*) dew point
(*c*) wet-bulb temperature (*d*) bubble point.

49. For any vapour-gas mixture the adiabatic saturation curve is

(*a*) straight line
(*b*) slightly concave upward
(*c*) slightly concave downward.

50. The psychrometric ratio is defined as

(*a*) h_G/k_Y (*b*) k_Y/h_G
(*c*) $h_G/k_Y C_s$ (*d*) N_{Sc}/N_{Pr}.

51. The Lewis number of a mixture is defined as

(*a*) N_{Pr}/N_{Sc} (*b*) $N_{Pr}N_{Sc}$
(*c*) N_{Sc}/N_{Pr} (*d*) $C_s\,(N_{Sc}/N_{Pr})$.

52. For the system air-water vapour, $h_G/k_Y C_s$ is approximately equal to

(*a*) 1 (*b*) 0·24
(*c*) 2·4 (*d*) 3.

53. The Lewis number of a mixture is one when mass diffusivity is equal to

(*a*) momentum diffusivity (*b*) thermal diffusivity
(*c*) thermal conductivity (*d*) 1/thermal diffusivity.

54. For pure air at atmospheric conditions the Lewis number is

(*a*) $<< 1$ (*b*) $>> 1$
(*c*) ≈ 1 (*d*) ∞.

55. For pure air at atmospheric conditions the Schmidt number is

(*a*) < 1 (*b*) 1
(*c*) > 1 (*d*) $>> 1$.

56. The temperature of water cooled in a cooling tower is

(*a*) always less than the wet-bulb temperature of entering air
(*b*) always equal to the wet-bulb temperature of entering air
(*c*) always greater than the wet-bulb temperature of entering air
(*d*) always equal to the dry-bulb temperature of entering air.

57. In the design of cooling towers the wet-bulb temperature approach is ordinarily specified to be

(*a*) from 5 to 10°F (*b*) from 20 to 30°F
(*c*) from 30 to 35°F (*d*) from 10 to 25°F.

58. In a cooling tower makeup fresh water must be added to replace losses from

(*a*) entrainment (*b*) evaporation losses
(*c*) blowdown (*d*) all of the above.

59. In an operating cooling tower the wet-bulb temperature of entering air is increased keeping all other variable constant. The outlet water temperature will

(*a*) remain constant (*b*) decrease
(*c*) increase.

60. The cooling effect in a cooling tower can be increased by

(*a*) lowering the barometric pressure
(*b*) reducing the humidity of entering air
(*c*) increasing the air velocity over the wet surfaces
(*d*) all of the above.

61. When can the relative humidity of air decrease inspite of an increase in the absolute humidity ?

(*a*) When the pressure rises
(*b*) When the pressure falls
(*c*) When the temperature rises
(*d*) When the temperature falls.

62. Under the same conditions

(*a*) 1 m^3 of dry air is lighter than 1 m^3 of humid air
(*b*) 1 m^3 of humid air is lighter than 1 m^3 of dry air
(*c*) both 1 m^3 of dry air and 1 m^3 of humid air have the same weight.

63. The percentage saturation and relative saturation of a vapour-gas mixture approach equality when the vapour concentration approaches

(*a*) 0 (*b*) 1
(*c*) 0·5 (*d*) 0·6.

64. The ratio of the percentage saturation to the relative saturation of the water vapour-air mixture at a total pressure P_t and temperature T is given by

(*a*) P_s/p_v (*b*) p_v/P_s
(*c*) $(P_t - P_s)/(P_t - p_v)$ (*d*) $(P_t - p_v)/(P_t - P_s)$

where p_v = partial pressure of the vapour
P_s = vapour pressure of the liquid at temperature T.

65. The absolute humidity (Y') of water vapour-air mixture is given by

(*a*) $Y' = \dfrac{p_v}{P_t - p_v}$ (*b*) $Y' = \dfrac{29\,p_v}{18\,(P_t - p_v)}$

(*c*) $Y' = \dfrac{18\,(P_t - p_v)}{29\,p_v}$ (*d*) $Y' = \dfrac{18\,p_v}{29\,(P_t - p_v)}$

where p_v = partial pressure of water vapour
P_t = total pressure.

66. The Lewis number is the ratio of

(*a*) thermal diffusivity to mass diffusivity
(*b*) mass diffusivity to thermal diffusivity
(*c*) mass diffusivity to momentum diffusivity
(*d*) momentum diffusivity to thermal diffusivity.

67. Lewis number plays an important role in problems of

(*a*) heat transfer only
(*b*) mass transfer only
(*c*) simultaneous heat and mass transfer
(*d*) momentum transfer only.

68. Relative volatility, α, for a binary system

(*a*) decreases with increase in pressure
(*b*) increases with increase in pressure
(*c*) increases with increase in temperature at constant pressure
(*d*) has no significance in distillation operation.

69. Relative volatility, α, for a binary system is a measure of separability by distillation. If $\alpha = 1$, the separation by distillation is

(*a*) maximum possible (*b*) least possible
(*c*) impossible (*d*) optimum possible.

70. If $y^* = x$, the relative volatility, α, for a binary system is always

(*a*) zero (*b*) one
(*c*) infinity (*d*) one except at $x = 0$ or 1.

71. To separate a binary mixture the relative volatility should be

(*a*) equal to one (*b*) less than one
(*c*) greater than one (*d*) greater than zero.

72. Component *A* is said to be more volatile than component *B*, if for all temperature in the closed interval $T_A < T < T_B$,

(*a*) the vapour pressure of *A* is less than the vapour pressure of *B*
(*b*) the vapour pressure of *A* is more than the vapour pressure of *B*
(*c*) the vapour pressure of *A* is equal to 1 atm
(*d*) the vapour pressure of *A* is equal to the vapour pressure of *B*.

73. A two-phase is said to be in physical equilibrium if

(*a*) the temperature of the vapour phase is equal to the temperature of the liquid phase
(*b*) the total pressure throughout the vapour phase is equal to the total pressure throughout the liquid phase
(*c*) the tendency of each phase is exactly equal to its tendency to escape from the vapour phase to the liquid phase
(*d*) all of the above.

74. The normal boiling points of benzene and toluene are 80·1°C and 110·6°C, respectively. A mixture containing 50 mole per cent benzene and 50 mole per cent toluene will boil at 1 atm at

(*a*) 80·1°C
(*b*) 110·6°C
(*c*) a temperature in between 80·1°C and 110·6°C
(*d*) a temperature of more than 110·6°C.

75. Ethanol-water solution containing 50 mole per cent ethanol can be separated to get 97 mole per cent ethanol by

(*a*) atmospheric distillation
(*b*) distillation at higher pressures
(*c*) vacuum distillation
(*d*) all of the above.

76. The ratio of the actual equilibrium partial pressure of a component to the ideal value is called

(*a*) activity coefficient (*b*) turndown ratio
(*c*) relative volatility (*d*) fugacity.

77. Azeotropes

(*a*) are mixtures with constant boiling point at the specified pressure
(*b*) obey Raoult's law at all temperature

(*c*) are mixtures of partially miscible liquids
(*d*) none of the above.

78. Which one of the following systems does not form azeotrope at 1 atm ?

(*a*) Ethanol-water (*b*) Benzene-toluene
(*c*) Hydrochloric acid-water (*d*) Acetone-chloroform.

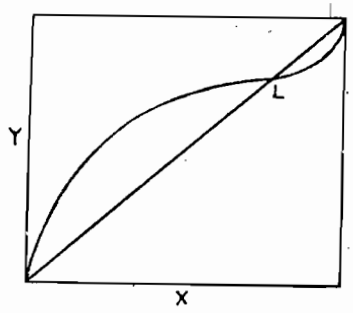


Fig. 4·1.

79. For a minimum-boiling azeotrope the vapour-liquid equilibria is shown in Fig. 4·1. For compositions to the right of *L*, the relative volatility is

(*a*) > 1 (*b*) < 1
(*c*) 1 (*d*) >> 1.

80. For ideal liquid phase and vapour phase the relative volatility of component *A* relative to component *B* is equal to

(*a*) P_A/P_t (*b*) P_B/P_t
(*c*) P_A/P_B (*d*) P_B/P_A.

where P_A = vapour pressure of component *A* at the existing temperature
P_B = vapour pressure of component *B* at the existing temperature
P_t = total pressure.

81. At the azeotropic composition

(*a*) $y^* > x$ (*b*) $y^* < x$
(*c*) $y^* = x$ (*d*) $x + y^* = 1$

where x = mole fraction of more volatile component in liquid phase;
y^* = equilibrium mole fraction of more volatile component in vapour phase.

82. An azeotropic mixture of two liquids has boiling point lower than either of them when it

(*a*) shows no deviation from Raoult's law
(*b*) shows positive deviation from Raoult's law

(*c*) shows negative deviation from Raoult's law
(*d*) is saturated.

83. An azeotropic mixture of two liquids has boiling point higher than either of the them when it

(*a*) is saturated
(*b*) shows negative deviation from Raoult's law
(*c*) shows positive deviation from Raoult's law
(*d*) shows no deviation from Raoult's law.

84. Which of the following is the most important to separate a mixture of two volatile liquids by distillation ?

(*a*) Solubility (*b*) Relative volatility
(*c*) Density difference (*d*) Selectivity.

85. At the azeotropic composition of a binary mixture the relative volatility is

(*a*) 0 (*b*) ∞
(*c*) 1 (*d*) < 1.

86. Which of the following systems is an example of minimum boiling azeotrope at 1 atm ?

(*a*) Ethanol-water (*b*) Hydrochloric acid-water
(*c*) Acetone-chloroform (*d*) Benzene-toluene.

87. Which of the following systems is an example of maximum-boiling azeotrope at 1 atm ?

(*a*) Carbon disulphide-acetone
(*b*) Ethanol-water
(*c*) Benzene-ethanol
(*d*) Acetone-chloroform.

88. The relative volatility of component *A* relative to component *B* is equal to the ratio of vapour pressure of component *A* to vapour pressure of component *B* at the existing temperature if

(*a*) the total pressure is 1 atm
(*b*) the liquid phase behaves as an ideal solution
(*c*) the vapour phase behaves as an ideal gas
(*d*) both the liquid phase and vapour phase are ideal.

89. The ethanol-water azeotrope at 1 atm occurs at

(*a*) 89·4 mole per cent ethanol and 78·2°C
(*b*) 89·4 mole per cent water and 78·2°C
(*c*) 96·0 mole per cent ethanol and 78·2°C
(*d*) 96·0 mole per cent ethanol and 100°C.

90. The flash process is carried out by

(*a*) reducing the pressure on the feed stream
(*b*) cooling the feed at constant pressure

(*c*) increasing the pressure on the feed steam
(*d*) none of the above.

91. The necessary condition for a flash of a given feed mixture to occur at the specified pressure is

(*a*) $T_{BP} = T_F = T_{DP}$ (*b*) $T_{BP} < T_F < T_{DP}$
(*c*) $T_{BP} > T_F > T_{DP}$ (*d*) $T_F = (T_{BP} + T_{DP})/2$

where T_F = flash temperature
T_{BP} = bubble point temperature
T_{DP} = dew point temperature.

92. Flash distillation operation is suitable for separating components which

(*a*) boil at very close temperature
(*b*) boil at widely different temperature
(*c*) form minimum-boiling azeotrope
(*d*) form maximum-boiling azeotrope.

93. If there is no condensation of carrier steam in the steam distillation of high-boiling organic materials, the steam consumption is minimum at

(*a*) the highest permissible temperature and pressure
(*b*) the lowest practicable temperature and pressure
(*c*) the highest permissible temperature and the lowest practicable pressure
(*d*) the lowest temperature and the highest practicable pressure.

94. If there is condensation of carrier steam in the steam distillation of high-boiling organic materials,

(*a*) both temperature and pressure must be fixed
(*b*) either the temperature or the pressure may be fixed
(*c*) the temperature is always more than 100°C at 1 atm
(*d*) the temperature is always equal to 100°C at 1 atm.

95. An ideal plate is defined as one where

(*a*) the vapour and liquid leaving streams are in equilibrium
(*b*) the vapour and liquid entering streams are in equilibrium
(*c*) the vapour leaving stream is in equilibrium with the liquid entering stream
(*d*) the vapour entering stream is in equilibrium with the liquid leaving stream.

96. The internal reflux ratio (R_i) is related to the external reflux ratio (R_0) by the equation

(*a*) $R_i = R_0$ (*b*) $R_i = \dfrac{R_0}{1 + R_0}$

(*c*) $R_i = \dfrac{R_0}{1 - R_0}$ (*d*) $R_i = \dfrac{1 + R_0}{1 - R_0}$.

97. The intercept on y-axis of the operating line for the rectifying section of a distillation column is

(a) $x_D R_i/R_0$ (b) $x_D L/V$
(c) $D x_B/L$ (d) none of the above.

where L and V are the liquid and vapour rates in the rectifying section taken to be constant over the section.

98. If q is interpreted to be the fraction of the feed stream that is liquid, then for superheated vapour feed to a distillation column

(a) $q > 1$ (b) $q < 1$
(c) $q = 0$ (d) $q = \dfrac{-C_{pv}(T_f - T_{dp})}{(H_V - H_L)}$.

99. The slope of the operating line for the stripping section of distillation column is

(a) 0 (b) ∞
(c) < 1 (d) > 1.

100. The slope of the operating line for the rectifying section of distillation column is

(a) ∞ (b) 0
(c) > 1 (d) < 1.

101. If q is interpreted to be the fraction of the feed that is liquid, then the slope of the feed line in distillation operation is

(a) $-(1-q)/q$ (b) $-q/(1-q)$
(c) $-q$ (d) $-q/(q-1)$.

102. When a dephlegmator is also used to condense partially the overhead vapour from a distillation column, the liquid reflux at its bubble-point

(a) has the same composition as the overhead product
(b) is richer in less volatile component than overhead product
(c) is richer in more volatile component than overhead product.

103. If q is interpreted to be the fraction of the feed stream that is liquid, then for saturated vapour feed to a distillation column

(a) $q = 1$ (b) $q = 0$
(c) $q > 1$ (d) $q < 0$.

104. If q is interpreted to be the fraction of the feed stream that is liquid, then for saturated liquid feed to a distillation column

(a) $q = 0$ (b) $q < 0$
(c) $q > 1$ (d) $q = 1$.

105. If the feed to a distillation column is a saturated liquid, then the slope of the feed line is

(a) 0 (b) ∞
(c) > 1 (d) < 1.

106. The slope of operating line in the rectifying section of a distillation column is unity if the reflux ratio is

(a) 0 (b) 1
(c) ∞ (d) R_{min}

where R_{min} = minimum reflux ratio

107. Fenske-Underwood equation

$$N_{min} = \frac{\ln\left[\left(\frac{x_D}{1-x_D}\right)\left(\frac{1-x_B}{x_B}\right)\right]}{\ln \alpha}$$

is used to calculate the minimum number of theoretical stages required to obtain a given separation by distillation. This equation is valid for

(a) total reflux
(b) constant molal overflow
(c) constant relative volatility
(d) all of these answers.

108. In a distillation operation the heat removed in condenser

(a) remains unaffected with change in reflux ratio
(b) increases with increase in reflux ratio
(c) decreases with increase in reflux ratio
(d) and the heat required in reboiler decrease with increase in reflux ratio.

109. In a distillation operation the reflux ratio may vary between

(a) zero and one (b) zero and infinity
(c) minimum and infinity (d) one and two.

110. In a distillation operation total reflux requires

(a) minimum number of plates
(b) infinite number of plates
(c) minimum reboiler and condenser load
(d) that the flow of fresh feed must continue.

111. Most distillation columns are designed for reflux ratios between

(a) 3 to 5 times R_{min} (b) 1·2 to 1·7 times R_{min}
(c) 2 to 10 times R_{min} (d) 0·2 to 0·7 times R_{min}

where R_{min} = minimum reflux ratio.

112. At minimum reflux ratio the fixed cost of a distillation column is

(a) minimum (b) infinite
(c) optimum.

113. At minimum reflux ratio the operating cost of a distillation column is

(a) maximum (b) optimum
(c) minimum (d) infinite.

114. At total reflux the capacity of a distillation column is

(*a*) zero (*b*) maximum
(*c*) minimum (*d*) optimum.

115. In a distillation column the minimum reflux ratio

(*a*) is the maximum ratio which will require an infinite number of trays for the separation desired
(*b*) corresponds to the maximum reboiler heat load for the separation desired
(*c*) corresponds to the maximum condenser cooling load for the separation desired
(*d*) is always zero.

116. For obtaining a given separation in distillation column the minimum number of theoretical stages is obtained with

(*a*) minimum reflux ratio (*b*) optimum reflux ratio
(*c*) total reflux (*d*) zero reflux ratio.

117. Solvent used in extractive distillation

(*a*) alters the relative volatility of the original components
(*b*) is of low volatility
(*c*) must form no azeotrope with the original substances
(*d*) all of these answers.

118. Entrainer used in azeotropic distillation of binary mixture

(*a*) forms no azeotrope with the original substances
(*b*) forms a minimum-boiling azeotrope with one or both of the feed components
(*c*) should be of very high viscosity to provide high tray efficiencies
(*d*) should have very high latent heat of vaporization.

119. Which of the following is more accurate to determine the number of theoretical stages required for the separation of nonideal binary systems by distillation ?

(*a*) McCabe—Thiele method
(*b*) Ponchon—Savarit method
(*c*) Both McCabe—Thiele and Ponchon—Savarit methods are equally good.

120. McCabe—Thiele method is used to find the number of theoretical stages required in a distillation operation. This method is based on the assumption(s) that

(*a*) the liquid/vapour loading in each section of the tower remains constant
(*b*) Trouton's rule is applicable
(*c*) *the sensible heat differences are small because the temperature change from tray to tray is small*
(*d*) all of the above.

121. The flooding in a distillation column is detected by

(*a*) a sharp increase in pressure drop
(*b*) a sharp increase in Murphree plate efficiency
(*c*) a sharp decrease in pressure drop
(*d*) a sharp decrease in liquid hold-up in the column.

122. Entrainment in a distillation column

(*a*) is defined as the liquid carried with the vapour from one tray to the tray above
(*b*) is detected by decrease in Murphree plate efficiency
(*c*) may be detrimental since it can carry non-volatile constituents upward
(*d*) all of these answers.

123. Inside the distillation column

(*a*) the driving for the vapour flow is the pressure drop
(*b*) the driving force for the liquid flow is its weight
(*c*) the liquids and vapours are always at their bubble point and dew point, respectively
(*d*) all of these answers.

124. Inside the distillation column

(*a*) the pressure decreases gradullay from bottom to top of the column
(*b*) the highest temperature is at the top of the column
(*c*) the pressure increases gradually from bottom to top of the column
(*d*) the pressure remains constant.

125. Murphree plate efficiency (E_{MV}) is defined as

(*a*) $E_{MV} = \dfrac{y_n - y_{n+1}}{y_n^* - y_{n+1}}$ (*b*) $E_{MV} = \dfrac{y_n - y_{n+1}}{y_n - y_{n+1}^*}$

(*c*) $E_{MV} = \dfrac{x_n - x_{n+1}}{x_n^* - x_{n-1}}$ (*d*) $E_{MV} = \dfrac{y_n - y_{n+1}}{y_n^* - x_{n-1}}$.

126. Overall tray efficiency is

(*a*) the ratio of the number of ideal trays required to the number of real trays required
(*b*) the ratio of the number of real trays required to the number of ideal trays required
(*c*) the ratio of the number of ideal trays required to the number of overall gas transfer units
(*d*) the ratio of the number of overall gas transfer units to the number of ideal trays required.

127. In a perfectly mixed flow model the ratio of the Murphree plate efficiency to point efficiency is

(*a*) $<< 1$ (*b*) 1
(*c*) > 1 (*d*) 0.

128. In a plug flow model the ratio of Murphree tray efficiency to point efficiency is always

(*a*) < 1 (*b*) 1
(*c*) > 1 (*c*) 0.

129. $N_{pe} = 0$ corresponds to

(*a*) plug flow (*b*) laminar flow
(*c*) complete back mixing (*d*) $D_E = 0$
where D_E = eddy diffusivity.

130. $N_{pe} = \infty$ corresponds to

(*a*) complete back mixing (*b*) laminar flow
(*c*) plug flow (*d*) $D_E = \infty$
where D_E = eddy diffusivity.

131. If Murphree plate efficiency and the overall efficiency are equal, the operating and equilibrium lines are

(*a*) straight and parallel (*b*) straight but not parallel
(*c*) curved and parallel (*d*) curved but not parallel.

132. The minimum residence time for the liquid in the downspout of a distillation column is

(*a*) 8 min (*b*) 8 sec
(*c*) 60 sec (*b*) 80 sec.

133. The recommended tray spacing for distillation tower of diameters upto 4 ft is

(*a*) 36 in (*b*) 30 in
(*c*) 5 in (*d*) 18 to 20 in.

134. In the atmospheric distillation tower the pressure drop per tray is about

(*a*) 0·07—0·12 psi (*b*) 0·15—0·20 psi
(*c*) 1—2 mm Hg (*d*) 0·20—0·30 psi.

135. To ensure reasonably uniform distribution of liquid flow on single-pass trays in the distillation column, a weir length used is about

(*a*) 25 to 30 per cent of the tower diameter
(*b*) 60 to 75 per cent of the tower diameter
(*c*) 15 to 20 per cent of the tower diameter
(*d*) 5 to 15 per cent of the tower diameter.

136. The liquid gradient on a tray of distillation tower should be kept to about

(*a*) 2 in (*b*) 3 in
(*c*) 2·5 in (*d*) 0·5 in.

137. Which one of the following tray arrangements is recommended for distillation towers of diameter upto 4 ft ?

(*a*) Cross-flow tray (*b*) Radial flow tray
(*c*) Split flow tray (*d*) Cascade trays.

138. According to Francis formula the rate of liquid flow over a straight rectangular weir is proportional to

(*a*) h (*b*) $h^{2/3}$
(*c*) $h^{3/2}$ (*d*) $h^{1/2}$
where h = liquid crest over weir.

139. At a fixed gas velocity, the gas pressure drop for counterflow of liquid and gas in random packings

(*a*) remains unaffected with change in liquid rate
(*b*) increases with increase in liquid rate
(*c*) decreases with increase in liquid rate
(*d*) decreases linearly with increase in liquid rate.

140. Flooding velocities for regular packings

(*a*) will be considerably greater than for random packing
(*b*) will be considerably smaller than for random packing
(*c*) will be equal to that for random packing.

141. For a given type of tray at flooding, the superficial velocity of gas V_F (cu. ft. gas/sec divided by the net cross section for gas flow, sq. ft.) is related to fluid densities by

(*a*) $V_F = C_F \left(\frac{\rho_L - \rho_G}{\rho_G}\right)^{3/2}$ (*b*) $V_F = C_F \left(\frac{\rho_L - \rho_G}{\rho_L}\right)^{1/2}$

(*c*) $V_F = C_F \left(\frac{\rho_L - \rho_G}{\rho_G}\right)^{1/2}$ (*d*) $V_F = C_F (\rho_G/\rho_L)^{1/2}$

142. For non-foaming mixtures the vapour velocity in a distillation column is in the range

(*a*) 0·6—0·7 times flooding velocity
(*b*) 1·6—1·7 times flooding velocity
(*c*) 0·1—0·2 times flooding velocity
(*d*) 0·2—0·3 times flooding velocity.

143. Separation of a binary mixture of gases by absorption in the liquid solvent depends upon their differences in

(*a*) density (*b*) solubility
(*c*) viscosity (*d*) kinematic viscosity.

144. Which of the following is not desirable characteristic of solvent for gas absorption ?

(*a*) The gas solubility in the solvent should be high

(*b*) The solvent should have very low vapour pressure
(*c*) The solvent should have low viscosity
(*d*) The gas solubility in the solvent should be low.

145. Low viscosity of solvent is preferred for gas absorption because of
(*a*) rapid absorption rates
(*b*) improved flow characteristics
(*c*) low pressure drops on pumping
(*d*) all of the above.

146. For a single component absorber the operating line
(*a*) always lies below the equilibrium-solubility curve
(*b*) always lies above the equilibrium-solubility curve
(*c*) is straight only when plotted in terms of the more fraction units
(*d*) has a negative slope for countercurrent operation

147. For a single component stripper the operating line
(*a*) always lies above the equilibrium-solubility curve
(*b*) always lies below the equilibrium-solubility curve
(*c*) is straight only when plotted in terms of the partial pressure units
(*d*) has a negative slope for countercurrent operation.

148. For a single component absorber the operating line is straight only when plotted in terms of
(*a*) the mole fraction units (*b*) the partial pressure units
(*c*) the mole ratio units (*d*) all of the above

149. For a single component cocurrent absorber the slope of the operating line when plotted in terms of the more ratio units is
(*a*) negative (*b*) zero
(*c*) positive (*d*) infinity.

150. The absorption factor is defined as
(*a*) the ratio of the slope of the equilibrium curve to that of the operating line
(*b*) the product of the slopes of the operating line and the equilibrium curve
(*c*) the ratio of the slope of the operating line to that of the equilibrium curve
(*d*) the reciprocal of the product of the slopes of the operating line and the equilibrium curve.

151. For a fixed degree of absorption from a fixed amount of gas the absorption factor would be
(*a*) equal to unity (*b*) less than unity
(*c*) greater than unity (*d*) equal to or less than unity.

152. The most economical value of absorption factor varies in the range from

(*a*) 0 to 1 (*b*) 1·25 to 2
(*c*) 5 to 10 (*d*) 0 to 2.

153. When of the following is used as solvent for the absorption of H_2S from natural gas ?
(*a*) Sulphuric acid (*b*) Water
(*c*) Liquid sulphur dioxide (*d*) Monoethanol amine.

154. In a single component absorber
(*a*) the liquid phase resistances are small relative to those in the gas phase
(*b*) the gas phase resistances are small relative to those in the liquid phase
(*c*) the gas phase resistances are negligible
(*d*) both the liquid phase resistance and gas phase resistance are nearly equal.

155. The Hatta number plays an important role in problems of
(*a*) gas absorption without chemical reaction
(*b*) gas absorption with chemical reaction
(*c*) multicomponent distillation without chemical reaction
(*d*) solvent extraction.

156. At fixed temperature, the solubility of gases in solvent
(*a*) remains constant with change in pressure
(*b*) decreases with increase in pressure
(*c*) increases with increase in pressure
(*d*) decreases exponentially with increase in pressure.

157. At fixed pressure, the solubility of ammonia in water
(*a*) remains constant with change in temperature
(*b*) increases with increase in temperature
(*c*) decreases with increase in temperature
(*d*) increases linearly with increase in temperature.

158. The total vapour pressure of an ideal solution
(*a*) varies linearly with composition expressed as mole fractions
(*b*) varies exponentially with composition expressed as mole fractions
(*c*) varies inversely with composition expressed as mole fractions
(*d*) is always 760 mm Hg.

159. The solubility of a particular gas in ideal solution in any solvent is
(*a*) always the same (*b*) always the different
(*c*) always zero (*d*) none of the above.

160. For a fixed degree of absorption from a fixed amount of gas, the number of transfer units N_{tOG}

(*a*) remains unaffected with change in solvent rate
(*b*) increases with increase in solvent rate
(*c*) decreases with increase in solvent rate
(*d*) decreases linearly with increase in solvent rate.

161. For absorption of solute gas *A* in solvent *B* with chemical reaction of first-order in *A* and *B* ; the Hatta number is defined as

(*a*) $\dfrac{k_1}{(k_{AB} C_B D_A)^{1/2}}$ (*b*) $\left(\dfrac{k_{AB} C_B D_A}{k_1^2}\right)^2$

(*c*) $\dfrac{(k_{AB} C_B D_A)^{1/2}}{k_1^2}$ (*d*) $\dfrac{(k_{AB} C_B D_A)^{1/2}}{k_1}$.

where k_{AB} = reaction rate constant
k_1 = liquid phase mass transfer coefficient by physical absorption
D_A = diffusion coefficient of *A* in liquid

162. For a fixed degree of gas absorption by a fixed amount of solvent, the number of transfer units N_{tOG}

(*a*) remains constant with change in gas rate
(*b*) decreases with increase in gas rate
(*c*) increases with increase in gas rate
(*d*) decreases exponentially with increase in gas rate.

163. The stripping factor is defined as

(*a*) the product of slopes of the operating line and equilibrium curve
(*b*) the reciprocal of the product of slopes of the operating line and equilibrium curve
(*c*) the ratio of the slope of the operating line to the slope of the equilibrium curve
(*d*) the ratio of the slope of the equilibrium curve to the slope of the operating line.

164. The absorption factor can be increased by

(*a*) increasing both gas flow rate and solvent flow rate
(*b*) decreasing both gas flow rate and solvent flow rate
(*c*) decreasing gas flow rate and increasing solvent flow rate
(*d*) increasing gas flow rate and decreasing solvent flow rate.

165. Which of the following is more economical to separate acetic acid from very dilute solution of acetic acid in water ?

(*a*) Evaporation (*b*) Solvent
(*c*) Atmospheric distillation (*d*) Drying.

166. The distribution coefficient for the system water (A)—chloroform (B)—acetone (C) is

(*a*) 1 (*b*) > 1
(*c*) < 1 (*d*) 0.

167. The solutropic systems are those systems in which

(*a*) the direction of the tie-line slope remains unchanged
(*b*) the direction of the tie-line slope changes and one tie line will be horizontal
(*c*) all tie lines are horizontal
(*d*) all tie lines are vertical.

168. The mutual solubility of two liquids

(*a*) decreases with increase in temperature
(*b*) increases with increase in temperature
(*c*) remains constant with change in temperature
(*d*) decreases linearly with increase in temperature.

169. If the selectivity of the solvent used in liquid-liquid extraction is unity,

(*a*) any degree of separation of solute is possible
(*b*) only little amount of solute may be separated
(*c*) no separation is possible.

170. For all useful liquid-liquid extraction operations the selectivity of solvent must be

(*a*) more than zero (*b*) more than one
(*c*) less than one (*d*) less than or equal to one.

171. For a given degree of separation of feed and given amount of solvent continuous cross-current multistage extraction requires

(*a*) equal stages as the continuous countercurrent multistage extraction
(*b*) more stages than the continuous countercurrent multistage extraction
(*c*) fewer stages than the continuous countercurrent multistage extraction.

172. In liquid-liquid extraction the solvent *B* is used to separate solute *C* from a given solution of *A* and *C*. If *A* and *B* are completely insoluble in one another, the selectivity of *B* will be

(*a*) 0 (*b*) 1
(*c*) ∞ (*d*) > 1.

173. In solvent extraction operation the selectivity of solvent

(*a*) remains unaffected with change in temperature
(*b*) increases with decrease in temperature
(*c*) decreases with decrease in temperature
(*d*) increases linearly with decrease in temperature.

174. Which of the following is undesirable for the solvents for extraction operations ?

(*a*) Solvent should form no azeotrope with extracted solute and the mixture should have high relative volatility
(*b*) Solvent should be chemically stable and inert toward the other component of the system
(*c*) Solvent-rich product and solvent-lean product of solvent extraction should have difference in density
(*d*) Interfacial tension between equilibrium phases in solvent extraction should be zero.

175. For solvent economy in extraction operation the distribution coefficient must be

(*a*) equal to one (*b*) less than one
(*c*) greater than zero (*d*) as large as possible.

176. Select the wrong statement. The selectivity of solvent for extraction operation

(*a*) is analogous to relative volatility for distillation operation
(*b*) must be greater than unity
(*c*) is unity at the plait point
(*d*) must be unity for maximum possible separation with minimum amount of solvent.

177. In crosscurrent liquid-liquid extraction the solvent *B* is used to separate solute *C* from a given solution of *A* and *C*. The liquids *A* and *B* are insoluble. The slope of the operating line for each stage will be

(*a*) zero (*b*) positive
(*c*) infinity (*d*) negative.

178. Operating pressure for solvent extraction operation

(*a*) should be sufficiently high to maintain completely condensed system
(*b*) should be below vapour pressures of all components
(*c*) should be equal to vapour pressure of the most volatile component
(*d*) should be equal to vapour pressure of the least volatile component.

179. A mixture of para and ortho-nitrobenzoic acids can be separated by solvent extraction operation using

(*a*) chloroform as solvent
(*b*) water as solvent
(*c*) both chloroform and water as solvents
(*d*) none of the above.

180. Solvent *B* is used to extract solute *C* from a given feed containing *A* and *C*. If solute *C* is more soluble in *A* than in *B*, the distribution coefficient for *C* will be

(*a*) $>>1$ (*b*) 1
(*c*) < 1 (*d*) > 1.

181. At plait point for a ternary system

(*a*) the selectivity of solvent will be unity
(*b*) the distribution coefficient for solute will be unity
(*c*) the density difference between the two equilibrium phases becomes zero
(*d*) all of the above.

182. In countercurrent liquid-liquid extraction, the maximum concentration of solute in extract layer

(*a*) is that corresponding to equilibrium with the incoming feed
(*b*) is less than the concentration corresponding to equilibrium with the incoming feed
(*c*) can be increased than that obtained in (*a*) above by using raffinate reflux
(*d*) none of the above.

183. In countercurrent liquid-liquid extraction the solvent *B* is used to separate solute *C* from a given solution *A* and *C*. The liquids *A* and *B* are insoluble. The slope of the operating line will be

(*a*) zero (*b*) infinity
(*c*) positive (*d*) negative.

184. The use of reflux at the extract end of a continuous countercurrent extraction plant

(*a*) does not increase the concentration of solute in extract phase
(*b*) increases the concentration of solute in extract phase
(*c*) increases the concentration of solute in raffinate
(*d*) increases the concentration of solute in extract and raffinate both.

185. For a fixed extent of extraction in a continuous liquid-liquid extraction plant, the number of stages required

(*a*) remains constant with change in solvent rate
(*b*) remains constant with change in reflux ratio
(*c*) increases with increase in solvent rate and reflux ratio
(*d*) decreases with increase in solvent rate and reflux ratio.

186. Sugar is leached from surgar beats with

(*a*) cold water (*b*) hot water
(*c*) sulphuric acid (*d*) nitric acid.

187. Vegatable oils are recovered from oil seeds by leaching with

(*a*) hot sulphuric acid (*b*) cold water
(*c*) nitric acid (*d*) hexane.

188. Coffee is prepared from coffee beans by leaching with

(*a*) cold water (*b*) naphtha
(*c*) hot water (*d*) hot sulphuric acid.

189. The rate of extraction in solid-liquid systems

(*a*) is unaffected by temperature
(*b*) increases with increase in temperature
(*c*) decreases with increase in temperature
(*d*) increases linearly with increase in temperature.

190. Increased temperature increases the rate of extraction in solid liquid systems due to

(*a*) increased liquid viscosity and decreased diffusivity
(*b*) increased liquid viscosity and increased diffusivity
(*c*) decreased liquid viscosity and decreased diffusivity
(*d*) decreased liquid viscosity and increased diffusivity.

191. A certain manufacturer of activated charcoal advertises that one pound of their product has 150 acres of surface area for adsorption purposes. How many square meters of surface area are there in one gram of this material ?
(1 acre = 4840 square yards)

(*a*) 1338 (*b*) 34·0
(*c*) 37·2 (*d*) 148·7.

192. Adsorption of acetone vapour on activated carbon is

(*a*) a highly endothermic process
(*b*) an exothermic process
(*c*) a slightly endothermic process
(*d*) none of the above.

193. At a given equilibrium pressure, the concentration of adsorbed gas on adsorbent solid

(*a*) remains constant with change in temperature
(*b*) increases with increased temperature
(*c*) decreases with increased temperature
(*d*) decreases linearly with increased temperature.

194. When hystersis is observed, the adsorption equilibrium pressure

(*a*) is always equal to that obtained by adsorption
(*b*) is always higher than that obtained by adsorption
(*c*) is always lower than that obtained by adsorption
(*d*) may be equal to or higher than that obtained by adsorption.

195. Physical adsorption is

(*a*) due to van der Waal's forces
(*b*) accompanied by a chemical reaction
(*c*) accompanied by adsorption of heat
(*d*) none of the above.

196. Chemisorption is adsorption

(*a*) accompanied by absorption of heat

(*b*) accompanied by a chemical reaction or chemical bonding
(*c*) due to intermolecular forces of attraction between the molecules of the solid and the substance adsorbed

197. What is the pore size of molecular sieves 5 *A*?

(*a*) 5 nm (*b*) 0·5 nm
(*c*) 0·05 nm (*d*) 0·05 m.

198. Molecular sieves are regenerated by heating to temperatures

(*a*) below 100°C (*b*) above 800°C
(*c*) between 200 and 315°C (*d*) below 200°C.

199. Silica gel is

(*a*) produced by pyrolysis of coal
(*b*) an extremely porous form of aluminium oxide
(*c*) an amorphous and extremely porous form of SiO_2
(*d*) normally regenerated by heating to 50—60°C.

200. Which of the following could be used as an adsorbing material for carbon dioxide ?

(*a*) Heated copper oxide (*b*) Activated alumina
(*c*) Heated charcoal (*d*) Cold, solid calcium hydroxide.

201. At a given equilibrium pressure and temperature, the adsorbate concentration on an activated carbon is higher for

(*a*) benzene (*b*) acetone
(*c*) oxygen (*d*) methane.

202. At a given temperature, lowering the quilibrium pressure

(*a*) will reduce the amount of adsorbate upon the adsorbent
(*b*) will increase the amount of adsorbate upon the adsorbent
(*c*) will not affect the amount of adsorbate upon the adsorbent
(*d*) none of the above.

203. Molecular sieves are

(*a*) porous, synthetic zeolite crystals, metal aluminosilicates
(*b*) obtained by the destructive distillation of wood
(*c*) porous form of aluminium oxide
(*d*) porous form of SiO_2.

204. Activated alumina is

(*a*) porous form of aluminium oxide
(*b*) porous form of SiO_2
(*c*) porous, metal aluminosilicates
(*d*) produced by destructive distillation of crushed, dried bones.

205. The relative adsorptivity of paraffin hydrocarbons on carbon

(*a*) remains unaffected with change in pressure and temperature

(*b*) decreases with increased pressure
(*c*) increases with increased pressure
(*d*) increases linearly with increased pressure.

206. Desorption of the adsorbed solute by solvent is called

(*a*) reverse osmosis (*b*) dialysis
(*c*) sublimation (*d*) elution.

207. Bound moisture in a solid is that liquid which exerts an equilibrium vapour pressure

(*a*) equal to that of the pure liquid at the given temperature
(*b*) less than that of the pure liquid at the given temperature
(*c*) greater than that of the pure liquid at the given temperature
(*d*) equal to or less than that of the pure liquid at the given temperature.

208. Unbound moisture in a solid is that liquid which exerts an equilibrium vapour pressure

(*a*) equal to that of the pure liquid at the given temperature
(*b*) greater than that of the pure liquid at the given temperature
(*c*) equal to or less than that of the pure liquid at the given temperature
(*d*) less than that of the pure liquid at the given temperature.

209. Free moisture content

(*a*) is that moisture contained by a substance in excess of the equilibrium moisture
(*b*) is that liquid which is removable at a given temperature and air humidity
(*c*) may include bound and unbound moisture
(*d*) all of the above.

210. All moisture in a non-hygroscopic material is

(*a*) bound moisture (*b*) free moisture
(*c*) unbound moisture (*d*) equilibrium moisture.

211. A wet solid is to be dried from 80 to 10% moisture, wet basis. The moisture to be evaporated, per 1000 kg of dried product is

(*a*) 630 kg (*b*) 3888·89 kg
(*c*) 700 kg (*d*) 3500 kg.

212. Constant rate period is that drying period during which

(*a*) the rate of vaporization per unit of drying surface area is constant
(*b*) the rate of vaporization continually decreases with time
(*c*) the rate of vaporization continually increases with time
(*d*) the moisture content of the substance remains constant.

213. If radiation and conduction through the solid are negligible, the rate of drying during the constant-rate period

(*a*) increases with increase in the mass velocity of gas
(*b*) decreases with increase in the mass velocity of gas
(*c*) remains unaffected with change in the mass velocity of gas
(*d*) increases linearly with increase in the mass velocity of gas for parallel flow.

214. The rate of drying during constant-rate period

(*a*) is unaffected by the air temperature
(*b*) decreases with increase in air temperature
(*c*) increases with increase in air temperature
(*d*) increases linearly with increase in air temperature.

215. The rate of drying during constant-rate period

(*a*) is unaffected by the air humidity
(*b*) increases with increased air humidity
(*c*) decreases with increased air humidity
(*d*) increases linearly with increase in air humidity.

216. Rotary driers are operated with the holdups of material in the range of

(*a*) 0·20 to 0·30 (*b*) 0·6 to 0·75
(*c*) 0·40 to 0·50 (*d*) 0·05 to 0·15.

217. The average retention time (θ) of solid in a rotary drier is given by

(*a*) $\theta = \dfrac{Z\phi_D\rho_s}{L_s}$ (*b*) $\theta = \dfrac{L_s}{Z\phi_D\rho_s}$

(*c*) $\theta = \dfrac{\phi_D\rho_s}{L_s}$ (*d*) $\theta = \dfrac{Z\phi_D}{L_s\rho_s}$

where Z = length of drier, m
ρ_s = apparent solid density, kg/m^3
L_s = rate of flow of dry solids, kg/(s) (m^2 drier cross section)
ϕ_D = hold up of solid.

218. For most purposes, the flights extend from the wall of the rotary drier a distance of

(*a*) 0·25 d to 0·30 d (*b*) 0·40 d to 0·42 d
(*c*) 0·08 d to 0·12 d (*c*) 0·20 d to 0·25 d
where d = diameter of the drier.

219. Higher hold up of the solid in the rotary drier results in

(*a*) increased kiln action
(*b*) poor exposure of the solid to the gas
(*c*) an increase in power required for operating the drier
(*d*) all of the above.

220. For countercurrent flow rotary drier, the slopes are usually in the range

(*a*) 0 to 0·8 ft/ft (*b*) 0 to 1·8 ft/ft

(*c*) 0 to 1 ft/ft (*d*) 0 to 0·08 ft/ft.

221. Rotary driers are most readily built with length/diameter ratios of

(*a*) 1 to 2 (*b*) 4 to 10
(*c*) 15 to 20 (*d*) 1 to 1·5.

222. Rotary driers are most economically designed for the number of heat-transfer units from

(*a*) 0·05 to 0·5 (*b*) 1·5 to 2·5
(*c*) 5·0 to 7·5 (*c*) 10 to 15.

223. For a drum drier,

(*a*) the heat transfer is the controlling factor
(*b*) diffusion is the controlling factor
(*c*) both the heat transfer and diffusion are equally important.
(*d*) none of the above.

224. Cylinder driers are used in

(*a*) detergent industry (*b*) dairy industry
(*c*) pharmaceutical industry (*d*) paper industry.

225. Rotary driers are

(*a*) used to make milk powder
(*b*) used to make synthetic detergent powder
(*c*) suitable for handling free-flowing granular materials
(*d*) suitable for handling sticky materials.

226. Synthetic detergent powder is produced by drying detergent slurry in a

(*a*) spray drier (*b*) cylinder drier
(*c*) freeze drier (*d*) open pan evaporator.

227. Milk powder is made from milk by drying in a

(*a*) drum drier (*b*) rotary drier
(*c*) spouted bed drier (*d*) spray dryer.

228. For the same duty the pressure drop through packed towers

(*a*) may be less than the pressure drop through plate towers
(*b*) may be more than the pressure drop through plate towers
(*c*) will be equal to the pressure drop through plate towers
(*d*) will be equal or more than the pressure drop through plate towers.

229. The rate of leaching depends upon

(*a*) the particle size (*b*) the temperature
(*c*) the agitation (*d*) all of the above.

230. The composition in mole per cent is exactly same as the composition in volumetric per cent for

(*a*) liquid system (*b*) solid system
(*c*) ideal gases (*d*) all of the above

231. Molality is defined as

(*a*) grams of solute per gram of solvent
(*b*) gram moles of solute per gram mole of solvent
(*c*) gram moles of solute per 1000 gram of solvent
(*d*) grams of solute per 1000 gram of solvent.

232. In a solution containing 0·27 kmol of solute and 540 kg of solvent, the molality is

(*a*) 0·27 (*b*) 0·50
(*c*) 0·54 (*d*) 5.

233. Molality is defined as

(*a*) the number of gram moles of solute per litre of solution
(*b*) the number of gram moles of solute per 1000 gram of solvent
(*c*) the number of gram moles of solute per gram mole of solution
(*d*) the number of gram moles of solute per litre of solution.

234. For dilute solution the more fraction of solute is

(*a*) directly proportional to the molality of the solution and the proportionality factor depends only on the molecular weight of the solvent.
(*b*) inversely proportional to the molality of the solution and the proportionality factor depends only on the molecular weight of the solute
(*c*) directly proportional to the molality of the solution and the proportionality factor depends only on the molecular weight of the solute
(*d*) inversely proportional to the molality of the solution and the proportionality factor depends only on the molecular weight of the solvent.

235. The molality of a solution containing n_2 moles of solute and n_1 moles of solvent is

(*a*) n_2 (*b*) $1000\ n_1/n_2$
(*c*) $1000\ n_2/(n_1+n_2)$ (*d*) $1000\ (n_2/n_1\ M_1)$

where M_1 = molecular weight of the solvent.

236. For a very dilute solution containing n_2 moles of solute and n_1 moles of solvent, the mole fraction of the solute is approximately equal to

(*a*) $1-(n_2/n_1)$ (*b*) n_2/n_1
(*c*) $1/n_1$ (*d*) n_2.

237. By adding solute in the solvent

(*a*) the boiling point of solution decreases
(*b*) the freezing point of solution increases

(*c*) the vapour pressure of solution decreases
(*d*) the boiling point of solution remains constant.

238. Gas A diffuses to the surface of a catalyst where it is converted into B according to the chemical reaction $3A \rightarrow B$. The product B diffuses back. The ratio of molar flux of B to A at steady state is ..... .

239. The dimensions for mass diffusivity in fluids are ..... .

240. Mass diffusivity has the same dimensions as ..... viscosity.

241. ..... diffusion in a free stream, away from a phase boundary, is the process by which gases leaving a stack are dispersed into the atmosphere.

242. The isothermal reversible work required for recovery of a pure material from a mixture is roughly proportional to the ..... of the reciprocal of the concentration in the mixture in which the substance is found or produced.

243. A temperature gradient can lead to diffusion of species in a mixture even in the absence of a concentration gradient. This process is known as ..... diffusion.

244. A completely quiescent gas or liquid mixture will develop a ..... gradient in the direction of an imposed temperature gradient.

245. ..... is the diffusion of a small amount of tracer in a mixture of two or more substances.

246. The diffusion coefficient in gases ..... with increase in temperature and ..... with increase in pressure.

247. Peclet number for mass transfer is the product of Reynolds and ..... numbers.

248. Lewis number is the ratio of ..... number to Prandtl number.

249. Sherwood number in mass transfer is analogous to ..... number in heat transfer.

250. At a constant temperature, the gas solubility increases with ..... in pressure.

251. The solubility of any gas is influenced by the temperature, in a manner which is described by ..... law of mobile equilibrium.

252. At a constant pressure, the solubility of ammonia in water decreases with ..... in temperature.

253. At the boiling point of solvent, provided its vapour pressure is less than that of the gas or vapour solute, the gas solubility will be ..... .

254. The total vapour pressure of an ideal solution varies ..... with composition expressed as mole fractions.

255. The solubility of a particular gas in ideal solution in any solvent is the same in terms of ..... for all solvents.

256. The rise in temperature causes a decrease in solute solubility, which in turn results in a ..... minimum L/G and a ..... number of trays than for isothermal absorption.

257. At ambient temperature and pressure, gas-phase diffusion coefficients are of the order of ..... m^2/s.

258. When the solute is very soluble, the ..... film represents the controlling resistance in gas absorption process.

259. For low-solubility gases, the ..... film represents the controlling resistance in gas absorption process.

260. The design of packed towers uses the concepts of height equivalent to a theoretical plate (HETP) and overall gas phase height of a transfer unit (HTU_{OG}). HETP and HTU_{OG} values are equal when the operating and equilibrium lines are ..... and ..... .

261. A purge gas is absorbed in a solvent in which the gas is highly soluble. The controlling resistance is in the ..... film.

262. In an absorber the equilibrium curve lies always ....., the operating line.

263. Kremser-Brown-Souders equation is used to calculate the ..... in a plate tower.

264. In a continuous countercurrent packed absorber operating on very dilute concentrations, the volumetric gas mass transfer coefficient is proportional to $G^{0.83}$ where G is the gas flow rate in moles per unit time per unit empty area. If G is doubled, the ratio of the height of gas transfer unit at the increased gas flow rate to the one at the original gas flow rate is (Assuming the flow rates are below the flooding point) ..... .

265. For a stripper the operating line is always ..... the equilibrium curve.

266. If the equilibrium curve is concave upward, the minimum quantity of liquid to be used for countercurrent absorption corresponds to an exit-liquid concentration in equilibrium with the ..... gas.

267. The reciprocal of absorption factor is called ..... factor.

268. If the operating line and equilibrium curve are straight lines, the ratio of $HETP/HTU_{OG}$ is ..... at unity value of the absorption factor and it increases with ..... in the absorption factor.

269. The key difference in packed and plate columns is that counterflowing vapour and liquid are contacted ..... with packing and ..... with plates.

270. Absorption factor is the ratio of slopes of the operating and equilibrium lines and it is constant when these two lines are ..... .

271. The number of equilvalent theoretical plates for a packed tower is intermediate between ..... and NTU_{OG}.

272. The height equivalent to a theoretical plate is intermediate between ..... and HTU_{OG}.

273. If the operating line and equilibrium curve are straight lines, the ratio of $HETP/HTU_{OG}$ is a function of ..... only.

274. Distillation separates components of a liquid mixture based on their different ..... .

275. The number of theoretical stages required in a fractionating column is the least at ..... reflux.

276. Starting at the minimum reflux ratio, as the reflux ratio is increased for a given separation, the fixed cost of a fractionating column first ..... and then ..... .

277. Fick's second law of diffusion can be rigorously applied for the case of the interdiffusion of ..... .

278. Energy requirements in a binary distillation are minimised when the slopes of the stripping and rectifying operating lines are ..... to the equilibrium curve on a McCabe-Thiele diagram.

279. The q-line's slope is determined by ..... of the feed.

280. The slope of the rectifying operating line is determined by the ..... and it is always ..... unity.

281. When the q-line moves from vertical (saturated liquid feed) to horizontal (saturated vapour feed), the slope of both operating lines can usually be ..... to achieve the same separation with a fixed number of trays.

282. When the q-line moves from vertical (saturated liquid feed) to horizontal (saturated vapour feed), the slope of both operating lines can usually be increased to achieve the same separation with a fixed number of trays. This results in ..... reflux ratio and ..... reboiler boilup.

283. The slope of the stripping operating line is always ..... unity.

284. At the azeotrope liquid composition ..... the vapour composition.

285. For McCabe-Thiele method, the rectifying and stripping operating lines coincide with the diagonal line at ..... reflux.

286. For Ponchon-Savarit method, the rectifying and stripping operating lines are ..... at total reflux.

287. Minium theoretical stages in a binary fractionating column at total reflux may be determined analytically by means of the ..... equation.

288. An infinite number of stages are required at a theoretically ..... reflux ratio.

289. Liquid-liquid extraction separates components of a liquid mixture based on their different ..... .

290. The Residual Oil Solvent Extraction (ROSE) process employs supercritical ..... to recover liquid fuels from heavy oils.

291. The rate of leaching is increased with increased temperature as the viscosity of the liquid is ..... and the diffusivities ..... at higher temperatures.

292. The rate of settling decreases with ..... initial concentration of the solids owing to the ..... of the effective density and viscosity of the medium through which the particles settle.

293. The solid in the form of coarse lumps is leached by ..... .

294. The solid after fine grinding is leached by agitation and ..... .

295. Thickeners are mechanical devices designed especially for continuously ..... the ratio of solid to liquid in a dilute suspension of finely sized particles by settling and decanting, producing a clear liquid and a thickened sludge as two separate products.

296. The concentration of adsorbed gas decreases with ..... temperature at a given equilibrium pressure.

297. Adsorption is an ..... process.

298. Both the differential and integral heat of solution are function of ..... and ..... concentration for any system.

299. Lowering the pressure ..... the amount of adsorbate upon the adsorbent at a given temperature.

300. At the boiling point of a completely immiscible system of two liquids, the partial pressure of one component in the vapour phase is ..... its vapour pressure at that temperature.

301. Clausius-Clapeyron equation relates the slope of the vapour-pressure curve to the ..... of vaporization.

302. Clausius-Clapeyron equation predicts a straight line plot of logarithm of the vapour pressure versus the reciprocal of absolute temperature for the ..... latent heat of vaporization and ..... behaviour of the vapour phase.

303. The latent heat of vaporization ..... with increased temperature. It becomes ..... at the critical point.

304. At the boiling point of liquid at the prevailing total pressure, saturated absolute humidity is ..... .

305. The mass absolute humidity was first introduced by ..... and is sometimes called the ..... humidity.

306. Enthalpy of a vapour-gas mixture may be ..... by increasing the temperature at constant humidity.

307. Enthalpy of a vapour-gas mixture may be ..... by increasing the humidity at constant temperature.

308. Enthalpy of a vapour-gas mixture may be ..... by increasing the temperature and the humidity.

309. Liquid and vapour represented by points on the vapour-pressure curve (vapour pressure versus temperature) are called ..... liquid and ..... vapour, respectively.

310. The latent heat of vaporization is the quantity of heat that must be added in order to transform a substance from the liquid to the vapour state at the same ..... .

311. The latent heat of vaporization decreases as pressure ..... . It becomes zero at the ..... .

312. The following relation between vapour pressure and temperature, $dP/dT = \lambda/T (V_G - V_L)$ where P is vapour pressure, T is absolute temperature, λ is latent heat of vaporization, V_G and V_L are volumes of gas and liquid, respectively, is the ..... equation.

313. Clausius-Clapeyron equation is applicable if the vapour obeys ..... and the volume in the liquid state is ..... .

314. The end points of a vapour-pressure curve (vapour pressure versus temperature) are ..... and critical point.

315. A substance at a temperature above its critical temperature is called a ..... .

316. Heat added or given up with changing temperature is called ..... heat.

317. The boiling temperature corresponding to ..... is known as the normal boiling point.

318. A vapour-gas mixture is unsaturated if the partial pressure of the vapour is ..... the equilibrium vapour pressure of the liquid at the same temperature.

319. Saturated molal absolute humidity depends on the ..... and vapour pressure at the dry-bulb temperature of the vapour-gas mixture.

320. Relative saturation and percentage saturation are not numerically *equal for an ..... vapour-gas mixture.*

321. The volume of an unsaturated vapour-gas mixture is the product of the ..... and the mass of the dry gas in the mixture.

322. The humid volume of an unsaturated vapour-gas mixture increases with ..... in absolute humidity at a given temperature and total pressure.

323. The humid volume may be increased by ..... the temperature at constant humidity.

324. The humid volume may be increased by ..... the humidity at constant temperature.

325. The humid volume may be increased by ..... the temperature and humidity.

326. In convection dryers, the ..... in the inlet gas temperature leads to very high air flows.

327. In the production of albumin from blood plasma by freeze drying, a crude albumin is first produced by the addition of ..... and ..... .

328. The recirculation of large quantities of air ..... the humidity of the air in the drier above that of the fresh air.

329. In direct driers employing the recirculation of large quantities of air, low percentage humidity is obtained by using as high a ..... as possible.

330. Relative humidity is ..... of barometric pressure.

331. Chemical dehumidification is a process whereby the water vapour from the air is absorbed or adsorbed by a ..... .

332. If the chemical dehumidification process of air is one of constant enthalpy, the temperature of the air must ..... .

333. The moisture content of a solid can be reduced to the ..... moisture content for the prevailing air humidity.

334. The critical moisture content, in general increases with ..... drying rate and thickness of solid.

335. The equilibrium moisture content of solid can be reduced by ..... the absolute humidity.

336. Unbound moisture in granular and porous solids moves through the capillaries and the interstices of the solids by a mechanism involving ..... .

337. During the constant-rate period of drying, surface evaporation of ..... occurs.

338. During the constant-rate period of drying, the rate of drying in the absence of radiation and conduction through the solid is proportional to $G^{0.8}$ for ..... of gas, where G is mass flow rate of gas.

339. During the constant-rate period of drying, increasing the air temperature ..... the rate of drying.

340. During the constant-rate period of drying, increased air humidity ..... the rate of drying.

341. If drying occurs from all surfaces of the solid, the time required for

drying between fixed moisture contents within the constant-rate period is ..... to solid thickness.

342. The effects of temperature, humidity and velocity of the gas and thickness of the solid are the ..... for constant-rate drying and unsaturated surface drying.

343. When surface evaporation occurs, there must be movement of ..... from the depths of the solid to the surface.

344. Diffusion of liquid moisture may result because of ..... between the depths of solid, where the concentration is high, and the surface, where it is low.

345. The critical moisture content increases with ..... drying rate and thickness of solid.

346. The drying time between fixed moisture contents within diffusion controlled falling rate should be proportional to the ..... of the solid thickness.

347. Chilton-Colburn analogy connects the ....., ... and ..... transfer processes in a given flow geometry.

Match the items in the left column with the appropriate item in the right column :

348. (*a*) Distillation	(*I*)	Solvent
(*b*) Absorption	(*II*)	Heat
(*c*) Adsorption	(*III*)	Adsorbent
(*d*) Ion exchange	(*IV*)	Resin
349. (*a*) $\frac{\text{Momentum diffusivity}}{\text{Mass diffusivity}}$	(*I*)	Lewis number
(*b*) $\frac{\text{Momentum diffusivity}}{\text{Thermal diffusivity}}$	(*II*)	Schmidt number
(*c*) $\frac{\text{Thermal diffusivity}}{\text{Mass diffusivity}}$	(*III*)	Prandtl number
(*d*) $\frac{\text{Inertial force}}{\text{Viscous force}}$	(*IV*)	Reynolds number
350. (*a*) Direct dryer	(*I*)	Convection from a hot gas
(*b*) Indirect dryer	(*II*)	Conduction from a hot surface
(*c*) Radiant dryer	(*III*)	Radiation from a hot gas
(*d*) Dielectric dryer	(*IV*)	High-frequency electric fields
351. (*a*) Rotary atomizer	(*I*)	Kinetic energy
(*b*) Relative volatility	(*II*)	Centrifugal energy
(*c*) Pneumatic nozzle	(*III*)	Distillation
(*d*) Selectivity	(*IV*)	Liquid-liquid extraction

352. (*a*) $J_{AZ} = -D_{AB}\frac{\partial C_A}{\partial Z}$	(*I*)	Graham's law
(*b*) $\frac{\partial C_A}{\partial t} = \frac{\partial}{\partial z}\left(D_{AB}\frac{\partial C_A}{\partial Z}\right)$	(*II*)	Bosanquet formula
(*c*) $\frac{1}{D_T} = \frac{1}{D_{AB}} + \frac{1}{D_{KA}}$	(*III*)	Fick's first law
(*d*) $N_A/N_B = -(M_B/M_A)^{1/2}$	(*IV*)	Fick's second law
353. (*a*) $\frac{\mu}{\rho D_{AB}}$	(*I*)	Sherwood number
(*b*) $\frac{k_L d}{D_{AB}}$	(*II*)	Grashof number
(*c*) $\frac{gL^3\Delta\rho}{\rho}\left(\frac{\rho}{\mu}\right)$	(*III*)	Schmidt number
(*d*) $\frac{d\bar{V}\rho}{\mu}$	(*IV*)	Reynolds number
354. (*a*) V/(–dP/dz)	(*I*)	Absorption factor
(*b*) L/mG	(*II*)	Molal absolute humidity
(*c*) $\frac{y_n - y_{n+1}}{y_n^* - y_{n+1}}$	(*III*)	Murphree tray efficiency
(*d*) $\frac{p_A}{P_t - p_A}$	(*IV*)	Permeability
355. (*a*) Desalination of sea water	(*I*)	Zone refining
(*b*) Separation of He^3 from its mixture with He^4	(*II*)	Foam separation
(*c*) Separation of detergent from water	(*I*)	Thermal diffusion
(*d*) Ultrapure metals and semiconductors	(*IV*)	Reverse osmosis
356. (*a*) $100\,p_A/P_A^{Sat}$	(*I*)	Psychrometric ratio
(*b*) $100Y/Y_S$	(*II*)	Lewis number
(*c*) h_G/k_Y	(*III*)	Relative saturation
(*d*) N_{SC}/N_{Pr}	(*IV*)	Percentage saturation
357. (*a*) $p_A = x_A P_A^{Sat}$	(*I*)	Rayleigh equation
(*b*) $p_A = H_A x_A$	(*II*)	Fenske equation
(*c*) $\ln\frac{F}{W} = \int_{xW}^{xF}\frac{dx}{y^* - x}$	(*III*)	Raoult's law

(*d*) $N = \dfrac{\ln\left(\dfrac{x_D}{1-x_D}\cdot\dfrac{1-x_W}{x_W}\right)}{\ln \alpha} - 1$ (*IV*) Henry's law

358. (*a*) $\dfrac{y^*(1-y^*)}{x(1-x)}$ (*I*) Reflux ratio

(*b*) L/D (*II*) q

(*c*) $\dfrac{H_v - H_F}{H_v - H_L}$ (*III*) K-value

(*d*) y^*/x (*IV*) Relative volatility

ANSWERS

1. (*a*)	2. (*b*)	3. (*b*)	4. (*d*)	5. (*b*)
6. (*d*)	7. (*b*)	8. (*d*)	9. (*c*)	10. (*b*)
11. (*a*)	12. (*a*)	13. (*a*)	14. (*b*)	15. (*a*)
16. (*d*)	17. (*a*)	18. (*c*)	19. (*c*)	20 (*a*)
21. (*a*)	22. (*c*)	23. (*a*)	24. (*a*)	25. (*b*)
26. (*a*)	27. (*b*)	28. (*b*)	29. (*d*)	30. (*a*)
31. (*d*)	32. (*c*)	33. (*b*)	34. (*a*)	35. (*b*)
36. (*d*)	37. (*a*)	38. (*b*)	39. (*b*)	40. (*a*)
41. (*a*)	42. (*c*)	43. (*d*)	44. (*b*)	45. (*c*)
46. (*b*)	47. (*b*)	48. (*c*)	49. (*b*)	50. (*a*)
51. (*c*)	52. (*a*)	53. (*b*)	54. (*c*)	55. (*a*)
56. (*a*)	57. (*a*)	58. (*d*)	59. (*c*)	60. (*d*)
61. (*c*)	62. (*b*)	63. (*a*)	64. (*c*)	65. (*d*)
66. (*a*)	67. (*c*)	68. (*a*)	69. (*c*)	70. (*d*)
71. (*c*)	72. (*a*)	73. (*d*)	74. (*c*)	75. (*c*)
76. (*a*)	77. (*a*)	78. (*b*)	79. (*b*)	80. (*c*)
81. (*c*)	82. (*b*)	83. (*b*)	84. (*b*)	85. (*c*)
86. (*a*)	87. (*d*)	88. (*d*)	89. (*a*)	90. (*a*)
91. (*b*)	92. (*b*)	93. (*c*)	94. (*b*)	95. (*a*)
96. (*b*)	97. (*a*)	98. (*d*)	99. (*d*)	100. (*d*)
101. (*b*)	102. (*b*)	103. (*b*)	104. (*d*)	105. (*b*)
106. (*c*)	107. (*d*)	108. (*b*)	109. (*c*)	110. (*a*)
111. (*b*)	112. (*b*)	113. (*c*)	114. (*a*)	115. (*b*)
116. (*c*)	117. (*d*)	118. (*b*)	119. (*b*)	120. (*d*)
121. (*a*)	122. (*d*)	123. (*d*)	124. (*a*)	125. (*a*)
126. (*a*)	127. (*b*)	128. (*c*)	129. (*c*)	130. (*c*)
131. (*a*)	132. (*b*)	133. (*d*)	134. (*a*)	135. (*b*)
136. (*d*)	137. (*a*)	138. (*c*)	139. (*b*)	140. (*a*)
141. (*c*)	142. (*a*)	143. (*b*)	144. (*d*)	145. (*d*)
146. (*b*)	147. (*b*)	148. (*c*)	149. (*a*)	150. (*c*)

151. (*c*)	152. (*b*)	153. (*d*)	154. (*a*)	155. (*b*)
156. (*c*)	157. (*c*)	158. (*a*)	159. (*a*)	160. (*c*)
161. (*d*)	162. (*c*)	163. (*d*)	164. (*c*)	165. (*b*)
166. (*b*)	167. (*b*)	168. (*b*)	169. (*c*)	170. (*b*)
171. (*b*)	172. (*c*)	173. (*b*)	174. (*d*)	175. (*d*)
176. (*d*)	177. (*d*)	178. (*a*)	179. (*c*)	180. (*c*)
181. (*d*)	182. (*a*)	183. (*c*)	184. (*b*)	185. (*d*)
186. (*b*)	187. (*d*)	188. (*c*)	189. (*b*)	190. (*d*)
191. (*a*)	192. (*b*)	193. (*c*)	194. (*c*)	195. (*a*)
196. (*b*)	197. (*b*)	198. (*c*)	199. (*c*)	200. (*c*)
201. (*a*)	202. (*a*)	203. (*a*)	204. (*a*)	205. (*b*)
206. (*d*)	207. (*b*)	208. (*a*)	209. (*d*)	210. (*c*)
211. (*d*)	212. (*a*)	213. (*a*)	214. (*c*)	215. (*c*)
216. (*d*)	217. (*a*)	218. (*c*)	219. (*d*)	220. (*d*)
221. (*b*)	222. (*b*)	223. (*a*)	224. (*d*)	225. (*c*)
226. (*a*)	227. (*d*)	228. (*a*)	229. (*d*)	230. (*c*)
231. (*c*)	232. (*b*)	233. (*a*)	234. (*a*)	235. (*d*)
236. (*b*)	237. (*c*)			

238. $-1/3$
239. length^2/time
240. kinematic
241. Eddy
242. logarithm
243. thermal
244. concentration
245. Tracer diffusion
246. increases, decreases
247. Schmidt
248. Schmidt
249. Nusselt
250. increase
251. van't Hoff's
252. increase
253. zero
254. linearly
255. mole fraction
256. larger, larger
257. 10^{-5}–10^{-6}
258. gas
259. liquid
260. straight, parallel
261. gas
262. below
263. number of theoretical stages
264. $2^{0.17}$
265. below
266. entering
267. stripping
268. unity, increase
269. continuously, discretely
270. straight
271. NTU_{OL}
272. HTU_{OL}
273. absorption factor
274. boiling points
275. total
276. decreases, increases
277. ideal solutions
278. closest
279. thermal condition
280. reflux ratio, less than
281. increased
282. increased, reduced
283. greater
284. equals
285. total
286. vertical
287. Fenske

288. minimum
289. solubilities in a solvent
290. pentane
291. lower, larger
292. increased, increase
293. percolation
294. settling
295. increasing
296. increased
297. exothermic
298. temperature, adsorbate
299. reduces
300. equal to
301. latent heat
302. constant, ideal-gas law
303. decreases, zero
304. infinite
305. Grosvenor, Grosvenor
306. increased
307. increased
308. increased
309. saturated, saturated
310. temperature
311. increases, critical point
312. Clapeyron
313. ideal-gas law, negligible
314. triple point
315. gas
316. sensible
317. 1 atm
318. less than
319. total pressure
320. unsaturated
321. humid volume
322. increase
323. increasing
324. increasing
325. increasing
326. reduction
327. alcohol, salts
328. raises
329. temperature
330. independent
331. hygroscopic material
332. decrease
333. equilibrium
334. increased
335. lowering
336. surface tension
337. unbound moisture
338. parallel flow
339. increases
340. decreases
341. directly proportional
342. same
343. moisture
344. concentration gradients
345. increased
346. square
347. mass, heat, momentum

348. (*a*)–(*II*)
(*b*)–(*I*)
(*c*)–(*III*)
(*d*)–(*IV*)

349. (*a*)–(*II*)
(*b*)–(*III*)
(*c*)–(*I*)
(*d*)–(*IV*)

350. (*a*)–(*I*)
(*b*)–(*II*)
(*c*)–(*III*)
(*d*)–(*IV*)

351. (*a*)–(*II*)
(*b*)–(*III*)
(*c*)–(*I*)
(*d*)–(*IV*)

352. (*a*)–(*III*)
(*b*)–(*IV*)
(*c*)–(*II*)
(*d*)–(*I*)

353. (*a*)–(*III*)
(*b*)–(*I*)
(*c*)–(*II*)
(*d*)–(*IV*)

354. (*a*)–(*IV*)
(*b*)–(*I*)
(*c*)–(*III*)
(*d*)–(*II*)

355. (*a*)–(*IV*)
(*b*)–(*III*)
(*c*)–(*II*)
(*d*)–(*I*)

356. (*a*)–(*III*)
(*b*)–(*IV*)
(*c*)–(*I*)
(*d*)–(*II*)

357. (*a*)–(*III*)
(*b*)–(*IV*)
(*c*)–(*I*)
(*d*)–(*II*)

358. (*a*)–(*IV*)
(*b*)–(*I*)
(*c*)–(*II*)
(*d*)–(*III*)

5

Chemical Engineering Thermodynamics

DEFINITIONS

Absorption refrigeration. A process in which water is evaporated under a vacuum maintained by a solution of hygroscopic salt, providing refrigeration in the 40–50°F range.

Absorption refrigerator. A heat operated cooling machine in which the refrigerant is dissolved in an absorbent fluid then separated from the solvent by the heat supplied, condensed and evaporated where the cooling is obtained.

Acentric factor. The acentric factor, ω, is defined as

$$\omega = -1{\cdot}0 - \log\left(P_r^{Sat}\right)_{T_r = 0{\cdot}7}$$

where P_r^{Sat} = reduced vapour pressure, T_r = reduced temperature

Adiabatic process. A process in which there is no transfer of heat to or from the surroundings.

Availability. The maximum work that can be done as an amount of matter is brought to equilibrium with the infinite surroundings.

Brayton cycle. A heat engine cycle in which heat is added and rejected at constant pressure ; commonly used in gas turbine engines.

Carnot cycle. A theoretical heat-engine cycle in which heat is added and rejected at two constant temperatures. No real heat engine, operating between the same upper and lower temperature levels can be as efficient as a Carnot cycle, which is therefore used as standard of comparison.

Carnot engine. A cyclic device that can deliver the maximum amount of work while operating between a given heat source and a heat sink of fixed temperatures.

Closed system. A fixed quantity of matter with given initial values of parameters, such as one kilogram of oxygen in one cubic meter.

Coefficient of performance. (*a*) For a refrigerator, the ratio of the heat entering the evaporator (cooling energy) to the work input (in a mechanical cooler) or the heat input to the generator (in an absorptive cooler). (*b*) For a heat pump, the ratio of the heat leaving the condenser (heating energy) to the work input.

Compressibility factor. The ratio of real gas volume to ideal gas volume.

Compression. The process of raising the pressure of a gas through the application of work (the reverse of expansion).

Critical pressure. The pressure required to liquefy a gas at its critical temperature is termed the critical pressure.

Critical temperature. The temperature at which the molecular kinetic energy of translation equals the maximum potential energy of attraction is termed the critical temperature.

Critical volume. The volume at the critical state is termed critical volume.

Cycle. A process in which a fluid undergoes several changes of state in sequence eventually returning to its initial condition ; also an oscillation in a control loop.

Dalton's law. For an ideal solution it states that the total pressure is the sum of the partial pressures in the phase above the liquid solution.

Ejector. A device that compresses a fluid at lower pressure by a jet of fluid at high pressure ; steam at about 100 psig is commonly used to draw a vacuum by means of an ejector.

Electrical work. Energy transferred between system and surroundings as electrical current driven by a potential difference.

Enthalpy. The sum of the internal energy and the product of pressure and volume of a system in thermodynamic equilibrium.

Entropy. A state property of matter that is a measure of the way in which the internal energy is distributed under equilibrium conditions.

Equation of state. An equation that relates pressure, volume and temperature of a system.

Expansion. The process of reducing the pressure of a gas by extracting work. It is the reverse of compression.

Extensive property. Depends on the quantity of material involved.

Heat. A mode of energy transfer between system and surroundings that occurs as a result of an infinitesimal temperature difference between the two regions.

Heat engine. A device or machine that produces work from heat in a cyclic process.

Heat pump. A device for transferring heat from a low temperature to a high temperature ; by the Second law of thermodynamics, such a device will need to be supplied with work. A refrigerator is a type of heat pump.

Infinite surroundings. The large body of ambient air, water, and the like, at temperature T_O that can be used as an infinite heat reservoir.

Intensive property. Independent of the quantity of material involved.

Internal energy. Energy associated with the motions of molecules, atoms and electrons and the forces acting between molecules, atoms, electrons and nuclei relative to some arbitrary reference condition.

Irreversible process. A process in which there is a net increase in entropy.

Isenthalpic. A process in which there is no change in enthalpy.

Isentropic. A process in which there is no change in entropy.

Isothermal. Occurring at constant temperature.

Joule-Thomson coefficient. The numerical value of the slope of an isenthalpic curve on a T-P diagram at any point is called the Joule-Thomson coefficient, denoted by μ. Thus

$$\mu\,(T,P,y) = \left(\frac{\partial T}{\partial P}\right)_H$$

Laws of thermodynamics

—First law Although energy assumes many forms, the total quantity of energy is constant, and when energy disappears in one form it appears simultaneously in other forms. This law may be written as :

$$\Delta(\text{energy of system}) + \Delta(\text{energy of surroundings}) = 0$$

—Second law No process is possible which consists solely in the transfer of heat from one temperature level to a higher one.

—Third law The absolute entropy is zero for all crystalline substances at absolute zero temperature.

Lost work. A measure of the loss ability to do work. It is equal to $T_0\,\Delta S_{total}$.

Mechanical work. Energy transferred between the system and its surroundings by the effect of a force that acts through a distance.

Nozzle. A device that causes the interchange of internal and kinetic

energies of a fluid as a result of a changing cross-sectional area available for flow.

Open system. A control volume that surrounds the operating unit or collection of operating units under consideration and into and out of which matter can flow.

Operation. An action carried out on material in equipment for the purpose of changing the chemical species ; separating the chemicals or phases ; changing the temperature, pressure, phase, or particle size of solids ; mixing or dividing ; and so forth.

Phase rule. Defined by

$$F = C - P + 2$$

where F is number of degrees of freedom, C is number of individual chemical compounds or chemical substances in the system, and P is number of phases.

Process. A set of changes caused by physical and/or chemical operations that transform starting materials into desired products.

Reversible process. A set of changes that can be undone without net effects on the surroundings. (For a reversible process, the combined change in entropy for the system and the surroundings is zero.)

State. The condition that specifies the values of all properties.

State property. A property that depends only on the state and not on the history of a system. (Internal energy, enthalpy, and entropy are state properties.)

Steam-jet refrigeration. A process in which water is evaporated under a vacuum maintained by a series of steam-jet ejectors, providing refrigeration in the 50–60°F range.

Surroundings. Everything outside the boundaries of system.

System. The matter contained in an operating unit or collection of operating units on which attention is being focused.

Thermal efficiency of heat engine. Defined as the ratio of net work output to heat input.

Throttling. The process of reducing the pressure of a fluid without extracting work. It is isenthalpic and irreversible.

Torr. The pressure equivalent of 1 millimeter of mercury at 0°C in a standard gravitational field and is equal to 133·3 Pa.

Work. An interaction involving the exchange of energy only. When a force is applied on a system, the work is the product of the force and the distance over which its point of application is displaced.

1. The unit of energy is the same as the unit of
   (*a*) power (*b*) work
   (*c*) entropy (*d*) pressure.
2. The unit of power is
   (*a*) W only (*b*) J/s only
   (*c*) J/s and W both (*d*) J.
3. One kWh is equal to
   (*a*) $3{\cdot}6 \times 10^8$ J (*b*) $3{\cdot}6 \times 10^6$ J
   (*c*) $3{\cdot}6 \times 10^7$ J (*d*) $3{\cdot}6 \times 10^5$ J.
4. The unit of energy is
   (*a*) J/s (*b*) J
   (*c*) W (*d*) N.
5. Pascal is the unit of pressure and one pascal is equal to
   (*a*) 1 N/m^2 (*b*) 10^5 N/m^2
   (*c*) 133·32 N/m^2 (*d*) 10^4 N/m^2.
6. Torr is equal to the pressure of
   (*a*) 0·1 mm of Hg at 0°C in a standard gravitational field
   (*b*) 1 mm of Hg at 0°C in a standard gravitational field
   (*c*) 0·01 mm of Hg at 0°C in a standard gravitational field
   (*d*) 0·001 mm of Hg at 0°C in a standard gravitational field.
7. Which of the following is/are thermometric property(ies) ?
   (*a*) Pressure of a gas kept at constant-volume
   (*b*) Volume of a gas kept at constant-pressure
   (*c*) Thermal emf of a thermocouple
   (*d*) All of the above.
8. First law of thermodynamics is based on the
   (*a*) law of conservation of mass
   (*b*) law of conservation of energy
   (*c*) law of equipartion of energy
   (*d*) law of conservation of momentum.
9. For a closed system the correct mathematical expression for the first law of thermodynamics is
   (*a*) $dU = -dQ + dW$ (*b*) $dU = dQ + dW$
   (*c*) $dU = dQ - dW$ (*d*) $dU = Q + W$.
10. The mathematical expression for the first law of thermodynamics for a steady-state flow processes is
    (*a*) $\Delta H = Q + W_s$ (*b*) $\Delta H = Q - W_s$
    (*c*) $\Delta U = Q - W_s$ (*d*) $\Delta U = Q + W_s$

11. A control volume refers to
    (*a*) a fixed region in space (*b*) a definite mass
    (*c*) a closed system (*d*) an isolated system.
12. A system in which there may exchange energy but not mass is known as
    (*a*) open system (*b*) closed system
    (*c*) isolated system (*d*) insulated system.
13. An open system implies
    (*a*) the use of a control volume
    (*b*) no interchange between system and surroundings
    (*c*) the presence of a free surface
    (*d*) that a definite mass of material is considered.
14. A system is called open system if
    (*a*) only the energy crosses the system boundary
    (*b*) both energy and mass cross the system boundary
    (*c*) neither energy nor mass crosses the system boundary
    (*d*) only the mass crosses the system boundary.
15. A system is said to be an isolated system if
    (*a*) only the mass crosses the system boundary
    (*b*) only the energy crosses the system boundary
    (*c*) both energy and mass crosses the system boundary
    (*d*) neither energy nor mass crosses the system boundary.
16. Which of the following is an example of a closed system ?
    (*a*) Scooter engine
    (*b*) Liquid cooling system of an automobile
    (*c*) Boiler in steam power plant
    (*d*) Air compressor.
17. You turn off the water flowing into the tube and open the drain. This is an example of
    (*a*) an open steady-state system
    (*b*) an open unsteady-state system
    (*c*) a closed system
    (*d*) none of the above.
18. Select the wrong statement
    (*a*) Both heat and work cross the boundary of the system
    (*b*) Both heat and work are path functions
    (*c*) Both heat and work are property of the system
    (*d*) Heat flows when the system and surroundings are not in equilibrium which is not necessary for work.

19. In a reversible shaft work process

(*a*) the temperature forces are balanced
(*b*) the pressure forces are balanced
(*c*) the mechanical forces are balanced
(*d*) all the forces are balanced.

20. Intensive properties are the properties whose magnitude

(*a*) depends on the quantity of material involved
(*b*) does not depend on the quantity of material involved
(*c*) depends on the path followed
(*d*) none of the above.

21. Which of the following is an intensive property ?

(*a*) Internal energy (*b*) Enthalpy
(*c*) Density (*d*) Volume.

22. Which of the following is an extensive property ?

(*a*) Temperature (*b*) Pressure
(*c*) Specific volume (*d*) Volume.

23. Select the correct statement

(*a*) Both molecular weight and total weight of a gas are intensive properties
(*b*) Both molecular weight and total weight of a gas are extensive properties
(*c*) Total weight of a gas is an extensive property, molecular weight is an intensive property
(*d*) Total weight of a gas is an intensive property, molecular weight is an extensive property.

24. Which of the following is a state function ?

(*a*) Temperature (*b*) Pressure
(*c*) Specific volume (*d*) Work.

25. The internal energy of a substance

(*a*) decreases with increase in temperature
(*b*) increases with increase in temperature
(*c*) remains unaffected with change in temperature
(*d*) can be calculated by the relation $E = mc^2$.

26. The internal energy of an ideal gas depends on

(*a*) its pressure only (*b*) its volume only
(*c*) its temperature only (*d*) the size of its molecules only.

27. The enthalpy (H) of any system is defined by the mathematical expression

(*a*) $H = U - PV$ (*b*) $H = U + PV$

(*c*) $H = V + PU$ (*d*) $H = U + RT$.

28. The enthalpy of an ideal gas

(*a*) depends on its temperature only
(*b*) depends on its pressure only
(*c*) may decrease while the internal energy increases
(*d*) depends on its volume only.

29. A system receives 13·5 J of heat and at the same time work is transferred to the surroundings. Which of the following amount is possible ?

(*a*) 13·5 J (*b*) 20·0 J
(*c*) 1 J (*d*) 14·5 J.

30. In a certain process the heat flow into a system is 25 Btu. What is the change in internal energy if the work done by the system in the process is 55 Btu ?

(*a*) 30 Btu (*b*) – 80 Btu
(*c*) –30 Btu (*d*) 80 Btu.

31. The phase rule applicable to nonreacting system is

(*a*) $F = 2 + \pi + N$ (*b*) $F = 2 - \pi + N$
(*c*) $F = 2 - \pi - N$ (*d*) $F = 2 + \pi - N$

where π = degrees of freedom
π = number of phases
N = number of chemical species.

32. The minimum number of degrees of freedom for any system is

(*a*) 0 (*b*) 1
(*c*) 2 (*d*) 3.

33. The number of degrees of freedom at the triple point of water is

(*a*) 1 (*b*) 2
(*c*) 3 (*d*) 0.

34. For liquid water in equilibrium with a mixture of water vapour and nitrogen the number of degrees of freedom is

(*a*) 0 (*b*) 1
(*c*) 2 (*d*) 3.

35. For a three phase system in equilibrium made up of three non-reacting chemical species the number of degrees of freedom is

(*a*) 0 (*b*) 1
(*c*) 2 (*d*) 3.

36. The root-mean-square speed (C_{rms}) of molecules of a gas is given by

(*a*) $C_{rms} = \sqrt{\frac{2kT}{m}}$ (*b*) $C_{rms} = \sqrt{\frac{8kT}{\pi m}}$

(*c*) $C_{rms} = \sqrt{\frac{3kT}{m}}$ (*d*) $C_{rms} = \sqrt{\frac{kT}{m}}$.

where k = Boltzmann's constant
m = mass of the molecule.

37. Which of the following statements violates the postulates of the kinetic theory of gases ?

(*a*) Gases consist of a large number of tiny particles
(*b*) All the molecules are in a state of rapid motion
(*c*) The molecules in a gas remain at rest
(*d*) The pressure exerted by the gas results from the impact of the molecules on the walls of the containing vessel.

38. The number of molecules present in 1 g mol of a gas is known as

(*a*) atomic number (*b*) vapour density
(*c*) Avogadro number (*d*) none of the above.

39. Translational kinetic energy of molecules of an ideal gas is

(*a*) directly proportional to its absolute temperature
(*b*) directly proportional to square root of its absolute temperature
(*c*) directly proportional to square of its absolute temperature
(*d*) independent of its temperature.

40. When the temperature of an idealgas is increased from 27°C to 927°C, the kinetic energy will be

(*a*) same (*b*) twice
(*c*) eight times (*d*) four times.

41. The ratio of the root-mean-square-velocity to the average velocity of a gas molecule at a particular temperature is

(*a*) $\sqrt{\frac{3\pi}{8}}$ (*b*) $\sqrt{\frac{8}{3\pi}}$

(*c*) $\frac{3\pi}{8}$ (*d*) $\frac{8}{3\pi}$.

42. Air is

(*a*) a gas
(*b*) a mixture of gases
(*c*) a mixture of gases and vapour
(*d*) a mixture of vapours.

43. A closed vessel contains equal number of O_2 and H_2 molecules at a total pressure of 760 mm of Hg. If O_2 can be removed from the system, the pressure

(*a*) will be 380 mm of Hg

(*b*) will be 1520 mm of Hg
(*c*) will remain unchanged
(*d*) will initially decrease but will soon reach the original value.

44. Imperfect gases are those

(*a*) which contain impurities
(*b*) which do not obey Charle's and Boyle's law
(*c*) whose molecules are not spherical
(*d*) whose molecules cannot be regarded as point masses.

45. For an ideal gas Charle's law deals with the relationship between

(*a*) pressure and volume at constant temperature
(*b*) pressure and temperature at constant volume
(*c*) volume and temperature at constant pressure
(*d*) mass and volume at constant temperature.

46. Boyle's law for an ideal gas deals with the relationship between

(*a*) mass and volume at constant temperature
(*b*) pressure and volume at constant temperature
(*c*) volume and temperature at constant pressure
(*d*) pressure and temperature at constant volume.

47. A gas is termed an ideal gas if it obeys the gas equation $PV = RT$. When do you expect a gas to show deviation from ideality ?

(*a*) At high pressures and low temperatures
(*b*) At low pressures and low temperatures
(*c*) At high pressures and high temperatures
(*d*) At low pressures and high temperatures.

48. Under which of the following conditions is the law $PV = RT$ obeyed most closely by a real gas ?

(*a*) High pressure and high temperature
(*b*) Low pressure and low temperautre
(*c*) High pressure and low temperature
(*d*) Low pressure and high temperature.

49. For an ideal gas, x in the equation $PV = xT$ is a constant which depends upon

(*a*) the number of molecules present only
(*b*) the type of gas only
(*c*) both (*a*) and (*b*)
(*d*) neither (*a*) nor (*b*).

50. Which of the following methods will enable the volume of an ideal gas to be made four times greater ? Use absolute temperature

(*a*) Double the temperature, double the pressure
(*b*) Halve the temperature, double the pressure

(*c*) Quarter the pressure at constant temperature
(*d*) Quarter the temperature at constant pressure.

51. To double the volume of a given mass of an ideal gas at 27°C keeping the pressure constant, one must raise the temperature to

(*a*) 54°C (*b*) 270°C
(*c*) 327°C (*d*) 600°C.

52. The expansion of unit mass of an ideal gas at constant pressure is shown in Fig. 5·1, where

(*a*) *A* is volume, *B* is temperature (°C)
(*b*) *A* is volume, *B* is temperature (K)
(*c*) *A* is temperature (°C), *B* is volume
(*d*) *A* is temperature (K), *B* is volume.

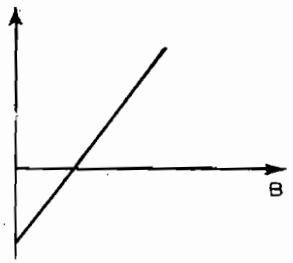


Fig. 5·1.

53. Which one of the following plots for a gas at about room temperature will suggest an absolute zero temperature, if extrapolated suitably ?
(*a*) Pressure against 1/volume (temperature constant)
(*b*) Pressure against volume (temperature constant)
(*c*) Volume against temperature (pressure constant)
(*d*) Volume against 1/pressure (temperature constant)

54. n_1 moles of an ideal monoatomic gas at temperature T_1 and pressure P are in one compartment of an insulated container. In an adjoining compartment, separated by an insulating partition are n_2 moles of another ideal monoatomic gas at temperature T_2 and pressure P. When the partition is removed, the final temperature of the mixture is

(*a*) $\dfrac{n_1 (T_1 + T_2)}{(n_1 + n_2)}$ (*b*) $\dfrac{(T_1 + T_2)}{2}$

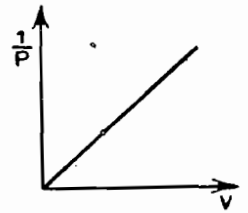
(*c*) $\dfrac{(n_1 T_1 + n_2 T_2)}{(n_1 + n_2)}$ (*d*) $\dfrac{(n_2 T_1 + n_1 T_2)}{(n_1 + n_2)}$

55. The volume of an ideal gas is 100 cm^3 at 100°C. If the pressure is held constant, at what temperature will the gas have a volume of 200 cm^3 ?

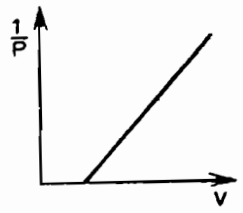
(*a*) 200°C (*b*) 473°C
(*c*) 746°C (*d*) 50°C.

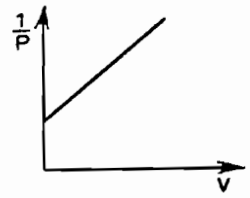
56. The correct graphical representation of a gas obeying Boyle's law with volume (V) along *x*-axis and inverse of pressure (1/*P*) along *y*-axis is

(*a*)



(*b*)





(*c*)

(*d*)

57. The volume (*V*) versus temperature (*T*) graphs for a certain amount of an ideal gas at three pressures P_1, P_2 and P_3 are shown in Fig. 5·2. It follows from the graph that

(*a*) $P_1 = P_2 = P_3$ (*b*) $P_1 > P_2 > P_3$
(*c*) $P_1 < P_2 < P_3$ (*d*) none of the above.

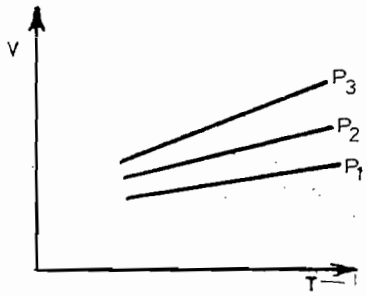


Fig. 5·2.

58. Specific volume of a gas is

(*a*) the reciprocal of its density
(*b*) equal to its density
(*c*) directly proportional to pressure
(*d*) the volume of gas at S.T.P.

59. At absolute zero temperature

(*a*) mass of the gas is zero

(*b*) volume of the gas is zero
(*c*) pressure of the gas is zero
(*d*) all (*a*), (*b*) and (*c*).

60. If the pressure of an ideal gas contained in a closed vessel is increased by 0·4 per cent when heated through 1°C, its initial temperature must be

(*a*) 250 K (*b*) 250°C
(*c*) 2500 K (*d*) 25°C.

61. Which one of the following gases is nearest to an ideal gas ?

(*a*) Helium (*b*) Hydrogen
(*c*) Oxygen (*d*) Nitrogen.

62. A vessel has two compartments *A* and *B* containing H_2 and O_2 respectively both at one atmospheric pressure. If the wall separating the two compartments is removed

(*a*) the pressure will remain unchanged
(*b*) the pressure will increase in *A*
(*c*) the pressure will increase in *B*
(*d*) the pressure will increase both in *A* and *B*.

63. The compressibility factor (Z) of a gas is defined as

(*a*) the ratio of the actual volume of the gas to the volume predicted by ideal-gas law
(*b*) the ratio of the volume predicted by ideal-gas law to the actual volume of the gas
(*c*) the difference between the actual volume of the gas and the volume predicted by ideal-gas law
(*d*) none of the above.

64. The compressibility factor (Z) of an ideal gas is always

(*a*) 0 (*b*) 1
(*c*) > 1 (*d*) < 1.

65. The compressibility factor of any gas

(*a*) is always less than 1
(*b*) is always equal to 1
(*c*) is always greater than 1
(*d*) may be less than, equal to or greater than 1 depending on the nature of the gas.

66. For values of compressibility factor (Z) less than 1 the volume of a real gas

(*a*) is always greater than the volume predicted by ideal-gas law
(*b*) is always less than the volume predicted by ideal-gas law
(*c*) is always equal to the volume predicted by ideal-gas law
(*d*) may be less than, equal to or greater than the volume predicted by ideal-gas law depending on the nature of the gas.

67. Generalized compressibility factor chart is a plot of

(*a*) compressibility factor versus reduced temperature with reduced pressure as parameter
(*b*) compressibility factor versus reduced pressure with reduced temperature as parameter
(*c*) compressibility factor versus pressure with absolute temperature as parameter
(*d*) compressibility factor versus absolute temperature with pressure as parameter.

68. All gases have approximately the same compressibility factor at the same

(*a*) temperature and pressure
(*b*) critical temperature and critical pressure
(*c*) reduced temperature and reduced pressure.

69. A substance above its critical temperature exists as

(*a*) solid (*b*) liquid
(*c*) gas (*d*) saturated vapours.

70. The temperature above which a substance can exists only in its gaseous state and cannot be liquefied regardless of the magnitude of pressure exerted on it, is called

(*a*) boiling point (*b*) saturation temperature
(*c*) critical temperature (*d*) inversion temperature.

71. A gas can be liquefied by pressure alone only when its temperature is

(*a*) higher than its critical temperature
(*b*) equal to or higher than its critical temperature
(*c*) less than or equal to its critical temperature
(*d*) less than its critical temperature.

72. The triple point of water occurs at 0·00602 atm and

(*a*) 0·01°C (*b*) 444·6°C
(*c*) 100°C (*d*) 4°C.

73. At the critical point of a substance

(*a*) $\left(\frac{\partial P}{\partial V}\right)_T = 0, \left(\frac{\partial^2 P}{\partial V^2}\right)_T \neq 0$

(*b*) $\left(\frac{\partial P}{\partial V}\right)_T \neq 0, \left(\frac{\partial^2 P}{\partial V^2}\right)_T = 0$

(*c*) $\left(\frac{\partial P}{\partial V}\right)_T = 0, \left(\frac{\partial^2 P}{\partial V^2}\right)_T = 0$

(*d*) $\left(\frac{\partial P}{\partial V}\right)_T \neq 0, \left(\frac{\partial^2 P}{\partial V^2}\right)_T \neq 0.$

74. The critical coefficient $\left(\frac{RT_c}{P_cV_c}\right)$ for all gases obeying van der Waals equation of state is equal to

(*a*) 3/8 (*b*) 8/3
(*c*) 5/2 (*d*) 3.

75. The critical volume (V_c) for all gases obeying van der Walls equation of state is equal to

(*a*) b (*b*) $2b$
(*c*) $3b$ (*d*) $4b$.

76. At the critical point of a substance

(*a*) there is no distinction between liquid and vapour phases
(*b*) the densities of the liquid and vapour become equal
(*c*) the surface tension vanishes
(*d*) all of these answers.

77. The reduced equation of state of a gas starting from van der Waals equation is

$$(P_r + 3/V_r^2)(3V_r - 1) = 8T_r$$

It is

(*a*) true for ideal gases only
(*b*) true for gases obeying van der Waals equation
(*c*) true for all gases.

78. Specific heat at constant-pressure (C_p) is defined by

(*a*) $\left(\frac{\partial U}{\partial T}\right)_P$ (*b*) $\left(\frac{\partial U}{\partial V}\right)_P$
(*c*) $\left(\frac{\partial H}{\partial T}\right)_P$ (*d*) $\left(\frac{\partial H}{\partial V}\right)_P$

79. Specific heat at constant-volume (C_v) is defined by

(*a*) $\left(\frac{\partial H}{\partial T}\right)_V$ (*b*) $\left(\frac{\partial U}{\partial T}\right)_V$
(*c*) $\left(\frac{\partial H}{\partial P}\right)_V$ (*d*) $\left(\frac{\partial U}{\partial P}\right)_V$

80. The SI unit of C_p is

(*a*) J/kg. K (*b*) J/kg
(*c*) W/kg. K (*d*) J/m^3. K.

81. Which of the following is/are true for a constant-volume system of mass m ?

(*a*) $m\,C_v = \frac{Q}{\Delta T}$ (*b*) $C_v = \frac{1}{n}\left(\frac{\partial Q}{\partial T}\right)_V$

(*c*) $C_v = \frac{1}{n}\left(\frac{\partial U}{\partial T}\right)_V$ (*d*) all of these answers.

where n = number of moles.

82. Specific heat of an ideal gas in a reversible polytropic process is

(*a*) 0 (*b*) ∞
(*c*) $C_v\left(\frac{\gamma - n}{1 - n}\right)$ (*d*) $C_P\left(\frac{\gamma - n}{1 - n}\right)$.

where γ = ratio of specific heats,
n = exponent in the relation, PV^n = constant.

83. If C_p is linear with temperature, C_{pm} in the equation

$$\int_{T_1}^{T_2} C_p\,dT = C_{pm}(T_2 - T_1)$$

is the heat capacity evaluated at

(*a*) the arithmetic mean of T_1 and T_2
(*b*) the geometric mean of T_1 and T_2
(*c*) the harmonic mean of T_1 and T_2
(*d*) the logarithmic mean of T_1 and T_2.

84. If C_p is linear with temperature, C_{pm} in the equation

$$\int_{T_1}^{T_2} C_p \frac{dT}{T} = C_{pm} \ln\left(\frac{T_2}{T_1}\right)$$

is the heat capacity evaluated at

(*a*) the arithmetic mean of T_1 and T_2
(*b*) the logarithmic mean of T_1 and T_2
(*c*) the geometric mean of T_1 and T_2
(*d*) the harmonic mean of T_1 and T_2.

85. The specific heats ratio (γ) for an ideal gas is given by

(*a*) $1 + \frac{R}{C_v}$ (*b*) $\frac{C_p}{C_p - R}$
(*c*) $\frac{C_p}{C_v}$ (*d*) any of these answers.

86. Equation, $C_p - C_v = R$, is

(*a*) true for an ideal gas only
(*b*) true for any real gas
(*c*) true for ideal as well as real gases
(*d*) not true for any gas.

87. The specific heat of saturated water vapour at 100°C is

(*a*) zero (*b*) positive
(*c*) negative (*d*) infinity.

88. The two specific heats at constant pressure and at constant volume are equal at
(*a*) 0°C (*b*) 0 K
(*c*) 0°F (*d*) 0°R.

89. Which of the following statements is correct :
(*a*) C_p can never be less than C_v
(*b*) C_p is always equal to C_v
(*c*) C_p may be less than C_v depending on the gas
(*d*) C_p may be equal to or less than C_v.

90. At the critical temperature and pressure the specific heat of a gas at constant-pressure (C_p)
(*a*) reaches a value of zero
(*b*) reaches a value of infinity
(*c*) is equal to 0·24 kcal/(kmol.K)
(*d*) is equal to 1 kcal/(kmol. K).

91. At low pressure the molal heat capacity of an ideal monoatomic gas at constant-volume is equal to
(*a*) 3 J/(kmol. K) (*b*) 3 kcal/(kmol. K)
(*c*) 0·24 kcal/(kmol. K) (*d*) 1 kcal/(kmol. K).

92. At low pressure the molal heat capacity at constant-pressure (C_p) of an ideal monoatomic gas is equal to
(*a*) 2·24 kcal/(kmol. K) (*b*) 5 J/(kmol. K)
(*c*) 5 kcal/(kmol. K) (*d*) 3 kcal/(kmol. K).

93. For all gases other than monoatomic gases the molal heat capacity at constant-volume is
(*a*) greater than 3 kcal/(kmol. K)
(*b*) less than 3 kcal/(kmol. K)
(*c*) equal to 3 kcal/(kmol. K)
(*d*) less than or equal to 3 kcal/(kmol. K) depending on the gas.

94. Above atmospheric pressure the specific heat of a gas at constant-pressure (C_p)
(*a*) increases with increase in pressure
(*b*) decreases with increase in pressure
(*c*) remains unaffected with change in pressure
(*d*) increases first and then decreases with increase in pressure.

95. For an ideal gas $C_p = 0{\cdot}445$ kcal/(kg. K) and $\gamma = 1{\cdot}33$, the gas constant, in kcal/(kg. K), is

(*a*) 0·147 (*b*) 0·592
(*c*) 0·885 (*d*) 0·110.

96. For an ideal gas $C_v = 0{\cdot}157$ kcal/(kg. K) and $R = 260$ m-N/(kg. K) the specific heats ratio (γ) is
(*a*) 1·333 (*b*) 1·396
(*c*) 2·532 (*d*) 1·653

97. For an ideal monoatomic gas the specific heats ratio is
(*a*) 1·40 (*b*) 1·67
(*c*) 1·33 (*d*) 1.

98. What is the difference in two specific heats C_p and C_v of one gram of helium ? The molecular weight of helium is 4. Assume that helium behaves as an ideal gas.
(*a*) 2 kcal/(kg. K) (*b*) 8 kcal/(kg. K)
(*c*) 1 kcal/(kg. K) (*d*) 0·5 kcal/(kg. K).

99. Which of the following has maximum specific heats ratio :
(*a*) Argon (*b*) Carbon dioxide
(*c*) Oxygen (*d*) Hydrogen.

100. Which of the following has minimum specific heats ratio :
(*a*) Hydrogen (*b*) Nitrogen
(*c*) Mercury vapour (*d*) Sulphur dioxide.

101. Specific heat of a gas for a reversible adiabatic process
(*a*) is zero
(*b*) is infinity
(*c*) is negative
(*d*) varies between zero and infinity.

102. For a real gas obeying van der Waals equation, $C_p - C_v$ is
(*a*) R (*b*) $< R$
(*c*) $> R$ (*d*) zero.

103. The heat capacities for the ideal gas state are
(*a*) functions of temperature only
(*b*) functions of pressure only
(*c*) functions of temperature as well as pressure
(*d*) independent of temperature as well as pressure.

104. For substances which are incompressible, C_p and C_v are related as
(*a*) $C_p \approx C_v$ (*b*) $C_p >> C_v$
(*c*) $C_p << C_v$.

105. Specific heat of acqueous solutions in general
(*a*) increases with increasing concentration

(*b*) decreases with increasing concentration
(*c*) remains unaffected with change in concentration of solute.

106. In absence of experimental values Kopp's rule may be used to calculate the heat capacity of

(*a*) gases only
(*b*) liquids only
(*c*) solids only
(*d*) gases, liquids and solids.

107. According to the law of Petit and Dulong the atomic heat capacities of the crystalline solid elements are nearly constant and equal to

(*a*) 3·2 cal/g atom (*b*) 6·2 cal/g atom
(*c*) 5·2 cal/g atom (*d*) 1·4 cal/g atom.

108. The atomic heat capacities of all solid elements

(*a*) decreases greatly with decrease in temperature
(*b*) increases greatly with decrease in temperature
(*c*) remains unaffected with change in temperature
(*d*) approaches a value of infinity at absolute zero temperature.

109. The amount of heat evolved or absorbed when one mole of any compound is formed from its elements is called

(*a*) heat of transition (*b*) heat of combustion
(*c*) heat of formation (*d*) heat of hydration.

110. The ΔH is constant in a chemical change and independent upon the path and time taken. This is known as

(*a*) Hess law of constant heat summation
(*b*) Lavoisier and Laplace law
(*c*) Vant Hoff's law
(*d*) Gibbs law.

111. Lenz's law is a consequence of the law of conservation of

(*a*) mass (*b*) energy
(*c*) linear momentum (*d*) angular momentum.

112. A reversible process requires that

(*a*) there be no viscous or friction in the system
(*b*) heat transfer occurs from system to surroundings only
(*c*) pressure of the system and surroundings be equal
(*d*) temperature of the system and surroundings be equal.

113. For reversible isobaric process the exponent n in the relation PV^n = constant, has the value of

(*a*) 1 (*b*) 0
(*c*) ∞ (*d*) γ.

where γ = ratio of specific heats.

114. For a reversible isothermal process the exponent n in the relation PV^n = constant, has the value of

(*a*) 0 (*b*) γ
(*c*) 1 (*d*) ∞.

where γ = ratio of specific heats.

115. For an isentropic process the exponent n in the relation PV^n = constant, has the value of

(*a*) 0 (*b*) 1
(*c*) γ (*d*) ∞.

where γ = ratio of specific heats.

116. The relation PV^γ = constant, holds only for those processes which are

(*a*) isentropic (*b*) irreversible adiabatic
(*c*) reversible polytropic (*d*) all of these answers.

117. An isentropic flow is one which is

(*a*) adiabatic and reversible
(*b*) adiabatic and irreversible
(*c*) isothermal and reversible
(*d*) isothermal and irreversible.

118. In reversible adiabatic processes

(*a*) pressure remains constant
(*b*) enthalpy remains constant
(*c*) temperature remains constant
(*d*) heat transfer between system and its surroundings does not occur.

119. In reversible polytropic processes

(*a*) temperature remains constant
(*b*) entropy remains constant
(*c*) enthalpy remains constant
(*d*) heat transfer between system and its surroundings occurs except when the exponent n in the relation PV^n = constant is equal to the ratio of specific heats (γ).

120. Which relation(s) is/are correct for a reversible adiabatic process ?

(*a*) $TV^{\gamma-1}$ = constant (*b*) PV^γ = constant
(*c*) $P^{1-\gamma}T^\gamma$ = constant (*d*) All of these answers.

121. A reversible polytropic process is given by

(*a*) P = constant (*b*) PV = constant
(*c*) PV^γ = constant (*d*) PV^n = constant

where $n \neq \gamma$.

122. Which of the following equations does not apply for a reversible polytropic non-flow process involving an ideal gas ?

(*a*) $dU = dQ - dW$ (*b*) $dW = PdV$
(*c*) $dQ = C_v\,dT$ (*d*) $dH = C_p\,dT$.

123. In a reversible polytropic processes the exponent n in the relation PV^n = constant, has the value

(*a*) $n = 0$ (*b*) $n > \gamma$
(*c*) between 1 and γ (*d*) $n = \gamma$.

124. For a reversible isometric processes the exponent n in the relation PV^n = constant, has the value

(*a*) 0 (*b*) ± 1
(*c*) γ (*d*) $\pm \infty$.

125. In reversible isothermal expansion of an ideal gas

(*a*) $\Delta U = Q$ (*b*) $Q = W$
(*c*) $\Delta U = P\,\Delta\,V$ (*d*) $\Delta U = Q + P\,\Delta\,V$.

126. In a reversible adiabatic expansion

(*a*) heating takes place
(*b*) cooling takes place
(*c*) temperature remains constant
(*d*) pressure remains constant.

127. In a reversible adiabatic compression

(*a*) pressure remains constant
(*b*) temperature remains constant
(*c*) heating takes place
(*d*) cooling takes place.

128. Melting of ice is an example of

(*a*) an isothermal process (*b*) an adiabatic process
(*c*) an isometric process (*d*) none of all above.

129. Propagation of sound waves in air is an example of

(*a*) an isothermal process (*b*) an isometric process
(*c*) an adiabatic process (*d*) none of the above.

130. Compressed air from a container at normal temerpature is allowed to escape suddenly through a hole made in the container. The air inside

(*a*) starts becoming hotter
(*b*) starts becoming cooler
(*c*) remains at the same temperature
(*d*) may become hotter or cooler depending upon the amount of water vapour present.

131. *If a saturated water vapour is compressed adiabatically,*
(a) it remains saturated

(*b*) it becomes supersaturated
(*c*) it becomes superheated.

132. The pressure and density of a diatomic gas ($\gamma = 1{\cdot}4$) change adiabatically from (P, ρ) to (P', ρ'). If $\rho/\rho' = 32$, the ratio P/P' should be equal to

(*a*) 1/128 (*b*) 128
(*c*) 32 (*d*) 1/32.

133. The internal energy of an ideal gas does not change in

(*a*) a reversible isometric process
(*b*) a reversible isobaric process
(*c*) a reversible adiabatic process
(*d*) a reversible isothermal process.

134. The enthalpy change for an ideal gas in an isentropic process is given by

(*a*) $\Delta H = C_p T_1 \left[\left(\frac{P_2}{P_1} \right)^{(\gamma-1)/\gamma} - 1 \right]$

(*b*) $\Delta H = C_p T_1 \left[\left(\frac{P_2}{P_1} \right)^{\gamma-1} - 1 \right]$

(*c*) $\Delta H = C_p T_1 \left[\left(\frac{P_2}{P_1} \right)^{1/\gamma} - 1 \right]$

(*d*) $\Delta H = C_p T_1 \left[\left(\frac{P_2}{P_1} \right)^{\gamma/(\gamma-1)} - 1 \right]$.

135. What is the change in the internal energy when 5 gm of air are heated from 0°C to 2°C ? The specific heat at constant volume is 0·172 cal/(gm °C)

(*a*) 0·172 cal (*b*) 1·72 cal
(*c*) 17·2 cal (*d*) 0.

136. At constant temperature the internal energy of a real gas

(*a*) decreases as the volume increases
(*b*) increases as the volume increases
(*c*) is independent of its volume
(*d*) may decrease or increase with increase in volume depending on the nature of gas.

137. For a gas whose equation of state is $PV = RT + aP$, where a is positive constant, $(\partial U/\partial V)_T$ is equal to

(a) P (b) 0
(c) aP (d) $(a-1)P$.

138. A gas obeys the equation $P(V-b)=RT$, where b is a positive constant, and has a constant C_v. Which of the following relations holds for a reversible adiabatic process involving this gas ?

(a) PV^γ = constant (b) PV^b = constant
(c) $P(V-b)^\gamma$ = constant (d) $P(V^\gamma-b^\gamma)$ = constant.

139. A gas obeys the equation $P(V-b)=RT$, where b is a positive constant, and has a constant C_v. The internal energy of this gas

(a) depends on its temperature only
(b) depends on its pressure only
(c) depends on its volume only
(d) depends on its temperature, pressure and volume.

140. The work done in non-flow reversible processes is given by

(a) $-\int V\,dP$ (b) $\int P\,dV$
(c) $\int V\,dP$ (d) none of the above.

141. The work done in steady flow processes is given by

(a) $-\int P\,dV$ (b) $\int P\,dV$
(c) $-\int V\,dP$ (d) none of the above.

142. Which non-flow reversible compression process requires maximum work ?

(a) Isothermal process (b) Isobaric process
(c) Adiabatic process.

143. Which non-flow reversible expansion process produces maximum work ?

(a) Adiabatic process (b) Isobaric process
(c) Isothermal process.

144. The work done in reversible polytropic steady flow processes is given by

(a) $\dfrac{P_1V_1-P_2V_2}{(n-1)}$ (b) $\dfrac{n(P_1V_1-P_2V_2)}{(n-1)}$
(c) $n(P_1V_1-P_2V_2)$ (d) $\dfrac{n(P_1V_1-P_2V_2)}{(n+1)}$

145. The work done in a reversible polytropic non-flow processes is given by

(a) $\dfrac{n(P_1V_1-P_2V_2)}{(n-1)}$ (b) $\dfrac{n(P_1V_1-P_2V_2)}{n+1}$
(c) $\dfrac{(P_1V_1-P_2V_2)}{(n+1)}$ (d) $\dfrac{n(P_1V_1-P_2V_2)}{(n-1)}$

146. The expression for the work done for a reversible polytropic process can be used to obtain the expression for work done for all processes except

(a) reversible adiabatic process
(b) reversible isothermal process
(c) reversible isometric process
(d) reversible isobaric process.

147. In a reversible non-flow isothermal expansion of an ideal gas from an initial conditions P_1, V_1 to a final conditions P_2, V_2, the work done by the gas is given by

(a) $W = RT\ln\dfrac{P_2}{P_1}$ (b) $W = RT\ln\dfrac{V_2}{V_1}$
(c) $W = RT\ln\dfrac{P_2V_2}{P_2V_1}$ (d) none of these answer.

148. How much work is done by 1 mol of a gas during a reversible non-flow isothermal expansion from an initial volume V_1 to a final volume V_2 when the equation of state is $P(V-b)=RT$, b is a positive constant ?

(a) $W = RT\ln\dfrac{V_2}{V_1}$ (b) $W = RT\ln(V_2-V_1)$
(c) $W = RT\ln\dfrac{V_1-b}{V_2-b}$ (d) $W = RT\ln\dfrac{V_2-b}{V_1-b}$.

149. One mole of a gas undergoes a reversible non-flow change from state 1 to state 2. If the process can be represented by a straight line on a P-V diagram, the work done is given by

(a) $W = \frac{1}{2}(P_2-P_1)(V_2-V_1)$ (b) $W = (P_2+P_1)(V_1-V_1)$
(c) $W = \frac{1}{2}(P_2+P_1)(V_2-V_1)$ (d) $W = \frac{1}{2}(P_2+P_1)(V_2+V_1)$.

150. For a gas at a low peressure the compressibility factor (Z) is given by

$$Z = 1 + B'P,\ B' = \text{constant}$$

The work required (W) for a reversible non-flow isothermal compression from initial pressure P_1 to final pressure P_2 is

(a) $W = RT\ln(P_1/P_2)$ (b) $W < RT\ln(P_1/P_2)$
(c) $W > RT\ln\left(\dfrac{P_1}{P_2}\right)$ (d) $W > RT\ln\left(\dfrac{1+B'P_1}{1+B'P_2}\right)$.

151. The mathematical representation of the second law of thermodynamics is

(*a*) $dU = dQ - dW$ (*b*) $dQ = TdS$
(*c*) $W = TdS$ (*d*) $dS = TdQ$.

152. Select the only false statement in the following :

(*a*) The entire amount of heat produced can be converted into mechanical work.
(*b*) The entire amount of mechanical work can be converted into heat.
(*c*) Heat engine is a device which converts heat into mechanical work.
(*d*) The efficiency of a reversible engine is independent of nature and properties of working substance.

153. Select the correct relation for the slopes of an isothermal and adiabatic curves through a point on a *P-V* diagram of an ideal gas

(*a*) Slope of an isothermal curve = slope of an adiabatic curve
(*b*) Slope of an isothermal curve = γ (slope of an adiabatic curve)
(*c*) Slope of an adiabatic curve = γ (slope of an isothermal curve)
(*d*) Slope of an adiabatic curve = $\left(\frac{\gamma}{\gamma-1}\right)$ (slope of an isothermal curve).

154. Under what condition an isothermal curve will coincide with an adiabatic curve through a point on a *P-V* diagram of an ideal gas ?

(*a*) $C_p > C_v$ (*b*) $C_p = C_v$
(*b*) $C_p < C_v$ (*d*) $C_p \geq C_v$

155. Select the correct statement(s) for isothermal and adiabatic curves on a *P-V* diagram of an ideal gas.

(*a*) An isothermal curve cannot intersect a given adiabatic curve twice.
(*b*) Two adiabatic curves can never intersect each other.
(*c*) All the adiabatic curves will be parallel to each other.
(*d*) All of the above.

156. Two different adiabatic paths for an ideal gas intersect two isothermal paths at T_1 and T_2 as shown in Fig. 5·3. How does the ratio V_a/V_d compare with the ratio V_b/V_c ?

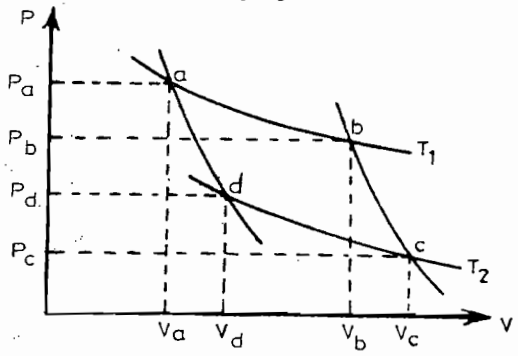


Fig. 5·3.

(*a*) $\frac{V_a}{V_d} = \frac{V_b}{V_c}$ (*b*) $\frac{V_a}{V_d} > \frac{V_b}{V_c}$
(*c*) $\frac{V_a}{V_d} < \frac{V_b}{V_c}$ (*d*) $\frac{V_a}{V_d} >> \frac{V_b}{V_c}$

157. In Problem 156, the ratio P_b/P_a is

(*a*) equal to the ratio P_c/P_d
(*b*) greater than the ratio P_c/P_d
(*c*) less than the ratio P_c/P_d
(*d*) much greater than the ratio P_c/P_d.

158. An ideal monoatomic gas is taken round the cycle *ABCDA* as shown in Fig. 5·4. The work done during the cycle is

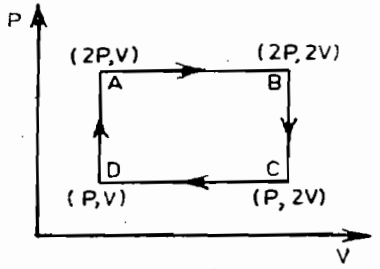


Fig. 5·4.

(*a*) 4 PV (*b*) 3 PV
(*c*) PV (*d*) 0.

159. The maximum possible efficiency of a Carnot reversible cycle working between absolute temperature T_1 and T_2 is given by

(*a*) T_2/T_1 (*b*) $1-(T_2/T_1)$
(*c*) $1-(T_1/T_2)$ (*d*) $(T_1-T_2)/T_2$.

where T_1 = absolute temperature at which heat is supplied
T_2 = absolute temperature at which heat is rejected.

160. In a Carnot engine if the temperature of the sink is decreased then the efficiency of the engine

(*a*) increases (*b*) decreases
(*c*) remains constant.

161. Two reversible heat engines are operating between absolute temperatures T_1, T_2 and T_3 as shown in Fig. 5·5. If the thermal efficiency of two engines are same, the temperature T_2 must be

(*a*) arithmetic mean of T_1 and T_3
(*b*) geometric mean of T_1 and T_3
(*c*) harmonic mean of T_1 and T_3
(*d*) logarithmic mean of T_1 and T_3.

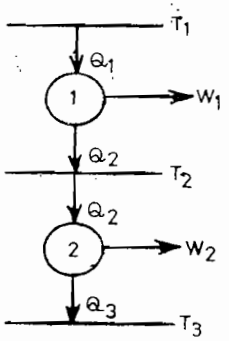


Fig. 5·5.

162. Two reversible heat engines are operating between absolute temperatures T_1, T_2 and T_3 as shown in Fig. 5·5. If the work done per cycle by the two engine are same, the temperature T_2 must be

(*a*) the arithmetic mean of T_1 and T_3
(*b*) the geometric mean of T_1 and T_3
(*c*) the harmonic mean of T_1 and T_3
(*d*) the logarithmic mean of T_1 and T_3.

163. Entropy of a substance is that quantity which remains constant during

(*a*) a reversible isothermal change
(*b*) a reversible adiabatic change
(*c*) an irreversible adiabatic change
(*d*) an irreversible isothermal change.

164. Entropy, for reversible flow, is defined by the expression

(*a*) $dS = dQ/T$ (*b*) $dS = TdQ$
(*c*) $dS = TdU + RT$ (*d*) $dS = dU + PdV$.

165. In any reversible cycle, the net change in entropy is always

(*a*) zero (*b*) infinity
(*c*) positive (*d*) negative.

166. Entropy of a substance has the units of

(*a*) J (*b*) J/K
(*b*) J/(kg. K) (*d*) J/kg.

167. In an irreversible process, the entropy of the system as a whole

(*a*) decreases (*b*) remains constant
(*c*) increases.

168. Entropy of the universe (system and surroundings combined) tends to a

(*a*) zero (*b*) minimum
(*c*) maximum.

169. In an irreversible flow d (losses) which is defined as d (losses) $= TdS - dQ$ is

(*a*) zero (*b*) negative
(*c*) positive (*d*) equal to C_pT.

170. In a reversible flow d (losses) which is defined as d (losses) $= TdS - dQ$ is

(*a*) zero (*b*) positive
(*c*) equal to C_pT (*d*) negative

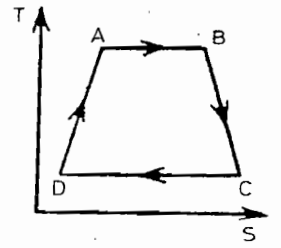
171. In an irreversible process lost work (W_{lost}) is given by

(*a*) $W_{lost} = \dfrac{\Delta S_{total}}{T_0}$ (*b*) $W_{lost} = T_0\, \Delta S_{total}$
(*c*) $W_{lost} = \Delta S_{total}$ (*d*) $W_{lost} = 0$.

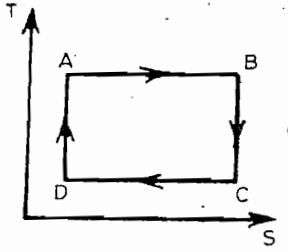
where T_0 = absolute temperature of the surroundings.

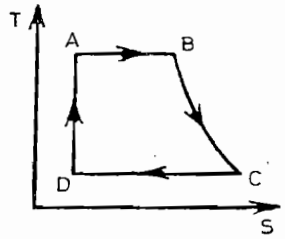
172. Which would be the correct T-S diagram for the Carnot cycle (T is the absolute temperature and S the entropy) ?

(*a*)

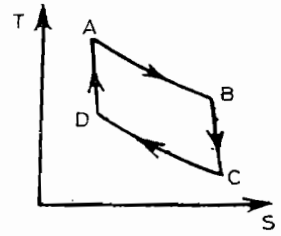


(*b*)





(*c*)



(*d*)

173. A Carnot cycle plotted on T-S axis is shown in Fig. 5·6. The area $ABCD$ represents

(*a*) the net change in entropy
(*b*) the available energy
(*c*) the unavailable energy
(*d*) the heat taken in from a source at temperature T_1.

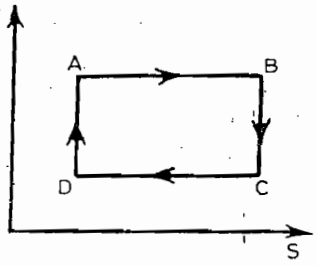


Fig. 5·6.

174. In all real (Irreversible) processes the available energy of an isolated system

(*a*) increases (*b*) decreases
(*c*) remains constant.

175. The temperature of an ideal gas with constant heat capacity is changed from T_1 to T_2 by

(*i*) a constant-pressure process
(*ii*) a constant-volume process.
The change in entropy of the gas is

(*a*) same in both processes
(*b*) greater in process (*i*)
(*c*) greater in process (*ii*)

176. The entropy change for an ideal gas could be given by

(*a*) $\Delta S = C_v \ln\left[\left(\frac{T_2}{T_1}\right)\left(\frac{V_2}{V_1}\right)^{\gamma-1}\right]$

(*b*) $\Delta S = C_v \ln\left[\left(\frac{P_2}{P_1}\right)\left(\frac{V_2}{V_1}\right)^{\gamma}\right]$

(*c*) $\Delta S = C_v \ln\left[\left(\frac{T_2}{T_1}\right)^{\gamma}\left(\frac{P_2}{P_1}\right)^{1-\gamma}\right]$

(*d*) any of these answers.

177. The change in entropy when a liquid of mass m(kg) and specific heat s (J/kg. K) is heated from a temperature $T_1(K)$ to $T_2(K)$ is given by

(*a*) $ms\ (T_2 - T_1)$ (*b*) $ms \log_{10}(T_2/T_1)$

(*c*) $ms \dfrac{(T_2 - T_1)}{\ln (T_2/T_1)}$ (*d*) $ms \ln (T_2/T_1)$.

178. In a reversible isothermal process an ideal gas expands to four times its initial volume. The change in entropy is

(*a*) $R \log_{10} 4$ (*b*) $R \ln 4$
(*c*) $C_v \log_{10} 4$ (*d*) $C_v \ln 4$.

179. An insulated container partitioned into two equal volumes, contains Avogadro's number N_0 of molecules of an ideal gas in one section and no molecules in the other. When the partition is withdrawn, the molecules quickly distributed themselves uniformly throughout the total volume. This process is an adibatic, free expansion that accomplishes no work. The entropy change is

(*a*) $C_v \ln 2$ (*b*) $C_v \log_{10} 2$
(*c*) $R \ln 2$ (*d*) zero.

180. In a perfectly reversible Carnot engine a quantity of heat Q_1 is taken in from a hot body at temperature T_1, a quantity of heat Q_2 is given up to a cold body at temperature T_2, the available energy is given by

(*a*) $Q_2\ (1-T_2/T_1)$ (*b*) $Q_1\ (1-T_1/T_2)$
(*c*) $Q_1\ (1-T_2/T_1)$ (*d*) $Q_2\ (1-T_1/T_2)$.

181. Entropy of an ideal gas is

(*a*) a function of temperature only
(*b*) a function of pressure only
(*c*) a function of temperature as well as pressure
(*d*) independent of temperaure and pressure.

182. The ratio of isothermal compressibility to adiabatic compressibility is always

(*a*) 1 (*b*) > 1
(*c*) < 1 (*d*) << 1.

183. Which of the following partial derivatives is/are not a constant for an ideal gas ?

(*a*) $\left(\frac{\partial P}{\partial V}\right)_T$ (*b*) $\left(\frac{\partial P}{\partial T}\right)_V$

(*c*) $\left(\frac{\partial V}{\partial T}\right)_P$ (*d*) All of the above.

184. The volume expansivity (β) is defined as

$$\beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$$

For the incompressible fluid, β

(*a*) is zero (*b*) is infinity
(*c*) is one (*d*) varies between zero and infinity.

185. At absolute zero temperature the volume expansivity (β) tends to

(*a*) one (*b*) infinity
(*c*) zero (*d*) minus infinity.

186. For an ideal gas the difference between isothermal compressibility and adiabatic compressibility is

(*a*) zero (*b*) positive
(*c*) negative.

187. The difference in two specific heats is given by

$$C_p - C_v = T\left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial P}{\partial T}\right)_V$$

For a gas obeying the relation $P(V-b) = RT$, where b is a positive constant, C_p–C_v is

(*a*) equal to R (*b*) greater than R
(*c*) less than R (*d*) equal to zero.

188. Select the correct relation for an ideal gas,

(*a*) $\left(\frac{dT}{dS}\right)_V = \left(\frac{dT}{dS}\right)_P$ (*b*) $\left(\frac{dT}{dS}\right)_V > \left(\frac{dT}{dS}\right)_P$

(*c*) $\left(\frac{dT}{dS}\right)_V < \left(\frac{dT}{dS}\right)_P$ (*d*) $\left(\frac{dT}{dS}\right)_V \ll \left(\frac{dT}{dS}\right)_P$

189. The two specific heats (C_p and C_v) are equal when $(\partial V/\partial T)_P$ is

(*a*) 0 (*b*) ∞
(*c*) R/P (*d*) P/R.

190. For an ideal gas $(\partial S/\partial P)_T$ is

(*a*) 0 (*b*) ∞
(*c*) R/P (*d*) $-R/P$.

191. Gibbs free energy (G^t) is defined as

(*a*) $G^t = U^t - TS^t$ (*b*) $G^t = H^t - TS^t$
(*c*) $G^t = U^t + TS^t$ (*d*) $G^t = H^t + TS^t$

Where superscript t signifies for the entire mass of the system.

192. Helmholtz free energy (A^t) is defined as

(*a*) $A^t = U^t - TS^t$ (*b*) $A^t = U^t + TS^t$
(*c*) $A^t = H^t - TS^t$ (*d*) $A^t = H^t + TS^t$

Where superscript t signifies for the entire mass of the system.

193. For an ideal gas $(\partial A^t/\partial T)_P$ is given by

(*a*) $R - S^t$ (*b*) $-S^t - R$
(*c*) $R + S^t$ (*d*) R.

194. The necessary and sufficient condition for the exact differentiality of the expression of the type

$$dz = M(x, y)\,dx + N(x, y)\,dy \text{ is}$$

(*a*) $\left(\frac{\partial M}{\partial x}\right)_y = \left(\frac{\partial N}{\partial y}\right)_x$ (*b*) $\left(\frac{\partial M}{\partial y}\right)_x = \left(\frac{\partial N}{\partial x}\right)_y$

(*c*) $\left(\frac{\partial^2 M}{\partial x^2}\right)_y = \left(\frac{\partial^2 N}{\partial y^2}\right)_x$ (*d*) $\left(\frac{\partial^2 M}{\partial y^2}\right)_x = \left(\frac{\partial^2 N}{\partial x^2}\right)_y$

195. Which of the following is a perfect (exact) differential ?

(*a*) dQ (*b*) dW
(*c*) $\frac{dQ}{T}$ (*d*) TdQ.

196. The reversible work for compression in steady state flow process under isothermal condition is

(*a*) the change in Gibbs free energy
(*b*) the change in Helmholtz free energy
(*c*) the change in enthalpy
(*d*) the change in internal energy.

197. The reversible work for compression in non-flow process under isothermal condition is

(*a*) the change in internal energy
(*b*) the change in enthalpy
(*c*) the change in Helmholtz free energy
(*d*) the change in Gibbs free energy.

198. The change in entropy of an ideal gas during a reversible isothermal expansion is

(*a*) zero (*b*) positive
(*c*) negative (*d*) infinity.

199. Which of the following charts is known as Mollier chart ?

(*a*) Pressure-enthalpy chart (*b*) Enthalpy-entropy chart
(*c*) Temperature-entropy chart (*d*) Pressure-volume chart.

200. On a Mollier chart the slope of the curve representing a reversible isothermal process is equal to

(*a*) $T - \frac{1}{\beta}$ (*b*) T
(*c*) $T - \beta$ (*d*) $T + \frac{1}{\beta}$.

201. On a Mollier chart the slope of the curve representing a reversible isobaric process is equal to

(*a*) $T - \beta$ (*b*) $T + \frac{1}{\beta}$
(*c*) T (*d*) $\beta T - 1$.

202. Which of the following is a function of temperature as well as pressure for an incompressible fluid ?

(*a*) Entropy (*b*) Internal energy
(*c*) Enthalpy (*d*) All of the above.

203. The temperature at which a real gas obeys the ideal gas law over a wide range of pressure is called

(*a*) critical temperature (*b*) inversion temperature
(*c*) reduced temperature (*d*) Boyle temperature.

204. For a single-phase fluid the equation $dU^t = TdS^t - PdV^t$, where superscript t signifies for the entire mass of the system, is

(*a*) applicable to an open system only
(*b*) applicable to a closed system only
(*c*) applicable to both open and closed systems
(*d*) not applicable to any system.

205. The internal energy of an incompressible fluid

(*a*) depends on pressure only
(*b*) depends on temperature only
(*c*) depends on temperature as well as pressure
(*d*) is independent of temperature as well as pressure.

206. A liquid is compressed reversibly and isothermally. Heat will flow out of the liquid if its volume expansivity is

(*a*) zero (*b*) positive
(*c*) negative (*d*) infinity.

207. A substance is compressed reversibly and adiabatically. The substance is heated if the volume expansivity is

(*a*) zero (*b*) negative
(*c*) positive (*d*) infinity.

208. Which of the following shows a heating effect when stretched reversibly and adiabatically ?

(*a*) Rubber string (*b*) Copper wire
(*c*) Nickel wire (*d*) Aluminium wire.

209. Which of the following has negative coefficient of linear expansion ?

(*a*) Copper (*b*) Aluminium
(*c*) Nickel (*d*) Rubber.

210. The residual property $\Delta M'$ is given by the equation

$$\Delta M' = M' - M$$

where the M's represent molar values for any extensive thermodynamic property and the prime designates the ideal-gas state. When pressure tends to zero at constant temperature, $\Delta M'$ is not zero for

(*a*) $\Delta M' \equiv \Delta V'$ (*b*) $\Delta M' \equiv \Delta H'$
(*c*) $\Delta M' \equiv \Delta S'$ (*d*) all of the above.

211. Which of the following does not change during a phase change such as melting, vaporization, or sublimation ?

(*a*) Specific internal energy (*b*) Specific enthalpy
(*c*) Specific entropy (*d*) Specific Gibbs free energy.

212. Select the correct statement.

(*a*) The logarithm of the vapour pressure of a material is approximately linear in the absolute temperature.
(*b*) The logarithm of the vapour pressure of a material is approximately linear in the reciprocal of absolute temperature
(*c*) The vapour pressure of a material is approximately linear in the reciprocal of absolute temperature
(*d*) The vapour pressure of a material is approximately linear in the absolute temperature.

213. Clausius-Clapeyron equation is applicable in

(*a*) melting processes only (*b*) vaporization processes only
(*c*) sublimation processes only (*d*) all of the above.

214. Which of the following changes during the phase transition ?

(*a*) Temperature (*b*) Pressure
(*c*) Volume (*d*) all of the above.

215. When liquids boils, there is an increase in the

(*a*) specific entropy (*b*) specific Gibbs free energy
(*c*) vapour pressure (*d*) all of the above.

216. The boiling point of every liquid

(*a*) increases with increase in pressure
(*b*) decreases with increase in pressure
(*c*) decreases linearly with increase in temperature
(*d*) remains unaffected with change in pressure.

217. The melting point of wax

(*a*) remains unaffected with change in pressure
(*b*) decreases with increase in pressure
(*c*) decreases linearly with increase in pressure
(*d*) increases with increase in pressure.

218. The melting point of ice

(*a*) remains unaffected with change in pressure
(*b*) decreases with increase in pressure
(*c*) increases with increase in pressure
(*d*) increases linearly with increase in pressure.

219. The freezing point of a liquid decreases when the pressure is increased if the liquid

(*a*) expands while freezing
(*b*) contracts while freezing

(*c*) does not change in volume while freezing
(*d*) none of the above.

220. When water is heated from 2°C to 4°C
(*a*) it expands
(*b*) it contracts
(*c*) its volume remains the same.

221. For most inorganic compounds the ratio λ_f/T_f varies
(*a*) from 2 to 3 (*b*) from 5 to 7
(*c*) from 9 to 11 (*d*) from 12 to 15.
where λ_f = heat of fusion, cal/g mol
T_f = melting point, K.

222. For a number of substances Trouton's ratio (λ_b/T_b) is
(*a*) 5 (*b*) 21
(*c*) 12 (*d*) 120.
where λ_b = molal heat of vaporization of a substance at its normal boiling point, cal/g mol
T_b = normal boiling point, K.

223. Kistyakowsky equation is used for calculation of Trouton's ratio of
(*a*) polar liquids only
(*b*) non-polar liquids only
(*c*) both polar as well as non-polar liquids.

224. The acentric factor (ω) of a material is defined as
(*a*) $\omega = -\log_{10} (P_r^{Sat})_{Tr=0.7} - 1$
(*b*) $\omega = -\ln (P_r^{Sat})_{Tr=0.7} - 1$
(*c*) $\omega = -\ln (P_r^{Sat})_{Tr=1} - 1$
(*d*) $\omega = -\log_{10} (P_r^{Sat})_{Tr=1} - 1$
where P_r^{Sat} = reduced vapour pressure
T_r = reduced temperature.

225. The accentric factor (ω) of all materials is always
(*a*) 0 (*b*) 1
(*c*) < 1 (*d*) > 1.

226. The vapour pressure P^{Sat} of a given liquid is represented by an equation of the form $\ln P^{Sat} = A - B/T$, where A and B are constants and T is absolute temperature. For this material ΔS^{vap} is equal to

(*a*) $\Delta V^{vap} (B/T^2)$ (*b*) $\Delta V^{vap} \left(\frac{B \ln P^{Sat}}{T^2}\right)$

(*c*) $\Delta V^{vap} \left(\frac{B P^{Sat}}{T^2}\right)$ (*d*) $\Delta V^{vap} \left(\frac{B P^{Sat}}{T}\right)$

where the superscript vap designates vaporization.

227. Fugacity has the units of
(*a*) temperature (*b*) pressure
(*c*) concentration (*d*) energy.

228. For an ideal gas the fugacity is equal to
(*a*) its pressure (*b*) zero
(*c*) infinity (*d*) 1 atm.

229. As the pressure tends to zero at constant temperature, Gibbs free energy of a pure fluid approaches
(*a*) zero (*b*) infinity
(*c*) minus infinity (*d*) none of the above.

230. In a mixture of ideal gases, the fugacity of component *i* is equal to
(*a*) the pressure of gas mixture
(*b*) the partial pressure of component *i* in the gas mixture
(*c*) zero
(*d*) 1 atm.

231. The fugacity coefficient is defined as the ratio of the fugacity of a material to its
(*a*) pressure (*b*) temperature
(*c*) volume (*d*) Gibbs free energy.

232. For an ideal gas the fugacity coefficient is always
(*a*) zero (*b*) one
(*c*) infinity (*d*) greater than one.

233. For a real gas the fugacity coefficient is always
(*a*) equal to one (*b*) less than one
(*c*) greater than one (*d*) less than zero.

234. If Henry's law is valid for component 1 in a binary system, then the Lewis-Randall rule must hold for
(*a*) component 1 in the same composition range
(*b*) component 2 in the same composition range
(*c*) both components 1 and 2 in the same composition range
(*d*) none of the above.

235. Which of the following has dimensions ?
(*a*) Fugacity coefficient (*b*) Activity coefficient
(*c*) Fugacity (*d*) Activity.

236. For a gas whose PVT behaviour is given by

$$Z = 1 + \frac{BP}{RT}, B = \text{constant}$$

the fugacity coefficient is

(c) $\frac{2\hat{a}_A\,\hat{a}_B}{3\hat{a}_C}$ (d) $\frac{3\hat{a}_{C^3}}{2\hat{a}_{A^2}\,\hat{a}_B}$

where a = activity of a component in the mixture.

264. For the reaction

$$H_2(g) + I_2(g) = 2HI(g)$$

the equilibrium constant changes with

(a) total pressure
(b) catalyst
(c) the amount of H_2 and I_2 present
(d) temperature.

265. For multicomponent multiple phases at the same temperature and pressure to be in equilibrium

(a) the fugacity of each component must be the same in all phases
(b) the chemical potential of each component must be the same in all phases.
(c) both (a) and (b)
(d) neither (a) nor (b).

266. For the reaction

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

the equilibrium conversion depends on the

(a) temperature (b) pressure
(c) steam-to-ethylene ratio (d) all of the above.

267. For the hydrogenation of acetylene to ethylene at a given temperature and pressure the required reaction is obtained by adding the following two reactions

$$C_2H_2 \rightarrow 2C + H_2 \quad ...(1)$$
$$2C + 2H_2 \rightarrow C_2H_4 \quad ...(2)$$

If K_1 and K_2 are the equilibirum constants for the reactions (1) and (2) respectively, the equilibrium constant for the hydrogenation of acetylene to ethylene is

(a) K_1/K_2 (b) K_2/K_1
(c) $K_1 + K_2$ (d) K_1K_2.

268. For system of two miscible non-reacting species in vapour-liquid equilibrium, forming an azeotrope, the number of degrees of freedom is

(a) 0 (b) 1
(c) 2 (d) 3.

269. For a system prepared by partially decomposing $CaCO_3$ into an evacuated space, the number of degrees of freedom is

(a) 0 (b) 1
(c) 2 (d) 3.

270. In a chemically reactive mixture of $ZnO(s)$, $ZnSO_4(s)$, $SO_2(g)$, and $O_2(g)$ the two solid phases are completely immiscible. The number of degrees of freedom for the system is

(a) 0 (b) 1
(c) 2 (d) 3.

271. Throttling process is

(a) a reversible and constant entropy process
(b) a reversible and constant enthalpy process
(c) an irreversible and constant enthalpy process
(d) a reversible and isothermal process.

272. The Joule-Thomson coefficient (η) at any point is defined as

(a) $\eta = \left(\frac{\partial P}{\partial T}\right)_H$ (b) $\eta = \left(\frac{\partial T}{\partial P}\right)_H$

(c) $\eta = \left(\frac{\partial T}{\partial V}\right)_H$ (d) $\eta = \left(\frac{\partial T}{\partial S}\right)_H$

273. The Joule-Thomson coefficient (η) for an ideal gas is

(a) zero (b) positive
(c) negative (d) infinity.

274. If cooling is to occur after throttling process, the Joule-Thomson coefficient (η) should be

(a) zero (b) positive
(c) negative (d) infinity.

275. The Joule-Thomson coefficient (η) is

(a) a function of temperature only
(b) a function of pressure only
(c) a function of both temperature and pressure
(d) independent of both temperature and pressure.

276. During throttling process at atmospheric temperature and pressure all gases show a cooling effect except

(a) nitrogen (b) hydrogen
(c) oxygen (d) carbon dioxide.

277. Assuming that the Joule-Thomson coefficient (η) is given by

$$\eta = \frac{1}{C_p}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$$

The Joule-Thomson coefficient (η) of the gas obeying the relation $P(V-b) = RT$, where b is a positive constant, is

(*a*) zero (*b*) positive
(*c*) negative (*d*) infinity.

278. At any point on the inversion curve the Joule-Thomson coefficient (η) is

(*a*) zero (*b*) infinity
(*c*) positive (*d*) negative.

279. In a throttling process

(*a*) the inversion temperature is same for all gases
(*b*) the inversion temperature is different for different gases
(*c*) there may be more than one inversion temperature for a gas
(*d*) the inversion temperature is the temperature at which $\eta = \infty$.

280. Every gas above its inversion temperature in a throttling process would show

(*a*) a cooling effect
(*b*) a heating effect
(*c*) no change in temperature.

281. At the inversion point of a gas in a throttling process

(*a*) $\left(\frac{\partial T}{\partial P}\right)_H = 0$ (*b*) $\left(\frac{\partial H}{\partial P}\right)_T = 0$

(*c*) $\left(\frac{\partial Z}{\partial T}\right)_P = 0$ (*d*) all of these answers.

282. A nozzle is a device which

(*a*) reduces kinetic energy and increases pressure
(*b*) increases kinetic energy and decreases pressure
(*c*) increases kinetic energy as well as pressure
(*d*) reduces kinetic energy as well as pressure.

283. Turbine is a device in which the fluid expands almost

(*a*) isothermally (*b*) isobarically
(*c*) adiabatically.

284. The critical pressure ratio for the flow of gases through a converging nozzle is given by

(*a*) $\left(\frac{2}{\gamma+1}\right)^{\gamma/(\gamma-1)}$ (*b*) $\left(\frac{1}{\gamma+1}\right)^{\gamma/(\gamma-1)}$

(*c*) $\left(\frac{2\gamma}{\gamma+1}\right)^{\gamma/(\gamma-1)}$ (*d*) $\left(\frac{2}{\gamma-1}\right)^{\gamma/(\gamma-1)}$

285. The critical pressure ratio for the flow of saturated steam through a converging nozzle is

(*a*) 1 (*b*) > 1
(*c*) < 1 (*d*) >> 1.

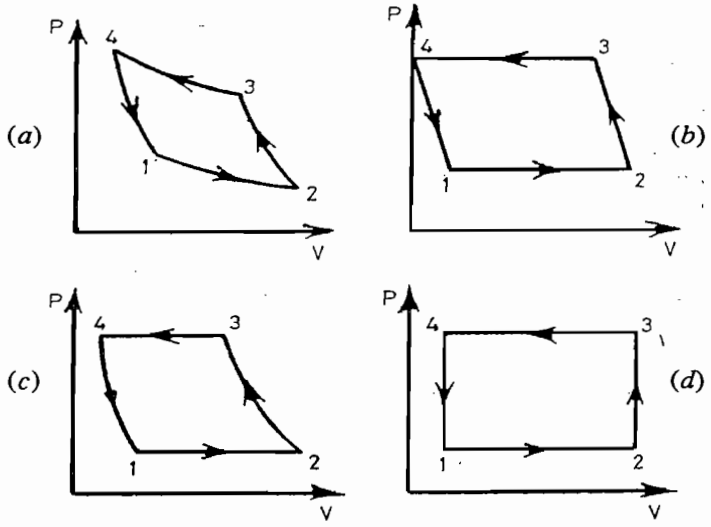
286. Which of the following gases has maximum critical pressure ratio for the flow through a converging nozzle :

(*a*) Argon (*b*) Oxygen
(*c*) Steam (*d*) Nitrogen.

287. Which of the following gases has minimum critical pressure ratio for the flow through a converging nozzle :

(*a*) Sulphur dioxide (*b*) Carbon dioxide
(*c*) Argon (*d*) Air.

288. Which would be correct P-V diagram for a single-stage reciprocating compressor cycle ?



289. The efficiency of the Otto engine

(*a*) increases with increase in compression ratio
(*b*) decreases with increase in compression ratio
(*c*) remains constant with change in compression ratio
(*d*) increases linearly with increase in compression ratio.

290. For a given compression ratio

(*a*) the Otto engine has a lower efficiency than the Diesel engine
(*b*) the Otto engine has a higher efficiency than the Diesel engine
(*c*) the efficiencies of both the Otto and Diesel engines are same.

(*b*) cooling by throttling
(*c*) cooling by expansion in an engine.

317. The equation $E = h\nu$ is known as

(*a*) De Broglie equation
(*b*) Einstein's relativity equation
(*c*) Planck's law.

318. Planck's constant h in the relation $E = h\nu$ has the units

(*a*) J (*b*) J-S
(*c*) J/S (*d*) J/kmol.

319. Select the correct statement.

(*a*) Energy of ground level is always zero
(*b*) Molecules of gases possess translational energy only
(*c*) A system of particles can have infinite number of energy levels
(*d*) The spacing of energy levels must be uniform.

320. Energy of the ground level is zero for

(*a*) translational mode (*b*) rotational mode
(*c*) vibrational mode (*d*) all of the above.

321. The distribution of energy levels can be assumed as continuum

(*a*) for translational mode only
(*b*) for rotational mode only
(*c*) for vibrational mode only.
(*d*) for translational and rotational modes.

322. The degeneracy of jth rotational energy level is

(*a*) 1 (*b*) j
(*c*) $2j + 1$ (*d*) $2(j + 1)$.

323. The N_i particles in the ith energy level can interact in

(*a*) $N_i\,!$ ways (*b*) $\dfrac{N_i\,!}{2\,!\,(N_i - 2)\,!}$ ways

(*c*) $\dfrac{N_i\,!}{3\,!\,(N_i - 3)\,!}$ ways (*d*) $\dfrac{N_i\,!}{(N_i - 2)\,!}$ ways.

324. The N_i particles from the ith energy level and N_j particles from jth energy level can interact in

(*a*) $N_i\,!\,N_j\,!$ ways (*b*) $(N_i\,N_j)\,!$ ways
(*c*) $N_i\,N_j$ ways (*d*) $(N_i - 1)(N_j - 1)$ ways.

325. As the number of particles increase, the ratio of the thermodynamic probability of most probable macrostate to the total thermodynamic probability

(*a*) remains constant
(*b*) goes on increasing
(*c*) goes on decreasing.

326. For very large N, Stirling's approximate formula for $\ln N\,!$ is

(*a*) $\ln N\,! = N \ln N$ (*b*) $\ln N\,! = N \ln N + N$
(*c*) $\ln N\,! = N \ln N - N$ (*d*) $\ln N\,! = \ln N + N$.

327. Lagrangian constant in the distribution law of particles in various energy level is

(*a*) directly proportional to absolute temperature
(*b*) inversely proportional to absolute temperature
(*c*) inversely proportional to square root of absolute temperature
(*d*) directly proportional to square root of absolute temperature.

328. Partition function (Z) is defined as

(*a*) $Z = \sum_i g_i e^{-\varepsilon_i}$ (*b*) $Z = \sum_i e^{-\beta\varepsilon_i}$

(*c*) $Z = \sum_i g_i e^{-\beta\varepsilon_i}$ (*d*) $Z = \sum_i g_i e^{\beta\varepsilon_i}$

where g_i = degeneracy of ith energy level
ε_i = energy associated with each particle in the ith energy
β = Langrangian constant in the distribution law.

329. For a given chemical species translational partition function

(*a*) depends on the temperature of the system only
(*b*) depends on the volume of the system only
(*c*) depends on the temperature as well as volume of the system
(*d*) is independent of the temperature and volume of the system.

330. Entropy of a system (S) is related to the thermodynamic probability of most probable macrostate (W_{mp}) as

(*a*) $S = ke^{-W_{mp}}$ (*b*) $S = k \ln W_{mp}$
(*c*) $S = -k \ln W_{mp}$ (*d*) $S = ke^{W_{mp}}$
where k = Boltzmann constant.

331. Entropy of a system is

(*a*) a measure of disorder of the system
(*b*) a measure of orderly behaviour of the system
(*c*) independent of temperature
(*d*) independent of pressure.

332. 'Entropy of a perfect crystalline substance is zero at absolute zero temperature'. This is known as

(*a*) second law of thermodynamics
(*b*) third law of thermodynamics
(*c*) zeroth law of thermodynamics
(*d*) first law of thermodynamics.

333. An equation relating pressure, volume and temperature of a gas is called

(*a*) Gibbs-Duhem equation
(*b*) ideal gas equation
(*c*) equation of state
(*d*) Maxwell's equation.

334. The point at which all three (solid, liquid and gas) phases co-exist is known as

(*a*) eutectic point (*b*) triple point
(*c*) critical point (*d*) ice point.

335. Refrigerator works on the principle of

(*a*) zeroth law of thermodynamics
(*b*) first law of thermodynamics
(*c*) second law of thermodynamics
(*d*) third law of thermodynamics.

336. A gas absorbs 100 calories of heat energy and is compressed from 10 to 5 litres by applying an external pressure of 2 atm. The change in internal energy for the gas is

(*a*) 110 cal (*b*) 342 cal
(*c*) 242 cal (*d*) 684 cal.

337. Gage pressures can be converted to absolute pressure by addition of ..... pressure.

338. For closed systems all energy passing across the boundary between the system and its surroundings is transferred as heat and ..... .

339. In thermodynamic sense, heat and work refer to energy in transit across the boundary between the system and its ..... .

340. Heat and work are forms of energy that can never be ..... .

341. Energy is stored in its potential, kinetic and ..... forms.

342. Closed system does not permit the transfer of ..... between the system and its surroundings.

343. Temperature, pressure and specific volume are ..... functions.

344. Work and heat are ..... functions.

345. Internal energy of a system is an ..... property.

346. Temperature is an ..... property.

347. Phase-rule variables are ..... properties.

348. According to the phase rule, a ..... system consisting of a single species is univariant.

349. The maximum number of phases which can coexist at equilibrium for a system containing N chemical species is ..... .

350. A process is reversible when its direction can be reversed at any point by an ..... change in external conditions.

351. A ..... process is frictionless.

352. For a mechanically reversible, constant volume, nonflow process, the heat transferred is equal to the change in ..... of the system.

353. For a mechanically reversible, constant pressure nonflow process, the heat transferred is equal to the change in ..... of the system.

354. Specific heats at constant pressure and constant volume are ..... functions.

355. State functions are ..... of path.

356. For a real gas at its critical point, $(\partial P/\partial V)_T$ and $(\partial^2 P/\partial V^2)_T$ are .....

357. The logarithm of the vapour pressure of a pure fluid is approximately linear in the ..... of the absolute temperature.

358. The acentric value of argon is ..... .

359. Enthalpy of a substance is independent of pressure. This is exactly true for ..... gases.

360. Internal energy of a substance is independent of volume. This is exactly true for ..... gases and ..... fluids.

361. A combustion reaction is defined as a reaction between an element or compound and ..... to form specified combustion products.

362. Heat and work are the two forms of energy. They differ in ..... .

363. Heat is a form of energy intrinsically less useful and hence less valuable than an equal quantity of work or ..... or ..... energy.

364. It is ..... by a cyclic process to convert the heat absorbed by a system completely into work.

365. Heat engine is a device or machine that produces work from heat in a ..... process.

366. Steam power plant is an example of ..... engine.

367. All heat-engine cycles consist of the absorption of heat at a ..... temperature, the rejection of heat at a ..... temperature and the production of work.

368. Any reversible engine operating between two heat reservoirs is a ..... engine.

369. For two given heat reservoirs no engine can have a ..... thermal efficiency than a Carnot engine.

370. All Carnot engines operating between heat reservoirs at the same two temperatures have the ..... thermal efficiency.

371. Thermal efficiency of a Carnot engine depends only on the temperatures of heat reservoirs. It does not depend upon the ..... of the engine.

446. (*a*) $\left[\frac{\partial nG}{\partial n_i}\right]_{T,P,nj}$ (*I*) Compressibility factor

(*b*) f/P (*II*) Activity coefficient

(*c*) PV/RT (*III*) Chemical potential

(*d*) $y_iP/x_iP_i^{Sat}$ (*IV*) Fugacity coefficient

447. (*a*) $y_iP = x_iP_i^{Sat}$ (*I*) Gibbs-Duhem equation

(*b*) $\ln\left(P^{\text{Sat}}\right) = A - \frac{B}{T+C}$ (*II*) Raoult's law

(*c*) $\hat{f}_i^{id} = x_i f_i$ (*III*) Antoine equation

(*d*) $\sum_{i=1}^{2} x_i\left[\frac{d\ln\gamma_i}{dx_i}\right]_{T,P} = 0$ (*IV*) Lewis/Randall rule

448. (*a*) Steam (*I*) Air-standard Otto cycle

(*b*) Combustion products of hydrocarbons (*II*) Thermal power plant

(*c*) Liquid oxygen (*III*) Solid fuel rocket

(*d*) Ammonium perchlorate (*IV*) Liquid fuel rocket engine

449. (*a*) Rankine cycle (*I*) Internal combustion engine

(*b*) Brayton cycle (*II*) Steam thermal power plant

(*c*) Air-standard Otto cycle (*III*) Gas turbine power plant

(*d*) Carnot cycle (*IV*) Carnot heat engine

450. (*a*) $\eta = 1-T_C/T_H$ (*I*) Air-standard Otto cycle

(*b*) $\eta = 1-(1/r)^{\gamma-1}$ (*II*) Carnot heat engine

(*c*) $\eta = 1-\frac{1}{\gamma}\left[\frac{\left(\frac{1}{r_e}\right)^{\gamma}-\left(\frac{1}{r}\right)^{\gamma}}{\left(\frac{1}{r_e}\right)\left(\frac{1}{r}\right)}\right]$ (*III*) Brayton cycle

(*d*) $\eta = 1-(P_A/P_B)^{(\gamma-1)/\gamma}$ (*IV*) Air-standard Diesel cycle

451. (*a*) $(\partial U/\partial T)_v$ (*I*) Volume expansivity

(*b*) $(\partial H/\partial T)_P$ (*II*) Isothermal compressibility

(*c*) $(\partial V/\partial T)_P/V$ (*III*) Heat capacity at constant volume

(*d*) $-(\partial V/\partial P)_T/V$ (*IV*) Heat capacity at constant pressure

452. (*a*) $U + PV$ (*I*) Helmholtz energy

(*b*) U-TS (*II*) Gibbs energy

(*c*) H-TS (*III*) Universal gas constant

(*d*) C_P–C_v (*IV*) Enthalpy

453. (*a*) $(\partial S/\partial V)_T = (\partial P/\partial T)_V$ (*I*) Bernoulli's equation

(*b*) $\frac{dP^{\text{Sat}}}{dT} = \frac{\lambda}{T(V_G - V_L)}$ (*II*) Maxwell's equation

(*c*) $\frac{\Delta P}{\rho} + \frac{\Delta u^2}{2} + g\Delta z = 0$ (*III*) Clapeyron equation

(*d*) $\eta = 1-\frac{T_C}{T_H}$ (*IV*) Carnot's equation

454. (*a*) $\Delta H = Q$–W_S (*I*) van der Waals equation

(*b*) $P = \frac{RT}{v-b}-\frac{a}{v^2}$ (*II*) Stirling's formula

(*c*) $\ln N\,! = N\ln N$–N (*III*) First law for a steady-state flow process

(*d*) $F = C$–$P + 2$ (*IV*) Phase rule for nonreacting system

455. (*a*) $\log P = A\,[1-(B/T)]$ (*I*) Duhring rule

(*b*) $T_A = kT_B + C$ (*II*) Cox equation

(*c*) $\log P = A - \frac{B}{T+C}$ (*III*) van der Waals equation

(*d*) $z = \frac{v}{v-b}-\frac{a}{RTv}$ (*IV*) Antoine equation

ANSWERS

1. (*b*)	2. (*c*)	3. (*b*)	4. (*b*)	5. (*a*)
6. (*b*)	7. (*d*)	8. (*b*)	9. (*c*)	10. (*b*)
11. (*a*)	12. (*b*)	13. (*a*)	14. (*b*)	15. (*d*)
16. (*b*)	17. (*b*)	18. (*c*)	19. (*b*)	20 (*b*)
21. (*c*)	22. (*d*)	23. (*c*)	24. (*d*)	25. (*b*)
26. (*c*)	27. (*b*)	28. (*a*)	29. (*c*)	30. (*c*)
31. (*b*)	32. (*a*)	33. (*d*)	34. (*c*)	35. (*c*)
36. (*c*)	37. (*c*)	38. (*c*)	39. (*a*)	40. (*d*)
41. (*a*)	42. (*b*)	43. (*a*)	44. (*b*)	45. (*c*)
46. (*b*)	47. (*a*)	48. (*d*)	49. (*a*)	50. (*c*)
51. (*c*)	52. (*c*)	53. (*c*)	54. (*c*)	55. (*b*)
56. (*b*)	57. (*b*)	58. (*a*)	59. (*b*)	60. (*a*)
61. (*a*)	62. (*a*)	63. (*a*)	64. (*b*)	65. (*d*)
66. (*b*)	67. (*b*)	68. (*c*)	69. (*c*)	70. (*c*)
71. (*c*)	72. (*a*)	73. (*c*)	74. (*b*)	75. (*c*)
76. (*d*)	77. (*c*)	78. (*c*)	79. (*b*)	80. (*a*)
81. (*d*)	82. (*c*)	83. (*a*)	84. (*b*)	85. (*d*)
86. (*a*)	87. (*c*)	88. (*b*)	89. (*a*)	90. (*b*)

91. (*b*)	92. (*c*)	93. (*a*)	94. (*a*)	95. (*d*)
96. (*b*)	97. (*b*)	98. (*d*)	99. (*b*)	100. (*c*)
101. (*a*)	102. (*c*)	103. (*a*)	104. (*a*)	105. (*b*)
106. (*c*)	107. (*b*)	108. (*a*)	109. (*c*)	110. (*a*)
111. (*b*)	112. (*a*)	113. (*b*)	114. (*c*)	115. (*c*)
116. (*a*)	117. (*a*)	118. (*d*)	119. (*d*)	120. (*d*)
121. (*d*)	122. (*c*)	123. (*c*)	124. (*d*)	125. (*b*)
126. (*b*)	127. (*c*)	128. (*a*)	129. (*c*)	130. (*b*)
131. (*c*)	132. (*b*)	133. (*d*)	134. (*a*)	135. (*b*)
136. (*b*)	137. (*b*)	138. (*c*)	139. (*a*)	140. (*b*)
141. (*c*)	142. (*c*)	143. (*b*)	144. (*b*)	145. (*d*)
146. (*b*)	147. (*b*)	148. (*d*)	149. (*c*)	150. (*a*)
151. (*b*)	152. (*a*)	153. (*c*)	154. (*b*)	155. (*d*)
156. (*a*)	157. (*a*)	158. (*c*)	159. (*b*)	160. (*a*)
161. (*b*)	162. (*a*)	163. (*b*)	164. (*a*)	165. (*a*)
166. (*b*)	167. (*c*)	168. (*c*)	169. (*c*)	170. (*a*)
171. (*b*)	172. (*b*)	173. (*b*)	174. (*b*)	175. (*b*)
176. (*d*)	177. (*d*)	178. (*b*)	179. (*c*)	180. (*c*)
181. (*c*)	182. (*b*)	183. (*a*)	184. (*a*)	185. (*c*)
186. (*b*)	187. (*a*)	188. (*b*)	189. (*a*)	190. (*d*)
191. (*b*)	192. (*a*)	193. (*b*)	194. (*b*)	195. (*c*)
196. (*a*)	197. (*c*)	198. (*b*)	199. (*b*)	200. (*a*)
201. (*c*)	202. (*c*)	203. (*d*)	204. (*b*)	205. (*b*)
206. (*b*)	207. (*c*)	208. (*a*)	209. (*d*)	210. (*a*)
211. (*d*)	212. (*b*)	213. (*d*)	214. (*c*)	215. (*a*)
216. (*a*)	217. (*d*)	218. (*b*)	219. (*b*)	220. (*b*)
221. (*b*)	222. (*b*)	223. (*b*)	224. (*a*)	225. (*c*)
226. (*c*)	227. (*b*)	228. (*a*)	229. (*c*)	230. (*b*)
231. (*a*)	232. (*b*)	233. (*b*)	234. (*b*)	235. (*c*)
236. (*b*)	237. (*c*)	238. (*c*)	239. (*a*)	240. (*b*)
241. (*a*)	242. (*b*)	243. (*d*)	244. (*c*)	245. (*b*)
246. (*a*)	247. (*d*)	248. (*d*)	249. (*c*)	250. (*d*)
251. (*b*)	252. (*b*)	253. (*a*)	254. (*c*)	255. (*a*)
256. (*b*)	257. (*c*)	258. (*d*)	259. (*b*)	260. (*a*)
261. (*b*)	262. (*a*)	263. (*b*)	264. (*d*)	265. (*c*)
266. (*d*)	267. (*d*)	268. (*b*)	269. (*b*)	270. (*c*)
271. (*c*)	272. (*b*)	273. (*a*)	274. (*b*)	275. (*c*)
276. (*b*)	277. (*c*)	278. (*a*)	279. (*b*)	280. (*b*)
281. (*d*)	282. (*b*)	283. (*c*)	284. (*a*)	285. (*c*)
286. (*c*)	287. (*c*)	288. (*c*)	289. (*a*)	290. (*b*)
291. (*b*)	292. (*c*)	293. (*a*)	294. (*c*)	295. (*b*)
296. (*b*)	297. (*b*)	298. (*c*)	299. (*b*)	300. (*d*)
301. (*b*)	302. (*a*)	303. (*d*)	304. (*b*)	305. (*a*)

306. (*b*)	307. (*a*)	308. (*b*)	309. (*a*)	310. (*b*)
311. (*d*)	312. (*d*)	313. (*b*)	314. (*b*)	315. (*c*)
316. (*b*)	317. (*c*)	318. (*b*)	319. (*c*)	320. (*b*)
321. (*d*)	322. (*c*)	323. (*b*)	324. (*c*)	325. (*c*)
326. (*c*)	327. (*b*)	328. (*c*)	329. (*c*)	330. (*b*)
331. (*a*)	332. (*b*)	333. (*c*)	334. (*b*)	335. (*c*)
336. (*b*)				

337. barometric
338. work
339. surroundings
340. stored
341. internal
342. mass
343. state
344. path
345. extensive
346. intensive
347. intensive
348. two-phase
349. N + 2
350. infinitesimal
351. reversible
352. internal energy
353. enthalpy
354. state
355. independent
356. zero
357. reciprocal
358. zero
359. ideal
360. ideal, incompressible
361. oxygen
362. quality
363. mechanical, electrical
364. impossible
365. cyclic
366. heat
367. high, lower
368. Carnot
369. higher
370. same
371. working fluid
372. independent
373. infinity, zero
374. adiabatic
375. isentropic
376. state
377. heat transfer
378. reversible
379. decreases
380. intersect
381. does not
382. entropy
383. pressure
384. mechanical
385. electrolytic cell
386. 65
387. combustion
388. increased
389. increased
390. Rankine
391. zero
392. decreases
393. 14
394. independent
395. water, lithium bromide
396. freezing point
397. five
398. compression
399. throttle valve
400. lower
401. zero
402. decrease
403. minimum
404. $-RT \ln(K)$

405. decreases
406. ln K
407. endothermic
408. increase
409. negative
410. lost work
411. zero
412. entropy
413. chemical
414. Raoult's law
415. pressure
416. fugacity coefficient
417. pressure
418. unity
419. Poynting
420. partial pressure
421. high, low
422. increases
423. 'hard' volume, forces
424. Joule-Thomson coefficient
425. raises
426. working medium
427. volumes
428. increase
429. increase
429. constant-volume
431. low
432. higher
433. higher
434. pressure
435. more
436. high temperature
437. combustion
438. increases
439. inversion curve
440. ammonium perchlorate
441. aircraft
442. small
443. decrease

444. (*a*)—(II)
(*b*)—(IV)
(*c*)—(III)
(*d*)—(I)

445. (*a*)—(II)
(*b*)—(I)
(*c*)—(III)
(*d*)—(IV)

446. (*a*)—(III)
(*b*)—(IV)
(*c*)—(I)
(*d*)—(II)

447. (*a*)—(II)
(*b*)—(III)
(*c*)—(IV)
(*d*)—(I)

448. (*a*)—(II)
(*b*)—(I)
(*c*)—(IV)
(*d*)—(III)

449. (*a*)—(II)
(*b*)—(III)
(*c*)—(I)
(*d*)—(IV)

450. (*a*)—(II)
(*b*)—(I)
(*c*)—(IV)
(*d*)—(III)

451. (*a*)—(III)
(*b*)—(IV)
(*c*)—(I)
(*d*)—(II)

452. (*a*)—(IV)
(*b*)—(I)
(*c*)—(II)
(*d*)—(III)

453. (*a*)—(II)
(*b*)—(III)
(*c*)—(I)
(*d*)—(IV)

454. (*a*)—(III)
(*b*)—(I)
(*c*)—(II)
(*d*)—(IV)

455. (*a*)—(II)
(*b*)—(I)
(*c*)—(IV)
(*d*)—(III)

6

Fuels and Combustion

1. Combustion reaction is
   (*a*) an endothermic reaction
   (*b*) an exothermic reaction
   (*c*) an autocatalytic reaction
   (*d*) a photochemical reaction
2. Combustion requires
   (*a*) a supply of oxygen (*b*) a combustible fuel
   (*c*) a source of heat energy (*d*) all of the above.
3. The combustion process is usually accompanied by
   (*a*) rise in temperature and fall in pressure
   (*b*) rise in temperature and pressure
   (*c*) fall in temperature and pressure
   (*d*) fall in temperature and rise in pressure.
4. The temperature to which a substance must be heated before it may burn, is called
   (*a*) flash point (*b*) critical temperature
   (*c*) transition temperature (*d*) ignition temperature.
5. If the oxygen is entirely removed from a fire by smothering it with foam, the combustion will
   (*a*) slow down (*b*) stop entirely
   (*c*) speed up (*d*) not be affected at all.
6. A fire can be put out by
   (*a*) cutting off the supply of combustible fuel
   (*b*) smothering the fire
   (*c*) cooling the fire
   (*d*) all of the above.
7. Internal energy of the combustion products is
   (*a*) equal to that of reactants
   (*b*) greater than that of reactants
   (*c*) less than that of reactants.
8. A fuel is a substance which

   (*a*) burns on heating
   (*b*) produces smoke
   (*c*) burns to produce energy
   (*d*) undergoes oxidation on heating.
9. Fuels produce energy because
   (*a*) their oxidation reactions are endothermic
   (*b*) they produce large volumes of gases
   (*c*) their oxidation processes are exothermic
   (*d*) none of the above.
10. A fuel can be defined as any combustible matter that is used to produce heat. So the fuels may be
   (*a*) solids (*b*) gases
   (*c*) liquids (*d*) all of the above.
11. The lowest temperature at which a solid fuel produces enough vapours to support continuous combustion is called
   (*a*) flash point (*b*) kindling temperature
   (*c*) burning temperature (*d*) none of the above.
12. Ignition of liquid fuel at its flash point would cause
   (*a*) no combustion (*b*) continuous combustion
   (*c*) a momentary flash.
13. Ignition of liquid fuel at its fire point would cause
   (*a*) continuous combustion (*b*) a momentary flash
   (*c*) no combustion.
14. Excess air is to be supplied for combustion to be complete due to
   (*a*) its incomplete mixing
   (*b*) obstruction of inert gas molecules
   (*c*) chemical equilibrium
   (*d*) all of the above.
15. The most economic fuels are
   (*a*) solid fuels (*b*) liquid fuels
   (*c*) gaseous fuels.
16. Wood at its kindling temperature will
   (*a*) burn momentarily, then go out
   (*b*) not burn at all
   (*c*) burn continuously.
17. *Which would yield more energy when completely burned ?*
   (*a*) methane (*b*) ethane
   (*c*) propane (*d*) butane.

18. Which would give the greater amount of heat per cubic foot ?

(*a*) Hydrogen (*b*) Carbon monoxide
(*c*) Hydrogen sulphide (*d*) Methane.

19. Which would give the greater amount of heat per cubic foot ?

(*a*) Hydrogen
(*b*) Natural gas
(*c*) Liquefied petroleum gas (LPG)
(*d*) Gobar gas.

20. What is the explosive range for hydrogen ?

(*a*) 4·1 to 74·2% (*b*) 5·3 to 14·0%
(*c*) 3·2 to 12·5% (*d*) 2·1 to 9·4%.

21. Methane is flammable in concentrations from

(*a*) 4·1 to 74·2% (*b*) 5·3 to 14·0%
(*c*) 3·2 to 12·5% (*d*) 1·6 to 8·5%.

22. What is the explosive range for ethane ?

(*a*) 1·8 to 9·5% (*b*) 4·1 to 74·2%
(*c*) 3·2 to 12·5% (*d*) 1·6 to 8·5%.

23. Propane is flammable in concentrations from

(*a*) 4·1 to 74·2% (*b*) 2·1 to 9·4%
(*c*) 3·2 to 12·5% (*d*) 5·3 to 14·0%.

24. Butane is flammable in concentrations from

(*a*) 4·1 to 74·2% (*b*) 5·3 to 14·0%
(*c*) 1·6 to 8·5% (*d*) 3·2 to 12·5%.

25. The hottest part of flame lies in its

(*a*) blue zone (*b*) luminous zone
(*c*) non-luminous zone (*d*) zone of unburnt gases.

26. If the concentration of ethane were only 1·6% (half the lower limit of flammability) the M—S—A Explosivemeter would read

(*a*) 100% (*b*) 50%
(*c*) 1·6% (*d*) 16%.

27. If the concentration of ethane were 3·2% (lower limit of flammability)M—S—A Explosivemeter would read

(*a*) 100% (*b*) 50%
(*c*) 3·2% (*d*) 32%.

28. A reading of 100% on the explosivemeter would mean that the concentration of the combustible gas was 100% of the lower limit, that is, the concentration would be

(*a*) 1/4 the amount necessary to cause an explosion

(*b*) 1/2 the amount necessay to cause an explosion
(*c*) 1/10 the amount necessary to cause an explosion
(*d*) sufficient to cause an explosion.

29. Explosion will not occur if the methane concentration in air were

(*a*) 13% (*b*) above 14%
(*c*) 10% (*d*) 6%.

30. If the explosivemeter reading is zero, it means that

(*a*) there is just enough combustible gas in the air to cause an explosion
(*b*) there is too little gas in the air to cause an explosion
(*c*) the concentration of combustible gas lies between lower and upper limits of explosibility
(*d*) the concentration of oxygen is zero.

31. A reading of 100% on the explosivemeter means that the concentration of combustible gas is

(*a*) less than the lower limit of explosibility
(*b*) equal to the lower limit of explosibility
(*c*) higher than the lower limit of explosibility
(*d*) both (*b*) and (*c*).

32. Which one is the most dangerous gas ?

(*a*) Hydrogen (*b*) Methane
(*c*) Ethane (*d*) Butane.

33. If a gas is in the flammable range of concentration

(*a*) it will not explode at all
(*b*) it will explode always without requiring heat energy
(*c*) it will not explode unless a source of heat starts the reaction
(*d*) none of these answers.

34. The gross heat of combustion is

(*a*) the heat directly released by combustion
(*b*) the heat released by cooling down all combustion products to the temperature before combustion
(*c*) the latent heat of condensation of the water formed
(*d*) all of these answers.

35. One of the products formed by combustion of the hydrocarbon fuels is water which is in the

(*a*) solid state
(*b*) liquid state
(*c*) gaseous state
(*d*) solid, liquid, and gaseous states.

36. The net heat of combustion of the hydrocarbon fuels is

(*a*) equal to the gross heat of combustion of the hydrocarbon fuels
(*b*) greater than the gross heat of combustion of the hydrocarbon fuels
(*c*) equal to the gross heat of combustion minus the latent heat of condensation of the water formed during the combustion reaction
(*d*) equal to the latent heat of condensation of the water formed during the combustion reaction.

37. The complete and perfect combustion of a hydrocarbon fuel yields
(*a*) carbon monoxide gas and water vapour
(*b*) carbon dioxide gas only
(*c*) water vapour only
(*d*) both carbon dioxide gas and water vapour.

38. How many cubic foot of oxygen is required for the complete and perfect combustion of one cubic foot of methane ?
(*a*) one cubic foot (*b*) two cubic foot
(*c*) one and half cubic foot (*d*) three cubic foot.

39. The oxygen for fuel combustion comes from the air which consists of about
(*a*) 21% oxygen and 79% nitrogen by volume
(*b*) 21% oxygen and 79% nitrogen by weight
(*c*) 79% oxygen and 21% nitrogen by volume
(*d*) 79% oxygen and 21% nitrogen by weight.

40. How many cubic foot of air is required for the complete and perfect combustion of one cubic foot of methane
(*a*) 2·0 cu. ft. (*b*) 3·0 cu. ft.
(*c*) 7·5 cu. ft. (*d*) 9·52 cu. ft.

41. Which is not a combustible gas ?
(*a*) Carbon monoxide (*b*) Carbon dioxide
(*c*) Hydrogen (*d*) Gobar gas.

42. Incomplete combustion of hydrocarbon fuels
(*a*) yields carbon dioxide and water vapour
(*b*) takes place due to too much air
(*c*) takes place due to an insufficient amount of air
(*d*) yields hydrogen and carbon dioxide.

43. Which reaction takes place in CO boiler of fluid catalytic cracking units ?
(*a*) $2CO_2 \rightarrow 2CO + O_2$
(*b*) $2\,CO + O_2 \rightarrow 2CO_2 + \text{energy}$
(*c*) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
(*d*) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$.

44. The volume of oxygen at STP required for the complete combustion of 2 litres of CO at STP is
(*a*) 1/2 litre (*b*) 1 litre
(*c*) 2 litres (*d*) 4 litres.

45. The complete combusion of 1 pound of carbon requires
(*a*) 2·66 pounds of air (*b*) 29 pounds of air
(*c*) 11·5 pounds of air (*d*) 12·6 pounds of air.

46. The incomplete combustion reaction of carbon and oxygen is as follows :

$$C + 1/2\ O_2 \rightarrow CO$$

Air required for 1 pound of carbon burning is
(*a*) 1·33 lb (*b*) 29 lb
(*c*) 5·75 lb (*d*) 6·3 lb.

47. Fuel combustion is never 100% efficient due to
(*a*) incomplete combustion loss
(*b*) dry gas loss, or stack loss
(*c*) moisture loss, unaccountable loss
(*d*) all these answers.

48. Control of incomplete combustion loss would mean
(*a*) decreasing the amount of excess air
(*b*) increasing the amount of excess air
(*c*) increasing the fuel/air ratio
(*d*) to decrease moisture loss.

49. If the analysis of the flue gas revealed an oxygen content of 11%, this means that
(*a*) fuel is being wasted by incomplete combustion
(*b*) the combustion is proceeding efficiently
(*c*) the dry-gas loss is too great
(*d*) the dry-gas loss is negligible.

50. Within the range of ..... of oxygen in the flue gas the combustion has enough excess air to minimize incomplete combustion and not to much excess air to cause excessive dry-gas or stack loss
(*a*) 15 to 20% (*b*) 2·5 to 3·5%
(*c*) 15 to 30% (*d*) 10 to 30%.

51. When incomplete combustion loss is excessive, the flue-gas analysis reveals large amount of
(*a*) carbon dioxide (*b*) carbon monoxide
(*c*) oxygen (*d*) carbon.

52. Moisture loss is determined by

(*a*) the moisture content of the fuel
(*b*) the humidity of air used for combustion
(*c*) the moisture content of the fuel and the humidity of air used for combustion
(*d*) the water formed by combustion reaction.

53. With no excess air, flue gas from the complete and perfect combustion of methane would contain

(*a*) 11·7% N_2 and 88·3% CO_2 by volume
(*b*) 11·7% CO_2 and 88·3% N_2 by volume
(*c*) 24·8% CO_2 and 75·2% N_2 by volume
(*d*) 24·8% N_2 and 75·2% CO_2 by volume.

54. Under actual combustion conditions, unless there is sufficient excess air, the flue gas contains

(*a*) carbon monoxide (*b*) carbon dioxide
(*c*) oxygen, nitrogen (*d*) all of these answers.

55. As the carbon-hydrogen ratio of the fuel increases,

(*a*) the amount of CO_2 formed decreases for the same % of excess air
(*b*) the amount of CO_2 formed increases for the same % of excess air
(*c*) the amount of energy liberated by the combustion decreases for the same % of excess air
(*d*) the amount of CO_2 formed remains constant for the same % of excess air.

56. If the O_2 concentration of the flue gas rises too high, fuel is being wasted by

(*a*) incomplete combustion (*b*) dry-gas, or stack loss
(*c*) moisture loss (*d*) none of these answers.

57. If the oxygen concentration of flue gas is too low,

(*a*) the amount of excess air should be decreased
(*b*) the amount of excess air should be increased
(*c*) the amount of excess air should be kept constant
(*d*) there is dry-gas or stack loss.

58. The most important instrument for complete flue-gas analysis is the Orsat gas analyzer. The Orsat analyzes flue gases by the process of

(*a*) adsorption (*b*) distillation
(*c*) evaporation (*d*) absorption.

59. Which sequence is followed for the flue-gas analysis in the Orsat gas analyzer ?

(*a*) O_2, CO, CO_2 (*b*) O_2, CO_2, CO
(*c*) CO, O_2, CO_2 (*d*) CO_2, O_2, CO.

60. The potassium hydroxide solution absorbs

(*a*) CO_2 as well as CO (*b*) CO_2 as well as O_2
(*c*) CO_2, O_2 and CO (*d*) CO_2 as well as SO_2.

61. The pyrogallol solution absorbs

(*a*) CO_2 as well as CO (*b*) CO_2 as well as O_2
(*c*) CO_2, CO and O_2 (*d*) CO as well as O_2.

62. The cuprous chloride solution absorbs

(*a*) CO_2 only (*b*) O_2 only
(*c*) CO only (*d*) CO_2, O_2 and CO.

63. Incomplete combustion of hydrocarbon fuels may be due to

(*a*) presence of high percentage of carbon monoxide in the flue-gas
(*b*) a smoky stack
(*c*) increased fuel consumption for the same heating requirement
(*d*) all these answers.

64. Too much excess air gives

(*a*) high percentages of O_2 in the flue gas
(*b*) high stack temperature
(*c*) increased fuel consumption for the same heating requirement
(*d*) all these answers.

65. The correct amount of excess air is the amount that gives

(*a*) the maximum fuel consumption for the given requirement
(*b*) the high percentages of O_2 in the flue gas
(*c*) the high stack temperature
(*d*) the most efficient furnace operation and the minimum fuel consumption for the given heating requirement.

66. All the organic liquids are combustible except

(*a*) benzene (*b*) carbon tetrachloride
(*c*) toluene (*d*) cyclohexane.

67. Which of the three types of fuels, offer the highest heating values ?

(*a*) gaseous fuels (*b*) liquid fuels
(*c*) solid fuels.

68. The ultimate analysis of coal gives

(*a*) carbon, hydrogen and ash
(*b*) volatile matter, moisture, ash and fixed carbon
(*c*) carbon, hydrogen, sulphur and nitrogen
(*d*) volatile matter, moisture, nitrogen and fixed carbon.

69. The proximate analysis of coal gives

(*a*) carbon, hydrogen and ash
(*b*) volatile matter, moisture, ash and fixed carbon
(*c*) carbon, hydrogen, sulphur and nitrogen
(*d*) volatile matter, moisture, nitrogen and fixed carbon.

70. The ratio of the percentage carbon obtained in the ultimate analysis and the per cent fixed carbon obtained in the proximate analysis is always

(*a*) one (*b*) less than one
(*c*) greater than one.

71. Heating value of liquid fuels in Btu/lb

(*a*) decreases with decrease in specific gravity
(*b*) increases with decrease in specific gravity
(*c*) remains constant with change in specific gravity
(*d*) increases with decrease in degree API.

72. The hydrogen free combustible gas is

(*a*) CO_2 (*b*) O_2
(*c*) N_2 (*d*) CO.

73. The per cent difference between lower heating value and higher heating value is maximum in the case of

(*a*) hydrogen (*b*) LPG
(*c*) natural gas (*d*) carbon.

74. H/C ratio (by weight) is infinite for

(*a*) carbon (*b*) hydrogen
(*c*) methane (*d*) gobar gas.

75. H/C ratio (by weight) is zero for

(*a*) carbon (*b*) hydrogen
(*c*) methane (*d*) gobar gas.

76. A paraffinic hydrocarbon liquid fuel has a C/H ratio (by weight) of 5·1428. Its chemical formula is

(*a*) C_8H_{18} (*b*) C_7H_{16}
(*c*) C_6H_{14} (*d*) C_5H_{12}.

77. The fuel ratio of coal is defined as the ratio of

(*a*) its percentage fixed carbon to that of ash
(*b*) its percentage fixed carbon to that of volatile matter
(*c*) its percentage fixed carbon to that of moisture
(*d*) percentage carbon to that of hydrogen obtained in the ultimate analysis of coal.

78. H/C ratio (by weight) for the same number of carbon atoms is the highest in the

(*a*) paraffins (*b*) naphthenes
(*c*) olefins (*d*) aromatics.

79. H/C ratio (by weight) for the same number of carbon atoms is the lowest in the

(*a*) paraffins (*b*) naphthenes
(*c*) olefins (*d*) aromatics.

80. Select the correct statement

(*a*) Gaseous fuels are ideal from the standpoint of complete combustion
(*b*) Liquid fuels are ideal from the standpoint of complete combustion
(*c*) Solid fuels are ideal from the standpoint of complete combustion
(*d*) Liquid as well as solid fuels are ideal from the standpoint of complete combustion.

81. Heating value of gaseous fuels in Btu/cu. ft.

(*a*) decreases with increase in molecular weight
(*b*) increases with increase in molecular weight
(*c*) remains constant with change in molecular weight
(*d*) is always negative.

82. Select the correct statement

(*a*) 1 litre of LPG will produce lower quantity of heat than 1 litre of kerosine
(*b*) 1 litre of LPG will produce greater quantity of heat than 1 litre of kerosine
(*c*) 1 litre of LPG and 1 litre of kerosine will produce equal quantity of heat
(*d*) 1 kg of LPG will produce lower quantity of heat than 1 kg of furnace oil.

83. Select the correct statement

(*a*) Heating value of light paraffinic oil fuels is lower than that of equivalent olefins
(*b*) Heating value of light paraffinic oil fuels is higher than that of equivalent olefins
(*c*) Heating value of light paraffinic oil fuels is equal to that of equivalent olefins
(*d*) Heating value of *n*-paraffins is lower than that of isoparaffins of the same compounds.

84. Select the correct statement

(*a*) Combustion is any unit process in which the oxidation reaction takes place
(*b*) Oxidation of toluene to benzaldehyde is a combustion process
(*c*) Oxidation of hydrogen chloride to chlorine is a combustion process
(*d*) Combustion is that unit process in which oxidation reaction takes place as the union of carbon, hydrogen and sulphur with oxygen.

85. The dew point of the flue gases

(*a*) decreases with decrease in C/H ratio of a fuel
(*b*) decreases with increase in C/H ratio of a fuel
(*c*) is independent of C/H ratio of a fuel
(*d*) decreases with decrease in excess air.

86. Theoretical flame temperature is the temperature attained
(*a*) when a fuel is burned in air
(*b*) when a fuel is burned in oxygen
(*c*) when a fuel is burned in air or oxygen
(*d*) when a fuel is burned in air or oxygen without gain or loss of heat.

87. The maximum adiabatic flame temperature is attained when the fuel is burned with
(*a*) the theoretically required amount of air
(*b*) the theoretically required amount of pure oxygen
(*c*) more than the theoretically required amount of pure oxygen
(*d*) less than the theoretically required amount of pure oxygen.

88. Actual flame temperature is always lower than the adiabatic flame temperature because
(*a*) there is always loss of heat from the flame
(*b*) it is impossible to obtain complete combustion at high temperature
(*c*) both (*a*) and (*b*)
(*d*) neither (*a*) nor (*b*).

89. The adiabatic flame temperatures of pentane and hydrogen are T_p and T_h °C. The difference $T_p - T_h$ is always
(*a*) zero (*b*) negative
(*c*) positive.

90. The ratio of the maximum adiabatic flame temperature in air to the maximum adiabatic temperature in pure oxygen is always
(*a*) equal to one (*b*) much less than one
(*c*) much greater than one.

91. At a given temperature, the enthalpy is the highest for
(*a*) CO_2 (*b*) air
(*c*) SO_2 (*d*) H_2O.

92. AT a given temperature, the enthalpy is the lowest for
(*a*) CO_2 (*b*) air
(*c*) SO_2 (*d*) H_2O.

93. Flue gas viscosities at temperatures T_A, T_B and T_C °C were obtained as $0{\cdot}020 \times 10^{-3}$, $0{\cdot}030 \times 10^{-3}$ and $0{\cdot}040 \times 10^{-3}$ kg/m-s respectively. This means that
(*a*) $T_A = T_B = T_C$ (*b*) $T_A > T_B > T_C$

(*c*) $T_A < T_B < T_C$ (*d*) $T_A < T_C < T_B$.

94. Flue gas thermal conductivities at temperatures T_A, T_B and T_C °C were obtained as 0·020, 0·030 and 0·040 Btu/(hr. ft^2 °F/ft) respectively. This means that
(*a*) $T_A = T_B = T_C$ (*b*) $T_A < T_B < T_C$
(*c*) $T_A > T_B > T_C$ (*d*) $T_A > T_C > T_B$.

95. Emissivity of oil flames is
(*a*) equal to that of gas flames
(*b*) higher than that of gas flames
(*c*) lower than that of gas flames.

96. Production of flue gas as kg/kg of furnace oil at about 40% excess air will aproximately be
(*a*) 1·5 times (*b*) 1 times
(*c*) 20 times (*d*) 50 times.

97. Select the correct statement
(*a*) Vanadium from liquid fuels can be removed by desalting of crude oils
(*b*) Vanadium pentoxide produces less heat than hydrocarbons
(*c*) Vanadium is actually bonded onto the hydrocarbons
(*d*) The adverse effects of sodium and vanadium together are much less serious than the presence of either one alone.

98. The bright glow of a combustion process is the characteristic of
(*a*) fast and high temperature oxidation
(*b*) slow and low temperature oxidation
(*c*) slow and high temperature oxidation
(*d*) fast and low temperature oxidation.

99. Actual maximum flame temperatures for the pure combustible gases burnt in unpreheated air range from
(*a*) 1000 to 2000°F (*b*) 2000 to 2500°F
(*c*) 2700 to 3000°F (*d*) 3400 to 3800°F.

100. If CO_2 is not fully absorbed by the solution meant for its absorption in the Orsat apparatus, it will appear as
(*a*) N_2 (*b*) O_2
(*c*) CO.

101. An Orsat analysis of the combustion products of a hydrocarbon liquid fuel gave the following results: $CO_2 = 10\%$, $CO = 0{\cdot}6\%$, $O_2 = 5{\cdot}7\%$ and $N_2 = 79\%$ (by vol.). The C/H ratio (by weight) of the liquid fuel is
(*a*) 1·06
(*b*) 3·18

(*c*) 6·36
(*d*) cannot be determined due to inadequate information.

102. The gaseous fuel that produces more heat than other fuel gases is
(*a*) water gas (*b*) producer gas
(*b*) carburetted water gas (*d*) semi-water gas

103. An organic compound is found to contain C = 54·5%, O = 36·4% and H = 9·1% by weight. Its empirical formula is
(*a*) CHO_2 (*b*) CH_2O
(*c*) C_2H_4O (*d*) C_3H_4O.

104. A compound of empirical formula C_2H_5O has a molecular weight of 90. Its molecular formula is
(*a*) C_2H_5O (*b*) $C_4H_{10}O_2$
(*c*) $C_3H_6O_3$ (*d*) $C_4H_5O_2$.

105. A sooty flame can be made non-luminous
(*a*) by admitting more gas (*b*) by admitting more air
(*c*) by shutting air supply (*d*) by shutting gas supply.

106. There would be no combustion if a sample of kerosine is ignited at a temperature
(*a*) lower than its flash point
(*b*) greater than its flash point and lower than its fire point
(*c*) equal to its fire point
(*d*) greater than its fire point.

107. Which of the following elements present in fuel oil is not combustible?
(*a*) Carbon (*b*) Hydrogen
(*c*) Sulphur (*d*) Oxygen.

108. Moisture content is minimum in
(*a*) anthracite coal (*b*) bituminous coal
(*c*) lignite.

109. C/H ratio (by weight) is maximum for
(*a*) coal (*b*) furnace oil
(*c*) natural gas (*d*) naphtha.

110. C/H ratio (by weight) is minimum for
(*a*) furnace oil (*b*) natural gas
(*c*) coal (*d*) naphtha.

111. A gaseous mixture contains methane and inert gas. 20 ml of this mixture requires 16 ml of O_2 for complete combustion. What is the percentage of methane in the mixture ?

(*a*) 20 (*b*) 40
(*c*) 60 (*d*) 80.

112. Fuel gas can be produced from 'gobar' by the process of
(*a*) slow oxidation (*b*) fermentation
(*c*) sublimation (*d*) dehydration.

113. Which of the following statements is incorrect ?
(*a*) Coke contains more volatile matter than bituminous coal
(*b*) The calorific value of coke is more than that of bituminous coal
(*c*) The carbon content of bituminous coal is less than that of coke
(*d*) Coke is more costly than bituminous coal.

114. Which of the following has minimum calorific value ?
(*a*) LDO (*b*) Furnace oil
(*c*) Coal (*d*) Rice husk.

115. Which of the following has maximum calorific value ?
(*a*) LDO (*b*) Rice husk
(*c*) Coal (*d*) Furnace oil.

116. The quality of best fuel is
(*a*) its low cost (*b*) the negligible ash
(*c*) its high calorific value (*d*) its easy availability.

117. A mixture of CO_2, CO and C_2H_2 was passed through ammoniacal cuprous chloride solution. The unabsorbed gas(es) is/are
(*a*) CO (*b*) C_2H_2
(*c*) CO_2 (*d*) CO and CO_2.

118. Which of the following has maximum calorific value in kcal/cu m ?
(*a*) Producer gas (*b*) Water gas
(*c*) Coke oven gas (*d*) Natural gas.

119. Which of the following has minimum calorific value in kcal/ cu m ?
(*a*) LPG (*b*) Water gas
(*c*) Producer gas (*d*) Coke oven gas.

120. 1·6 kg of an organic compound on combustion gave 4·4 kg CO_2. The percentage of C in the organic compound is about
(*a*) 30% (*b*) 45%
(*c*) 75% (*d*) 60%.

On burning 1 litre of acetylene in excess of air, the volume of CO_2 formed under similar conditions of temperature and pressure would be about
(*a*) 1 litre (*b*) 2 litres
(*c*) 3 litres (*d*) 4 litres.

(a) less than 24% (b) greater than 24%
(c) less than 12·5% (d) greater than 12·5%.

9. The carbon content in steel varies from

(a) 0·1 to 1·50% (b) 0·35 to 2·5%
(c) 2 to 4% (d) 5 to 8%.

10. The percentage of carbon is the least in

(a) white cast iron (b) grey cast iron
(c) wrought iron (d) stainless steel.

11. The presence of impurities in iron

(a) lowers the melting point
(b) raises the melting point
(c) has no effect on melting point
(d) makes iron malleable.

12. An alloy is

(a) an intermetallic compound
(b) a solid substance containing two or more metallic elements
(c) a metallic material containing at least one metallic element
(d) a metallic material containing at least one non-metallic element.

13. Metalloid is

(a) an alloy
(b) an element which exhibits properties of metal and non-metal both
(c) highly electronegative
(d) highly electropositive.

14. A substance is said to be malleable if it

(a) does not react with acids and alkalies
(b) can be hammered to thin sheets
(c) has a very high melting point
(d) has a metallic lustre.

15. The property of metals or alloys which describes its ability to be drawn into wires is known as

(a) tenacity (b) ductility
(c) porosity (d) malleability.

16. Brittleness of a substance is a property of substance which describes its

(a) shining
(b) ability to be polished
(c) ability to be drawn into wires
(d) tendency to fracture without appreciable deformation.

17. The tempering of steel makes it

(a) hard (b) soft
(c) heavy (d) brittle.

18. Nitriding of steel is done for

(a) hardening the surface of steel
(b) hardening the steel
(c) softening the steel surface
(d) softening the steel.

19. Nitriding of steel is done in an electric furnace kept at about

(a) 1700°C (b) 2200°C
(c) 510°C (d) 125°C.

20. Select the correct statement

(a) Stainless steel is chromium plated iron
(b) German silver does not contain silver
(c) Brass is an alloy of copper and tin
(d) Bronze is an alloy of copper and zinc.

21. Stainless steel, in addition to iron and carbon contains

(a) aluminium (b) zinc
(c) lead (d) chromium.

22. Which one of the following statements is wrong ?

(a) Alloys containing copper may be white
(b) A soft metal may be hardened by alloying it with another metal or non-metal
(c) Silver-plated copper articles contain an alloy of copper and silver
(d) Alloys containing carbon are grey or black.

23. Which of the following pairs of elements might form an alloy ?

(a) Zinc and lead (b) Iron and carbon
(c) Iron and mercury (d) Mercury and platinum.

24. Brass is composed of

(a) Cu—Zn (b) Cu—Sn
(c) Sn—Zn (d) Al—B.

25. In bronze, copper is alloyed with

(a) Zn (b) Sn
(c) Be (d) Al.

26. Iron sheets are galvanised to

(a) increase lustre
(b) prevent action of oxygen
(c) prevent action of water
(d) harden the surface.

27. Galvanised iron is

(a) easy to be painted (b) of better look
(c) protected from rusting (d) harder.

28. Type 304, stainless steel contains

(a) 18% Cr, 8% Ni, 0·08% C (max)
(b) 8% Cr, 18% Ni, 0·08% C (max)
(c) 6% Cr, 18% Ni, 0·08% C (max)
(d) 18% Cr, 36% Ni, 0·08% (max).

29. Which of the following has maximum melting point ?

(a) Wrought iron (b) White cast iron
(c) Steel (d) Grey cast iron.

30. Compared to grey cast iron, white cast iron is

(a) very hard (b) very brittle
(c) more durable (d) all of the above.

31. In steel, carbon is

(a) present wholly in the combined form
(b) mostly present in the free state, as graphite
(c) not desirable
(d) none of the above.

32. Plastic deformation is

(a) the temporary distortion of a material under the action of applied stress
(b) the permanent distortion of a material under the action of applied stress
(c) related to plastics
(d) none of the above.

33. Erosion is the deterioration of metals by

(a) the corrosive action of fluids only
(b) the abrasive action of fluids only
(c) both corrosive action and abrasive action of fluids
(d) none of the above.

34. The total carbon content in pig iron may be

(a) 0·08 to 0·2% (b) 0·1 to 1·5%
(c) 3·0 to 3·5% (d) 16 to 24%.

35. Which of the following has maximum tensile strength ?

(a) White cast iron (b) Grey cast iron
(c) Pig iron (d) Nodular cast iron.

36. Grey cast iron is produced

(a) when molten pig iron is allowed to cool gradually
(b) when molten pig iron is chilled suddenly

(c) when white cast iron is subjected to slow prolonged heating
(d) from nodular cast iron.

37. White cast iron is produced

(a) when molten pig iron is allowed to cool gradually
(b) when molten pig iron is chilled suddenly
(c) when grey cast iron is subjected to slow prolonged heating
(d) none of the above.

38. Corrosion resisting properties of cast iron are very much improved by the addition of 12-15 per cent of

(a) vanadium (b) tungsten
(c) silicon (d) phosphorus.

39. Corrosion resisting chromium-nickel steels contain

(a) 16-24% Cr, 7-12% Ni, 1·5-2·0 Mn
(b) 35-36% Cr, 1·5-2·0% Ni, 8-14% Mn
(c) 7-12% Cr, 1·5-2·0% Ni, 16-24 Mn
(d) 1·5-2·0% Cr, 7-12% Ni, 16-24% Mn.

40. Corrosion resisting materials are the alloys containing chromium as a base alloyed with

(a) iron, vanadium, tungsten
(b) iron, molybdenum, tungsten
(c) iron, nickel, cobalt
(d) iron, vandadium, molybdenum.

41. In a body-centred cubic lattice system there are

(a) 1 atom per unit cell (b) 2 atoms per unit cell
(c) 3 atoms per unit cell (d) 4 atoms per unit cell.

42. In a face-centred cubic lattice there are

(a) 1 molecule per unit cell
(b) 2 molecules per unit cell
(c) 4 molecules per unit cell
(d) 8 molecules per unit cell.

43. The actual emf (E) of electrolysis cell is given by

(a) $E = E^\circ + (RT/nF) \ln (a_r/a_p)$
(b) $E = E^\circ + RT \ln (a_r/a_p)$
(c) $E = E^\circ + (nF/RT) \ln (a_r/a_p)$
(d) $E = E^\circ + nF \ln (a_r/a_p)$

where E° = emf when the reactants and products are in their standard states
a_r = activity of reactant
a_p = activity of product
F = 96,500 coulombs

n = number of equivalents involved
T = absolute temperature.

44. When Fe^{2+} changes to Fe^{3+} in a reaction

(a) it loses an electron (b) it gains an electron
(c) it gains a proton (d) it loses a proton.

45. A chemical change occurs when iron

(a) rusts (b) is magnetised
(c) is heated (d) melts.

46. Which of the following is most readily corroded in air ?

(a) Copper (b) Iron
(c) Tin (d) Silver.

47. When iron is rusted, it is

(a) reduced (b) decomposed
(c) oxidised (d) changed in a fine powder.

48. Rust of iron is

(a) powdered iron (b) ferrous oxide
(c) hydrated ferric oxide (d) none of the above.

49. Corrosion

(a) involves exchange of electrons in electrochemical corrosion only
(b) involves exchange of electrons in chemical corrosion only
(c) involves exchange of electrons, both in electrochemical and chemical corrosion
(d) is a physical phenomenon.

50. Corrosion is prevented or its rate is reduced by

(a) increasing the resistance between anodic and cathodic area
(b) decreasing anodic or cathodic polarization by increasing the diffusion of reactants and products
(c) decreasing the resistance between anodic and cathodic areas
(d) none of the above.

51. Atmospheric corrosion of metals takes place by

(a) rapid oxidation (b) slow oxidation
(c) rapid hydration (d) none of the above.

52. Iron pipes lying under acidic soil are often attached to blocks of magnesium for protection from rusting. Magnesium offers protection to iron against corrosion because it

(a) is lighter than air
(b) is more readily converted into positive irons
(c) prevents air from reaching the surface of iron
(d) forms a corrosion-resistant alloy with iron.

53. Electrochemical corrosion processes

(a) are accompanied by a flow of current from anodic to cathodic areas in the electrolyte
(b) are accompanied by a flow of current from cathodic to anodic areas in the electrolyte
(c) involve exchange of protons
(d) none of the above.

54. Carbon content of

(a) steel is in between those of cast iron and wrought iron
(b) cast iron is in between those of steel and wrought iron
(c) pig iron is in between those of steel and wrought iron
(d) wrought iron is in between those of steel and cast iron.

55. Percentage of carbon is same in

(a) cast iron and pig iron
(b) cast iron and steel
(c) pig iron and steel
(d) pig iron and wrought iron.

56. Cast iron is obtained by remelting

(a) pig iron and pouring into moulds
(b) steel and pouring into moulds
(c) wrought iron and pouring into moulds
(d) iron ore and pouring into moulds.

57. Which of the following is the least pure from of iron ?

(a) Pig iron (b) Wrought iron
(c) Steel (d) Bessemer iron.

58. Which of the following statements is not correct ?

(a) Rusting of iron can be stopped by carbon dioxide
(b) Rusting of iron takes place in moist air
(c) Rusting of iron produces hydrated iron (III) oxide
(d) Rusting of iron is electrochemical in nature.

59. The process of protection of iron by coating with zinc is called

(a) tempering (b) galvanizing
(c) nitriding (d) smelting.

60. The standard reduction potentials at 298 K for the following half reactions are given against each

(i) $Li^+(aq) + e^- \rightarrow Li(s)$ −3·05 V
(ii) $Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ −0·762 V
(iii) $2H^+(aq) + 2e^- + 2e \rightarrow H_2(g)$ 0·00 V
(iv) $Ag^+(aq) + e^- \rightarrow Ag(s)$ + 0·80 V

Which is the strongest reducing agent ?

(*a*) $Ag(s)$ (*b*) $H_2(g)$
(*c*) $Li(s)$ (*d*) $Zn(s)$.

61. Electrochemical reactions at the anode are oxidation reactions. Which one of the following is not an anodic reaction ?

(*a*) $Cl^- \rightarrow Cl + e^-$ (*b*) $Fe^{3+} + e^- \rightarrow Fe^{2+}$
(*c*) $Cu \rightarrow Cu^{2+} + 2e^-$ (*d*) $Zn \rightarrow Zn^{2+} + 2e^-$.

62. Which one of the following reactions does not take place at cathode ?

(*a*) $Cl^- \rightarrow Cl + e^-$ (*b*) $H^+ + e^- \rightarrow H$
(*c*) $Ag^+ + e^- \rightarrow Ag$ (*d*) $Cu^{2+} + 2e^- \rightarrow Cu$.

ANSWERS

1. (*b*)	2. (*b*)	3. (*a*)	4. (*a*)	5. (*d*)
6. (*d*)	7. (*a*)	8. (*d*)	9. (*a*)	10. (*c*)
11. (*a*)	12. (*c*)	13. (*b*)	14. (*b*)	15. (*b*)
16. (*d*)	17. (*b*)	18. (*a*)	19. (*c*)	20 (*b*)
21. (*d*)	22. (*d*)	23. (*b*)	24. (*a*)	25. (*b*)
26. (*c*)	27. (*c*)	28. (*a*)	29. (*a*)	30. (*d*)
31. (*a*)	32. (*b*)	33. (*b*)	34. (*c*)	35. (*d*)
36. (*a*)	37. (*b*)	38. (*c*)	39. (*a*)	40. (*c*)
41. (*b*)	42. (*c*)	43. (*a*)	44. (*a*)	45. (*a*)
46. (*b*)	47. (*c*)	48. (*c*)	49. (*c*)	50. (*a*)
51. (*b*)	52. (*b*)	53. (*a*)	54. (*a*)	55. (*a*)
56. (*a*)	57. (*a*)	58. (*a*)	59. (*b*)	60. (*c*)
61. (*b*)	62. (*a*)			

8

Chemical Reaction Engineering

DEFINITIONS

Activity of a catalyst pellet. The ratio of the rate at which the pellet converts reactant to the rate of reaction of reactant with a fresh pellet.

Age distribution of fluid. Elements of fluid taking different routes through the reactor may require different lengths of time to pass through the vessel. The distribution of these times for the stream of fluid leaving the vessel is called the exit age distribution E, or the residence time distribution (RTD) of fluid.

$$\int_0^\infty E\,dt = 1$$

Arrhenius's law. The reaction rate constant k is given by

$$k = k_0\, e^{-E/RT}$$

where k_0 is called the frequency factor, E is called the activation energy of the reaction.

Autocatalytic reaction. A reaction in which one of the products of reaction acts as a catalyst.

Axial dispersion coefficient, D. It characterizes the degree of backmixing during flow. It is defined by

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial z^2}$$

Dirac delta function, δ. It is a distribution curve defined to treat the discontinuous pulse.

$\delta(t-\tau) = \infty$ at $t = \tau$ and $\delta(t-\tau) = 0$ elsewhere such that

$$\int_{-\infty}^{\infty} \delta(t-\tau)\,dt = 1$$

Dispersion number. Defined as D/uL where D is axial dispersion coefficient, u is fluid velocity and L is length of reactor.

Effectiveness factor. Defined to measure the lowering of reaction rate due to the resistance of pore diffusion. It is defined as

$$\frac{\text{Actual reaction rate within pore}}{\text{Rate if not slowed by pore diffusion}}$$

It is equal to $\tanh\left(L\sqrt{k/D}\right)\Big/L\sqrt{k/D}$ for a first-order reaction.

Elementary reaction. Those reactions for which the rate equation corresponds to a stoichiometric equation.

Expansion factor. Fractional change in volume of the system between no conversion and complete conversion of reactant.

Equilibrium constant. The ratio of the rate constant for forward reaction to the rate constant for backward reaction.

Fractional conversion of reactant A, X_A. The fraction of reactant converted into product. It is given by

$$X_A = \frac{N_{AO} - N_A}{N_{AO}}$$

where N_A is number of moles of A at time t and N_{AO} is number of moles of A at start of reaction.

Half life of reaction. The time needed for the concentration of reactant to drop to one-half the original value.

Molecularity. The molecularity of an elementary reaction is the number of molecules involved in the reaction.

Order of reaction. The powers to which the concentrations in the rate equation are raised.

Photochemical reactions. These reactions proceed only in the presence of light with a rate dependent on the intensity of incident radiation.

Rate of reaction. The rate of reaction of any reaction component A is defined as

$$\frac{\text{Moles of } A \text{ which appear by reaction}}{\text{(Unit volume of reacting fluid) (time)}}$$

Recycle ratio. The ratio of volume of fluid returned to the reactor entrance to the volume leaving the system.

Space time. The time required to process one reactor volume of feed measured at specified conditions.

Space velocity. The number of reactor volumes of feed at specified conditions which can be treated in unit time.

Thiele modulus. Reactant concentration within a catalyst pore depends on a dimensionless quantity $L\sqrt{k/D}$ which is called Thiele modulus ; L is length of reactor, k is reaction rate constant and D is molecular diffusion coefficient.

1. Which one of the following statements about a chemical equation is true ?

(*a*) Mass is conserved
(*b*) Mass as well as atoms are conserved
(*c*) Atoms are conserved
(*d*) Ions are conserved.

2. A balanced chemical equation is in accordance with

(*a*) law of gaseous volumes
(*b*) law of Avogadro
(*c*) law of constant proportions
(*d*) law of conservation of mass.

3. An imbalanced equation is against the

(*a*) law of gaseous volumes
(*b*) law of constant proportions
(*c*) law of conservation of mass
(*d*) law of multiple proportions.

4. When a correctly written chemical equation is balanced

(*a*) the number of atoms of each kind on each side should be equal
(*b*) all molecules are diatomic
(*c*) all substances are in the same physical state
(*d*) the sum of the coefficient on both sides is the same.

5. Chemical reactions involve the participation of

(*a*) electrons (*b*) protons
(*c*) neutrons (*d*) nuclei.

6. The symbolic representation of the molecule of a compound is called

(*a*) structural formula (*b*) molecular formula
(*c*) empirical formula (*d*) graphic formula.

7. A chemical reaction occurs when the energy of the reacting molecules is

(*a*) less than the activation energy of the reaction
(*b*) equal to the activation energy of the reaction
(*c*) more than the activation energy of the reaction
(*d*) equal to or more than the activation energy of the reaction.

8. The reaction

$$CH_2 = CH_2 + Br_2 \longrightarrow CH_2Br—CH_2Br$$

is

(*a*) a substitution reaction (*b*) an addition reaction
(*c*) a molecular rearrangement (*d*) a photochemical reaction

9. Reaction between neutral solution of barium chloride and sodium carbonate goes to completion because

(*a*) the reaction is irreversible
(*b*) sodium chloride is only sparingly soluble in water
(*c*) barium carbonate is almost insoluble in water
(*d*) the solubility of $BaCl_2$ decreases in the presence of sodium carbonate.

10. The reversible reaction

$$CaCO_3 \rightleftharpoons CaO + CO_2$$

proceeds to comp etion in lime kilns because
(*a*) temperature is very high
(*b*) CO_2 escapes
(*c*) CaO is more stable than $CaCO_3$
(*d*) CaO and CO_2 do not combine.

11. A photochemical reaction is
(*a*) catalysed by light
(*b*) initiated by light
(*c*) accompanied with emission of light
(*d*) used to convert heat energy into light.

12. Plants manufacture carbohydrates from the carbon dioxide of the atmosphere by
(*a*) oxidation (*b*) polymerization
(*c*) condensation with water (*d*) a photochemical reaction.

13. The rates of purely photochemical reactions do not depend on temperature to any significant extent because
(*a*) they are exothermic reactions
(*b*) they are endothermic reactions
(*c*) the energy of the reacting molecules exceeds the activation energy by absorption of light
(*d*) they are reversible reactions.

14. The reaction between organic material and oxygen is
(*a*) an endothermic reaction (*b*) an exothermic reaction
(*c*) a photochemical reaction (*d*) a biochemical reaction.

15. An exothermic reaction is that in which the reacting substances
(*a*) have more energy than the products
(*b*) have less energy than the products
(*c*) have as much energy as the products
(*d*) are at a higher temperature than the products.

16. The formation of water from $H_2(g)$ and $O_2(g)$ is an exothermic reaction because
(*a*) $H_2(g)$ and $O_2(g)$ have a higher chemical energy than water
(*b*) $H_2(g)$ and $O_2(g)$ have a higher temperature than water

(*c*) $H_2(g)$ and $O_2(g)$ have a lower chemical energy than water
(*d*) energy considerations do not arise.

17. Which of the following is a catalytic reaction ?
(*a*) Synthesis of water by passing electric sparks through a mixture of hydrogen and oxygen
(*b*) Neutralization of a dilute alkali solution by a small amount of a conentrated acid
(*c*) Hydrolysis of an ester in the presence of H^+
(*d*) Darkening of silver halides in light.

18. A reaction which proceeds with absorption of heat is termed as
(*a*) exothermic reaction (*b*) endothermic reaction
(*c*) thermo-chemical reaction (*d*) photochemical reaction.

19. A reaction which proceeds with evolution of heat is called
(*a*) thermo-nuclear reaction (*b*) endothermic reaction
(*c*) exothermic reaction (*d*) photochemical reaction.

20. The excess energy of the reactants required to dissociates into products is known as
(*a*) activation energy (*b*) binding energy
(*c*) threshold energy (*d*) thermal energy.

21. Which one of the following reactions will be favoured by low pressure?
(*a*) $N_2O_4 \rightleftharpoons 2NO_2$ (*b*) $2HI \rightleftharpoons H_2 + I_2$
(*c*) $N_2 + O_2 \rightleftharpoons 2NO$ (*d*) $N_2 + 3H_2 \rightleftharpoons 2NH_3$.

22. For the reaction

$$H_2 + Cl_2 \xrightarrow{\text{Sunlight}} 2HCl$$

the order of reaction is
(*a*) 0 (*b*) 1
(*c*) 2 (*d*) 3.

23. For the hydrolysis of methyl acetate in presence of acids
(*a*) the order of reaction is 1 and molecularity is 2
(*b*) the order of reaction is 2 and molecularity is 2
(*c*) the order of reaction is 2 and molecularity is 1
(*d*) the order of reaction is 1 and molecularity is 1.

24. For a reaction $2A + B \xrightarrow{k} C$, the rate equation is given as

$$-r_A = kC_A^2C_B$$

The order of reaction will be
(*a*) one (*b*) two
(*c*) three (*d*) four.

25. If the time required to change the concentration of reactant to half its original value is independent of the initial concentration, the order of reaction is

(a) zero (b) one
(c) two (d) three.

26. The rate constant for a first-order reaction

(a) depends on the unit of time
(b) has units of reciprocal time
(c) does not change on changing the concentration units
(d) all of the above.

27. The rate at which a chemical substance reacts is proportional to its

(a) equivalent weight (b) atomic weight
(c) molecular weight (d) active mass.

28. Equilibrium state is

(a) dynamic
(b) static
(c) neither dynamic nor static
(d) sometimes static and sometimes dynamic.

29. At equilibrium

(a) the rate of forward reaction is equal to the rate of backward reaction
(b) the rate of forward reaction is more than the rate of backward reaction
(c) the rate of forward reaction is less than the rate of backward reaction
(d) chemical reaction stops.

30. The rate of reaction of any component is a function of

(a) temperature of the system only
(b) pressure of the system only
(c) composition of the component only
(d) temperature, pressure and composition.

31. The rate constant of a reaction depends on

(a) the temperature of the system
(b) the time of reaction
(c) the extent of reaction
(d) the initial concentration of the reactants.

32. Which of the following statements is incorrect ?

(a) A rise in temperature usually tends to reduce the reaction rate
(b) A rise in temperature usually increases reaction rates

(c) A rise in temperature does not affect photo-chemical reaction rates
(d) A rise in temperature has no effect on catalysed reaction.

33. If a_0 is the quantity of a reactant initially present, the quantity left after n half-life periods will be

(a) $(\frac{1}{2})^n a_0$ (b) $(\frac{1}{2} a_0)^n$
(c) $(\frac{1}{2} a_0)^{1/n}$ (d) $(a_0)^{1/2n}$.

34. Liquid A decomposes by irreversible first-order kinetics and the half-life period of this reaction is 12 min. The time required for 75% conversion of A is

(a) 21 min. (b) 16 min.
(c) 24 min (d) 18 min.

35. For the irreversible unimolecular type reaction $A \xrightarrow{k}$ products in a batch reactor, 80% reactant $A(C_{A0} = 1$ mole/lit.) is converted in a 480 second run and conversion is 90% after 18 minute. The order of this reaction is

(a) 1 (b) 2
(c) 1/2 (d) 3/2.

36. For the isothermal gas-phase reaction $2A \xrightarrow{k} R$, the value of ε_A which is defined as the fractional change in volume between no conversion and complete conversion, is

(a) 1 (b) 0·5
(c) – 0·5 (d) 2.

37. For the chemical reaction $3A + B \longrightarrow C$, the rate of formation of C is 0·30 mole/(1 hr). The rate of disappearance of A is

(a) 0·30 mole/(1 hr) (b) 0·90 mole/(1 hr)
(c) 0·10 mole/(1 hr) (d) – 0·30 mole/(1 hr).

38. For the chemical reaction $A \longrightarrow B$, it is found that the rate of the reaction doubles as the concentration of A is doubled. If rate $\alpha\ C_A^n$, what must n be for this reaction ?

(a) 0 (b) 1
(c) 2 (d) 0·5.

39. For the chemical reaction $A \longrightarrow B$, it is found that the rate of the reaction quadruples when the concentration of A is doubled. If rate $\alpha\ C_A^n$, what must n be ?

(a) 1/4 (b) 1
(c) 2 (d) 4.

40. For the chemical reaction $A \longrightarrow B$, it is found that the rate of the reaction increases by a factor of 8 when the concentration of A is doubled. If rate $\alpha\ C_A^n$, what must n be for this reaction ?

(*a*) 2 (*b*) 1/3
(*c*) 3 (*d*) 4.

41. For the chemical reaction $A \longrightarrow B$, it is found that the rate of the reaction triples when concentration of A is increased 9 times. If rate $\propto C_A^n$, what must n be for this reaction ?

(*a*) 3 (*b*) 9
(*c*) 1/3 (*d*) 1/2

42. A reaction follows the rate expression

$$\text{rate} = k\,C_A$$

If the rate is expressed in terms of mole/(1 sec) and the concentration of A (C_A) is in mole/lit, the units of the first-order rate constant (k) are

(*a*) 1/(mol. sec) (*b*) 1/sec
(*c*) mol/(1 sec) (*d*) sec.

43. The dimensions of the rate constant for nth order homogeneous reaction are

(*a*) $(\text{time})^{-n}$ (*b*) $(\text{time})^{-1}\,(\text{concentration})^{1-n}$
(*c*) $(\text{time})^{-n}\,(\text{concentration})^{n-1}$ (*d*) $(\text{time})\,(\text{concentration})^{n-1}$.

44. For the chemical reaction $D + E \xrightarrow{k} F$, the following rate data were found :

(*i*) the rate of formation of F doubles when concentration of E is doubled with concentration of D remaining the same ;
(*ii*) the rate of formation of F increases by a factor of 16 when the concentration of D and E are doubled.

The rate of formation of F for this reaction is given by

(*a*) $r_F = k\,C_D\,C_E$ (*b*) $r_F = k\,C_D^2\,C_E^2$
(*c*) $r_F = k\,C_D^3\,C_E$ (*d*) $r_F = k\,C_D C_E^3$.

45. For the chemical reaction $A + B + C \xrightarrow{k} D$, it was found that doubling the concentration of A doubles the rate of formation of D, doubling the concentration of B quadruples the rate of formation of D, and doubling the concentration of C has no effect of the rate of formation of D. The order of the reaction is

(*a*) 2 (*b*) 3
(*c*) 4 (*d*) 5.

46. For the chemical reaction $A + B + C \xrightarrow{k} D$, it was found that the rate of the reaction doubled when the concentration of B was doubled, that the rate of reaction doubled when the concentrations of both A and B were doubled, and quadrupled when the concentrations of both B and C were doubled. The order of the reaction is

(*a*) 2 (*b*) 3
(*c*) 4 (*d*) 6.

47. For the chemical reaction $D + 2E \xrightarrow{k} F$, it has been found that the rate of formation of F increased by a factor 2·82 when the concentration of D was doubled and increased by a factor of 9 when the concentration of E was tripled. The order of reaction is

(*a*) 3/2 (*b*) 5/2
(*c*) 7/2 (*d*) 9/2.

48. Suppose doubling the concentration of a reactant increases the rate of reaction by a facator of 4, and tripling the concentration of the reactant increases the reaction rate by a factor of 9. Then the rate of reaction is proportional to the concentration of the reactant raised to the

(*a*) first power (*b*) second power
(*c*) third power (*d*) fourth power.

49. The temperature dependence of the reaction rate constant (k) is given by the Arrhenius equation :

$$k = k_0\,e^{-E/RT}$$

where E is the energy of activation, T the absolute temperature, R the ideal gas constant, and k_0 the frequency factor which is a constant dependent on the particular reaction. What is the slope of a plot of ln k versus $1/T$ for a reaction where the energy of activation is a positive value ?

(*a*) $\ln k_0$ (*b*) $-E/R$
(*c*) E/R (*d*) $\ln (E/R)$.

50. What experimental information is necessary to determine the energy of activation for a chemical reaction ? (k_0 is an unknown constant in the Arrhenius equation)

(*a*) The reaction rate constant at one temperature is sufficient
(*b*) The reaction rate constants at two or more different temperatures must be known
(*c*) The reaction rate constants at three different temperatures must be known
(*d*) The reaction rate constants at two different temperatures and k_0 must be known.

51. If the reaction rate constants at two temperatures T_1 and T_2 are k_1 and k_2 respectively, the energy of activation, E, can be calculated using the equation

(*a*) $E = \dfrac{R\,T_1T_2}{(T_2 - T_1)} \cdot \ln\left(\dfrac{k_1}{k_2}\right)$ (*b*) $E = \dfrac{R\,T_1T_2}{(T_2 - T_1)} \cdot \ln\left(\dfrac{k_2}{k_1}\right)$

(*c*) $E = \dfrac{R\,T_1T_2}{(T_1 - T_2)} \cdot \ln(k_1 k_2)$ (*d*) $E = \dfrac{(T_2 - T_1)}{R\,T_1T_2} \cdot \ln\left(\dfrac{k_2}{k_1}\right)$

(*a*) a catalytic reaction (*b*) a photochemical reaction
(*c*) an autocatalytic reaction (*d*) a biochemical reaction.

81. The rate equation for an autocatalytic reaction

$$A + R \xrightarrow{k} R + R \text{ is}$$

$$-r_A = -\frac{dC_A}{dt} = kC_AC_R$$

The rate of disappearance of reactant A is maximum where

(*a*) $C_A = 2C_R$ (*b*) $C_A = C_R$
(*c*) $C_A = C_R/2$ (*d*) $C_A = (C_R)^{1/2}$.

82. For the consecutive unimolecular-type first-order reaction $A \xrightarrow{k_1} R \xrightarrow{k_2} S$, the concentration of component A, C_A at any time t is given by

(*a*) $C_A = C_{AO}\, e^{(k_1 + k_2)t}$ (*b*) $C_A = C_{AO}\, e^{-(k_1 + k_2)t}$
(*c*) $C_A = C_{AO}\, e^{-k_1 t}$ (*d*) $C_A = C_{AO}\, e^{k_1 t}$.

83. For the consecutive unimolecular-type first-order reactions $A \xrightarrow{k_1} R \xrightarrow{k_2} S$, the concentration of component R, C_R at any time t is given by

$$C_R = C_{AO}\, k_1 \left[\frac{e^{-k_1 t}}{(k_2 - k_1)} + \frac{e^{-k_2 t}}{(k_1 - k_2)}\right]$$

if $C_A = C_{AO}$, $C_R = C_{RO} = 0$ at $t = 0$.
The time at which the maximum concentration of R occurs is

(*a*) $t_{max} = \dfrac{k_2 - k_1}{\ln (k_2/k_1)}$ (*b*) $t_{max} = \dfrac{\ln (k_2/k_1)}{k_2 - k_1}$

(*c*) $t_{max} = \dfrac{e^{k_2/k_1}}{k_2 - k_1}$ (*d*) $t_{max} = \dfrac{e^{k_2 - k_1}}{k_2 - k_1}$.

84. For the consecutive unimolecular type first order reactions $A \xrightarrow{k_1} R \xrightarrow{k_2} S$,

(*a*) the concentration of component A increases continuously with time
(*b*) the concentration of component R increases continuously with time
(*c*) the concentration of the component S increases continuously with time
(*d*) the concentration of component R decreases to a minimum and then increases continuously with time.

85. For the irreversible elementary first-order reactions in parallel

$$A \xrightarrow{k_1} R\,;\, A \xrightarrow{k_2} S$$

a plot of concentration of component R versus concentration of component S gives a straight line with a slope of

(*a*) $k_1 + k_2$ (*b*) $k_1 - k_2$
(*c*) k_2/k_1 (*d*) k_1/k_2.

86. The rate equation for an autocatalytic reaction $A + R \xrightarrow{k_1} R + R$ is

$$-r_A = -\frac{dC_A}{dt} = kC_AC_R$$

A plot of $(-r_A)$ versus C_A gives a

(*a*) straight line with a slope of k
(*b*) straight line with a slope of 0
(*c*) parabola
(*d*) hyperbola.

87. The irreversible reaction is simply the special case of the reversible reaction if

(*a*) the concentration of the reactant at equilibrium conditions is zero
(*b*) the fractional conversion of the reactant at equilibrium conditions is zero
(*c*) the equilibrium constant is zero
(*d*) the equilibrium constant is one.

88. For the chemical reaction $A \rightarrow R$, the rate of disappearance of A is given by

$$-r_A = -\frac{dC_A}{dt} = k_1 C_A/(1 + k_2 C_A)$$

At high C_A (or $k_2C_A >> 1$)

(*a*) the reaction is of first-order with rate constant k_1
(*b*) the reaction is of first-order with rate constant k_1/k_2
(*c*) the reaction is of zero-order with rate constant k_1
(*d*) the reaction is of zero-order with rate constant k_1/k_2.

89. For the chemical reaction $A \rightarrow$ products, the rate of disappearance of A is given by

$$-r_A = -\frac{dC_A}{dt} = k_1 C_A/(1 + k_2 C_A)$$

At low C_A (or $k_2C_A << 1$) the reaction is of the first-order with rate constant

(*a*) k_1/k_2 (*b*) k_1
(*c*) k_1/k_2 (*d*) $k_1/(k_1 + k_2)$.

90. For the chemical reaction $A \rightarrow R$, the rate of disappearance of A is given by

$$-r_A = -\frac{dC_A}{dt} = k_1 C_A/(1 + k_2 C_A)$$

A plot of $1/(-r_A)$ versus $1/C_A$ gives a straight line of slope

(*a*) k_2/k_1 (*b*) $-1/k_2$
(*c*) k_1/k_2 (*d*) $1/k_1$.

91. If $-r_A = -\frac{dC_A}{dt} = 0{\cdot}2$ mol/(litre-sec) when $C_A = 1$ mol/litre, what is the rate of reaction when $C_A = 10$ mol/litre ?

(*a*) 2 mol/(litre-sec) (*b*) 0·2 mol/(litre-sec)
(*c*) 20 mol/litre-sec) (*d*) 0·02 mol/(litre-sec).

92. For the irreversible unimolecular-type first-order reaction

(*a*) the fractional conversion at any time is same for constant volume systems and variable-volume systems
(*b*) the fraction conversion at any time is more for constant volume systems than variable-volume systems
(*c*) the fractional conversion at any time is less for constant-volume systems than variable-volume systems
(*d*) the concentration of reactant at any time is same for constant-volume systems and variable-volume systems.

93. For the isothermal gas-phase reaction $A \rightarrow 3B$, the fractional change in volume of the system between no conversion and complete conversion is

(*a*) 1 (*b*) 3
(*c*) 2 (*d*) 2/3

94. For a homogeneous gas-phase reaction $A \rightarrow 3B$, the fractional change in volume of the system between no conversion and complete conversion of a 50% *A*—50% inert feed is

(*a*) 1 (*b*) 2
(*c*) 3 (*d*) 1/2.

95. The change in volume for a unimolecular-type first-order reaction $A \xrightarrow{k} 4R$

(*a*) increases linearly with time
(*b*) increases exponentially with time
(*c*) decreases exponentially with time
(*d*) varies parabolically with time.

96. The space-velocity is the proper performance measure of flow reactors. The space-velocity has the units of

(*a*) time (*b*) $(\text{time})^{-1}$
(*c*) velocity (*d*) $(\text{velocity})^{-1}$.

97. The space-velocity of 2 hr^{-1} means

(*a*) that every two hours one reactor volume of feed at specified conditions is being treated by the reactor
(*b*) that two reactor volumes of feed at specified conditions are being fed into the reactor per hour
(*c*) that the actual reactor volume is double that of the optimum reactor volume
(*d*) that one-half reactor volume of feed at specified conditions are being fed into the reactor.

98. For constant-density systems, the performance equations are identical for

(*a*) batch reactor and plug flow reactor
(*b*) batch reactor and backmix reactor
(*c*) plug flow reactor and backmix reactor
(*d*) batch reactor, plug flow reactor and backmix reactor.

99. For identical feed composition, flow rate, conversion and for all positive reaction orders, the ratio of volumes of the mixed reactor to the plug flow reactor is

(*a*) always one
(*b*) always less than one
(*c*) always greater than one
(*d*) equal to the order of reaction.

100. The batch reactor has the disadvantage(s) of

(*a*) high labour and handling cost
(*b*) poorer quality control of the product
(*c*) considerable shutdown time to empty, clean out and refill
(*d*) all of the above.

101. For identical feed composition and flow rate, *N* plug flow reactors in series with a total volume *V* gives the same conversion as a single

(*a*) plug flow reactor of volume *V*
(*b*) *CSTR* of volume *V*
(*c*) plug flow reactor of volume *V/N*
(*d*) plug flow reactor of volume *NV*.

102. *N* plug flow reactors in series with a total volume *V* gives the same conversion as a single plug flow reactor of volume *V*. The above statement is true for

(*a*) zero-order reactions only
(*b*) first-order reactions only
(*c*) second-order reactions only
(*d*) all reaction orders.

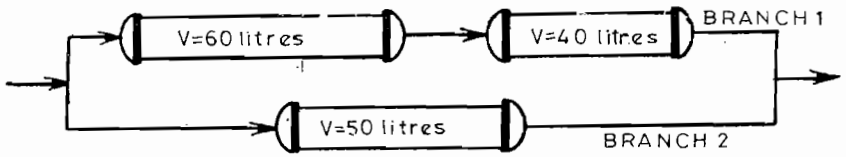


Fig. 8·1.

103. The reactor setup shown in Fig. 8·1 consists of three plug flow reactors in two parallel branches. Branch 1 has a reactor of volume 60 litres followed by a reactor of volume 40 litres. Branch 2 has a reactor of volume 50 litres. For the same conversion in each branch

(*a*) one-third of the feed must be fed to branch 1
(*b*) two-third of the feed must be fed to branch 1
(*c*) one-half the feed must be fed to branch 1
(*d*) three-fourth of the feed must be fed to branch 1.

104. The optimum size ratio for two mixed reactors in series is found in general to be dependent on the kinetics of the reaction and on the conversion level. For reaction order more than one

(*a*) the larger reactor should come first
(*b*) the smaller reactor should come first
(*c*) equal size reactors are best.

105. For a reaction whose rate-concentration curve rises monotonically (any *n*th order, $n > 0$) the reactors should be connected in series. The variation of rate with reactant concentration for a given reaction is shown in Fig. 8·2. If we have plug flow reactor, small mixed reactor, and large mixed reactor, the ordering of units for the case of Fig. 8·2 for $n > 1$ should be

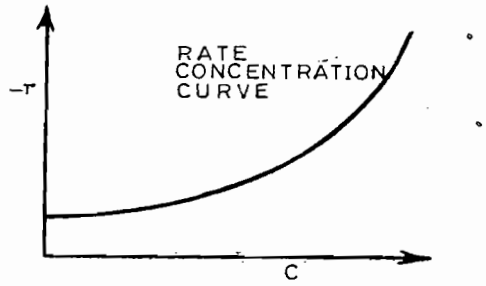


Fig. 8·2.

(*a*) plug flow, small mixed and large mixed reactor
(*b*) small mixed, large mixed and plug flow reactor
(*c*) large mixed, small mixed and plug flow reactor
(*d*) small mixed, plug flow and large mixed reactor.

106. For the reversible reaction $A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} P$, the equilibrium constant is affected

(*a*) by the pressure of the system
(*b*) by the presence or absence of inerts
(*c*) by the kinetics of the reaction
(*d*) by the temperature of the system.

107. For the reversible first-order reaction

$$A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} R \; ; \; C_A = C_{AO}, \; C_R = C_{RO} = 0 \text{ at } t = 0$$

to take place isothermally, the equilibrium fraction conversion X_{Ae} of A and the equilibrium constant K are related by

(*a*) $X_{Ae} = 1/(1 + K)$ (*b*) $X_{Ae} = (1 + K)/K$
(*c*) $X_{Ae} = 1/K$ (*d*) $X_{Ae} = K/(1 + K)$.

108. Pure gaseous reactant A ($C_{AO} = 100$ millimol/litre) is fed at steady rate into a mixed reactor where it dimerizes ($2A \longrightarrow R$). For a certain gas feed rate the concentration of A in the exit stream is found to be 50 millimol/litre. The fractional conversion of A is

(*a*) 50% (*b*) 33·33%
(*c*) 40% (*d*) 66·67%.

109. One litre per second of gaseous reactant A is introduced into a mixed reactor. The stoichiometry is $A \longrightarrow 3R$, the conversion is 50% and under these conditions the leaving flow rate is 2 litres per second. The space-time for this operation is

(*a*) 1 sec (*b*) ½ sec
(*c*) 2 sec (*d*) $^1/_3$ sec.

110. In the question 109 the holding time is

(*a*) $^1/_3$ sec (*b*) ½ sec
(*c*) 1 sec (*d*) 2 sec.

111. For a steady-state mixed reactor the space-time is equivalent to the holding time for

(*a*) constant fluid density systems
(*b*) variable fluid density systems
(*c*) non-isothermal gas reactions
(*d*) gas reactions with changing number of moles.

112. In an ideal plug flow reator at steady state

(*a*) there may be diffusion along the flow path
(*b*) there must be lateral mixing of fluid
(*c*) the composition of the reactant remains constant along a flow path
(*d*) the fractional conversion of the reactant varies from point to point along a flow path

113. In an ideal mixed reactor at steady-state

(*a*) the composition throughout the reactor remains same
(*b*) the exit stream has the same composition as the fluid within the reactor
(*c*) the space-time is equivalent to holding time for constant density systems
(*d*) all of these answers.

114. For an ideal steady-state mixed reactor the performance equation for constant-density systems is

(*a*) $\tau = \dfrac{C_{AO} - C_A}{(-r_A)V}$ (*b*) $\tau = \dfrac{C_{AO} - C_A}{(-r_A)\,C_{AO}}$

(*c*) $\tau = \dfrac{C_{AO} - C_A}{(-r_A)}$ (*d*) $\tau = \dfrac{(-r_A)}{(C_{AO} - C_A)}$.

115. For identical feed composition, flow rate, conversion and for all positive reaction orders the ratio of the volume of mixed reactor to the volume of plug flow reactor

(*a*) is independent of the order of reaction
(*b*) increases with increase in the order of reaction
(*c*) decreases with increase in the order of reaction
(*d*) increases linearly with increase in the order of reaction.

116. For identical feed composition, flow rate, conversion and for zero-order reactions the ratio of the volume of mixed reactor to the volume of plug flow reactor is

(*a*) 0 (*b*) 1
(*c*) < 1 (*d*) > 1

117. For identical feed composition, flow rate and for elementary first-order reactions, N equal-size mixed reactors in series with a total volume V gives the same conversion as a single plug flow reactor of volume V for constant-density systems. This is true for

(*a*) $N = 1$ (*b*) $N = \infty$
(*c*) $N > 1$ (*d*) $N > 1$.

118. The rate equation for an autocatalytic reaction

$$A + R \xrightarrow{k} R + R \text{ is}$$

$$-r_A = -\frac{dC_A}{dt} = kC_AC_R$$

At low conversions of A

(*a*) the mixed reactor is superior to the plug flow reactor
(*b*) the plug flow reactor is superior to the mixed reactor
(*c*) the mixed and plug flow reactors are equally good.

119. The rate equation for an autocatalytic reaction

$$B + P \xrightarrow{k} P + P \text{ is}$$

$$-r_B = -\frac{dC_B}{dt} = kC_BC_P$$

At high enough conversions of B

(*a*) the plug flow and mixed reactors are equally good
(*b*) the plug flow reactor is superior to the mixed reactor
(*c*) the mixed reactor is superior to the plug flow reactor.

120. The rate equation for an autocatalytic reaction

$$A + R \xrightarrow{k} R + R \text{ is}$$

$$-r_A = -\frac{dC_A}{dt} = kC_AC_R,\ k = 1 \text{ litre}/(\text{mol. min})$$

Feed consisting of A alone ($C_{AO} = 1$ mol/litre, $C_{RO} = 0$) is fed to a plug flow reactor at a rate of 1 mol/min. For 99% conversion of A the volume of the plug flow reactor must be

(*a*) 100 litres (*b*) 99 litres
(*c*) ∞ litres (*d*) 98 litres.

121. A first-order reaction is to be treated in a series of two mixed reactors. The total volume of the two reactors is

(*a*) minimum when the reactors are of different sizes
(*b*) maximum when the reactors are equal in size
(*c*) minimum when the reactors are equal in size.

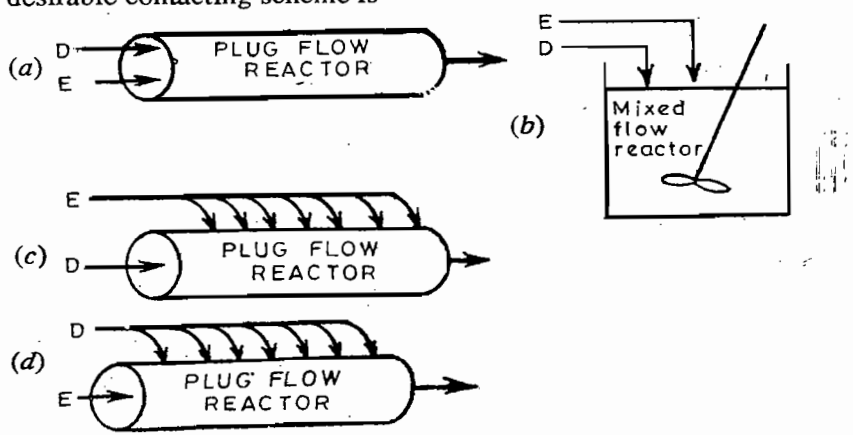
122. The desired liquid-phase reaction

$$D + E \xrightarrow{k_1} F,\ \frac{dC_F}{dt} = k_1 C_D C_E^{0.3}$$

is accompanied by the unwanted side reaction

$$D + E \xrightarrow{k_2} G,\ \frac{dC_G}{dt} = k_2 C_D^{0.5} C_E^{1.8}$$

From the standpoint of favourable product distribution, the most desirable contacting scheme is



151. Which of the following does not influence the rate of a reaction ?

(*a*) Temperature
(*b*) Concentration of reactants
(*c*) Catalyst
(*d*) Number of molecules of reactants taking part in a reaction.

152. At a certain temperature, the half-life period for the catalytic decomposition of NH_3 at 50 mmHg was 4 hour and at 100 mmHg pressure was 3·2 hour. The order of the reaction is

(*a*) two (*b*) three
(*c*) zero (*d*) one.

153. For the reaction

$$B + 2D \rightarrow 3T, -\frac{dC_B}{dt} = k C_B C_D^2$$

The expression for, $-\frac{dC_D}{dt}$ will be

(*a*) $2k\ C_B C_D^2$ (*b*) $\frac{1}{2}k\ C_B C_D^2$
(*c*) $4k\ C_B C_D^2$ (*d*) $\frac{1}{4}k\ C_B C_D^2$.

154. In a reaction, the threshold energy is equal to

(*a*) activation energy
(*b*) activation energy + normal energy of reactants
(*c*) normal energy of reactants
(*d*) activation energy—normal energy of reactants.

155. The equilibrium constant (K) for the reversible reaction $A + B \rightleftharpoons P + Q$ is 100. The rate constant for the forward reaction is $4{\cdot}5 \times 10^{-5}$. The rate constant for the backward reaction is

(*a*) $4{\cdot}5 \times 10^{-5}$ (*b*) $4{\cdot}5 \times 10^{-3}$
(*c*) $4{\cdot}5 \times 10^{-7}$ (*d*) $2{\cdot}2 \times 10^{6}$.

156. The rate of the reaction, $R + 2S \longrightarrow$ products, is given by the following equation :

$$-\frac{dC_D}{dt} = k C_R C_S^2$$

If S is present in large excess, the order of the reaction is

(*a*) zero (*b*) one
(*c*) two (*d*) three.

157. During the course of a chemical reaction, the rate of a reaction

(*a*) increases as the reaction proceeds
(*b*) decreases as the reaction proceeds
(*c*) cannot be predicted
(*d*) remains constant throughout the reaction.

158. A first order liquid-phase reaction is carried out in an ideal continuous stirred tank reactor. If a part of the outlet stream is recycled back to the reactor, the conversion will ..... .

159. In transition-state theory, the rate of the reaction is derived by assuming that the activated complex is in equilibrium with the ..... .

160. The dimensions of the rate constant for the second-order reaction are ..... .

161. Liquid A decomposes by first order kinetics in an isothermal batch reactor. Fifty percent of A is converted in 200 seconds. The time required for a conversion of 75 percent is ..... seconds.

162. In a plug flow reactor, there is ..... velocity profile.

163. The molecularity of an elementary reaction is always an integer since it refers to the ..... .

164. The reaction rate constant k is given by Arrhenius' law :

$$k = k_0 \exp(-E/RT)$$

where k_0 is called the ..... and E is called the activaion energy of the reaction.

165. According to Maxwell distribution law of molecular energies the fraction of all bimolecular collisions that involve energies in excess of minimum energy E is given approximately by ..... .

166. From Arrhenius's law a plot of ln k vs. $1/T$ gives a straight line, with large slope for ..... E.

167. Reactions with ..... activation energies are very temperature sensitive.

168. The necessary and sufficient condition for plug flow is that the ..... in the reactor is to be the same for all elements of fluid.

169. N plug flow reactors in series with a total volume V gives the same conversion as a plug flow reactor of volume ..... .

170. In the integral method of analysis, a particular form of ..... is guessed.

171. A reaction is of ..... order when the rate equation is independent of the concentration of materials.

172. Half-life of a reaction increases with increased initial concentration for orders ..... one.

173. The irreversible reaction $A \longrightarrow R$ is the special case of the reversible reaction $A \rightleftharpoons R$ in which concentration of A at equilibrium is ..... or fractional conversion of A at equilibrium is ..... or the equilibrium constant is ..... .

174. In a plug flow reactor there may be ..... mixing of fluid and there must be no mixing along the ..... .

175. A space velocity of $4h^{-1}$ means that ..... reactor volumes of feed at specified conditions are being fed into the reactor per hour.

176. For flow reactors the space time is ..... the holding time for constant-fluid density.

177. Recycling provides a mean for obtaining various degrees of ..... with a plug flow reactor.

178. The value of the integral $\int_a^b \delta(t-\tau) f(t)\, dt$ is equal to ..... if $a < \tau < b$ and ..... if ab interval does not contain τ.

179. In streamline flow of fluids through pipes, axial mixing is mainly due to fluid ..... whereas radial mixing is due to molecular diffusion alone.

180. From ..... the frequency factor does not affect the temperature sensitivity of a reaction.

Match the items in the left column with the appropriate item in the right column :

181.

(*a*) $k = k_0 e^{-E/RT}$	(*I*) Enzyme-catalyzed reaction
(*b*) Michaelis-Menten mechanism	(*II*) Arrhenius' law
(*c*) $\frac{d\ln(K)}{dT} = \frac{\Delta H_r}{RT^2}$	(*III*) Thiele modulus
(*d*) $L\sqrt{k/D}$	(*IV*) van't Hoff equation

182.

(*a*) $\int_2^4 \delta(t-3)\, t^2\, dt$	(*I*) 0
(*b*) $\int_0^2 \delta(t-3)\, t^2\, dt$	(*II*) 3
(*c*) $\int_{-\infty}^{\infty} \delta(t-3)\, t\, dt$	(*III*) 1
(*d*) $\int_{-\infty}^{\infty} \delta(t)\, e^{-kt}\, dt$	(*IV*) 9

183.

(*a*) $\frac{\tanh\left(L\sqrt{k/D}\right)}{L\sqrt{k/D}}$	(*I*) Fractional conversion
(*b*) $\frac{d\ln(k)}{dT} = E/RT^2$	(*II*) Arrhenius' law
(*c*) D/uL	(*III*) Effectiveness factor for first order reaction
(*d*) $(N_{AO}-N_A)/N_A$	(*IV*) Dispersion number

184.

(*a*) $(\ln 2)/k$	(*I*) Solid-catalyzed reactions
(*b*) Thiele modulus	(*II*) Age distribution of fluid
(*c*) Extent of non-ideal flow in a vessel	(*III*) Slope of plot of $\ln\{1/(1-X_A)\}$ vs. t for a first-order irreversible reaction
(*d*) k	(*IV*) Half life of a first-order reaction

ANSWERS

1. (*b*)	2. (*d*)	3. (*c*)	4. (*a*)	5. (*a*)
6. (*b*)	7. (*d*)	8. (*b*)	9. (*c*)	10. (*b*)
11. (*b*)	12. (*d*)	13. (*c*)	14. (*b*)	15. (*a*)
16. (*a*)	17. (*c*)	18. (*b*)	19. (*c*)	20 (*a*)
21. (*a*)	22. (*a*)	23. (*a*)	24. (*c*)	25. (*b*)
26. (*d*)	27. (*d*)	28. (*a*)	29. (*a*)	30. (*d*)
31. (*a*)	32. (*a*)	33. (*a*)	34. (*c*)	35. (*b*)
36. (*c*)	37. (*b*)	38. (*b*)	39. (*c*)	40. (*c*)
41. (*d*)	42. (*b*)	43. (*b*)	44. (*c*)	45. (*b*)
46. (*a*)	47. (*c*)	48. (*b*)	49. (*b*)	50. (*b*)
51. (*b*)	52. (*d*)	53. (*a*)	54. (*c*)	55. (*d*)
56. (*d*)	57. (*a*)	58. (*c*)	59. (*b*)	60. (*b*)
61. (*a*)	62. (*d*)	63. (*d*)	64. (*a*)	65. (*b*)
66. (*b*)	67. (*d*)	68. (*d*)	69. (*b*)	70. (*a*)
71. (*a*)	72. (*c*)	73. (*d*)	74. (*b*)	75. (*b*)
76. (*c*)	77. (*c*)	78. (*a*)	79. (*b*)	80. (*c*)
81. (*b*)	82. (*c*)	83. (*b*)	84. (*c*)	85. (*d*)
86. (*c*)	87. (*a*)	88. (*d*)	89. (*b*)	90. (*d*)
91. (*b*)	92. (*a*)	93. (*c*)	94. (*a*)	95. (*b*)
96. (*b*)	97. (*b*)	98. (*a*)	99. (*c*)	100. (*d*)
101. (*a*)	102. (*d*)	103. (*b*)	104. (*b*)	105. (*a*)
106. (*d*)	107. (*d*)	108. (*d*)	109. (*a*)	110. (*b*)
111. (*a*)	112. (*d*)	113. (*d*)	114. (*c*)	115. (*b*)
116. (*b*)	117. (*b*)	118. (*a*)	119. (*b*)	120. (*c*)
121. (*c*)	122. (*c*)	123. (*c*)	124. (*b*)	125. (*c*)

126. (*c*) 127. (*b*) 128. (*b*) 129. (*b*) 130. (*b*)
131. (*d*) 132. (*d*) 133. (*a*) 134. (*c*) 135. (*c*)
136. (*b*) 137. (*d*) 138. (*d*) 139. (*d*) 140. (*c*)
141. (*d*) 142. (*a*) 143. (*d*) 144. (*d*) 145. (*b*)
146. (*a*) 147. (*d*) 148. (*a*) 149. (*c*) 150. (*b*)
151. (*d*) 152. (*a*) 153. (*a*) 154. (*b*) 155. (*c*)
156. (*b*) 157. (*b*)

158. remain unchanged
159. reactants
160. $(\text{time})^{-1}\ (\text{conc.})^{-1}$
161. 400
162. flat
163. mechanism of reaction
164. frequency factor
165. exp (–E/RT)
166. large
167. high
168. residence time
169. V
170. rate equation
171. zero
172. greater than
173. zero, unity, infinite
174. lateral, flow path
175. four
176. equal to
177. backmixing
178. f(τ), zero
179. velocity gradients
180. Arrhenius' law

181. (*a*) - (II)
(*b*) - (I)
(*c*) - (IV)
(*d*) - (III)

182. (*a*) - (IV)
(*b*) - (I)
(*c*) - (II)
(*d*) - (III)

183. (*a*) - (III)
(*b*) - (II)
(*c*) - (IV)
(*d*) - (I)

184. (*a*) - (IV)
(*b*) - (I)
(*c*) - (II)
(*d*) - (III)

9

Instrumentation and Process Control

DEFINITIONS

Automatic control. The maintenance of desired value by measuring the existing value, comparing with the desired value and using this difference to initiate action for reducing the difference.

Cascade. A series of elements connected in sequence ; one controller manipulating the set point of another.

Controlled variable. That variable which directly or indirectly indicates the form or state of the product.

Dead time. The time interval between the application of a change to a process and the first observation of its effect.

Degree of freedom. Number of independent variables in a process.

Equal-percentage valve. A valve whose opening varies exponentially with stem position ; will change the valve opening by a percentage proportional to its opening at that point.

Installed valve characteristic. The actual relation between flow and stem position when the valve is installed in a process.

Integral control mode. Control action in which an output signal varies directly with the time integral of the deviation of the controlled variable from set point. The rate of change of output is proportional to deviation.

Laplace transform. $f(s) = \int_0^\infty e^{-st} f(t)\, dt$

Load variable. All other independent variables except controlled variable and manipulated variables.

Manipulated variable. That variable which is selected for adjustment by controller so as to maintain the controlled variable at a desired value.

On-off control. The manipulated variable is changed either to maximum value or minimum value depending on the controlled variable whether it is greater or less than the set point.

Time constant. The product of resistance and capacitance.

Transfer function. Represents the variation of one variable with any other variable in the process in the Laplacian form.

1. Which of the following is a static characteristic of instruments ?
   (*a*) Fidelity (*b*) Time lag
   (*c*) Dynamic error (*d*) Reproducibility
2. Which of the following is a dynamic characteristic of instruments ?
   (*a*) Time lag (*b*) Drift
   (*c*) Reproducibility (*d*) Span.
3. Which one of the following static characteristics of instruments is undesirable ?
   (*a*) Accuracy (*b*) Reproducibility
   (*c*) Sensitivity (*d*) Drift.
4. Which one of the following static characteristics of instruments is desirable ?
   (*a*) Static error (*b*) Drift
   (*c*) Reproducibility (*d*) Dead zone.
5. Accuracy of an instrument is judged in terms of
   (*a*) drift (*b*) dead zone
   (*c*) static error.
6. The bulb of a vapour pressure thermometer is a
   (*a*) primary element (*b*) secondary element
   (*c*) manipulating element (*d*) functioning element.
7. The Bourdon tube of a vapour pressure thermometer is a
   (*a*) primary element (*b*) secondary element
   (*c*) manipulating element (*d*) functioning element.
8. The corrector plate of a vapour pressure thermometer is
   (*a*) primary element (*b*) secondary element
   (*c*) functioning element (*d*) manipulating element.
9. The pointer of a vapour pressure thermometer is a
   (*a*) primary element (*b*) secondary element
   (*c*) manipulating element (*d*) functioning element.
10. Thermocouple in a temperature recorder is an example of
    (*a*) primary element (*b*) secondary element
    (*c*) manipulating element (*d*) functioning element.
11. Ordinary mercury-in-glass thermometer (without any covering or air gap) is an example of
    (*a*) first-order system
    (*b*) overdamped second-order system
    (*c*) underdamped second-order system
    (*d*) multiple first-order systems.

12. U-tube type mercury manometer is an example of
    (*a*) zero-order system (*b*) first-order system
    (*c*) second-order system (*d*) third-order system.
13. Which of the following is not a first order instrument ?
    (*a*) U-tube type mercury manometer
    (*b*) Bimetallic thermometer (bare)
    (*c*) Vapour pressure thermometer (bare)
    (*d*) Ordinary mercury-in-glass thermometer (without any covering or air gap).
14. Which of the following is a first-order instrument ?
    (*a*) U-tube type mercury manometer
    (*b*) Bimetallic thermometer with covering
    (*c*) Vapour pressure thermometer without any covering
    (*d*) Mercury thermometer with covering.
15. Measuring lag of a first-order instrument is taken as
    (*a*) zero (*b*) one time constant
    (*c*) two time constant (*d*) hal time constant.
16. Dynamic error for a ramp input (At) in a first-order instrument is
    (*a*) $\sqrt{AT}$ (*b*) AT
    (*c*) $2\,AT$ (*d*) $1/2\,AT$
    where T = time constant of instrument.
17. Time lag of a first-order instrument is
    (*a*) T (*b*) $(1/\omega)\tan^{-1}(\omega T)$
    (*c*) $\omega \tan^{-1}(\omega T)$ (*d*) e^{-T}
    where T = time constant of instrument
    ω = radian frequency.
18. Time lag of a second-order instrument is
    (*a*) $(1/\omega)\tan^{-1}(\omega T)$ (*b*) T
    (*c*) $(1/\omega)\tan^{-1}\left(\dfrac{2\xi\omega T}{1-\omega^2T^2}\right)$ (*d*) $\tan^{-1}\left(\dfrac{2\xi\omega T}{1-\omega^2T^2}\right)$
    where T = time constant of instrument
    ω = radian frequency
    ξ = damping coefficient.
19. Dynamic error for a ramp input (At) in a critically damped second-order instruments is
    (*a*) AT (*b*) $1/2\,AT$
    (*c*) $\sqrt{AT}$ (*d*) $2\,AT$
    where T = time constant of instrument.

(*b*) electrical resistance with temperature
(*c*) e.m.f. generated in a single homogeneous wire and the temperature difference.

54. For a given thermocouple, e.m.f. generated
(*a*) depends on the tempaterature of hot junction
(*b*) depends on the temperature of cold junction
(*c*) depends on the temperature difference between hot and cold junctions
(*d*) is constant for all temperature differences between hot and cold junctions.

55. The generation of e.m.f. in thermocouples is fundamentally explained by
(*a*) Seebeck effect (*b*) Peltier effect
(*c*) Thomson effect (*d*) all of the above.

56. Which one of the following properties of thermocouples for industrial use is undesirable ?
(*a*) Relative large thermal e.m.f.
(*b*) Resistance to corrosion and oxidation
(*c*) Non-linear relation of e.m.f. to temperature
(*d*) Precision of calibration.

57. The response of bare thermocouples of different size wires is shown in Fig. 9·1. Which curve shows the response of bare thermocouple of minimum wire size ?

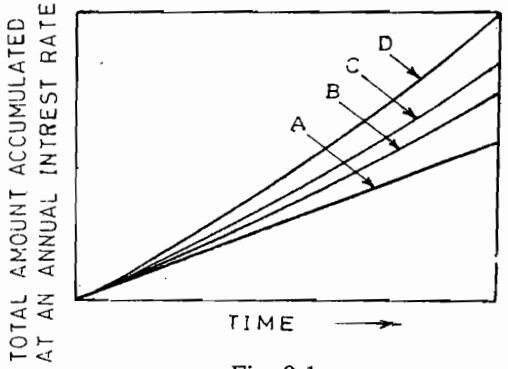


Fig. 9·1.

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*.

58. Which curve in Fig. 9·1 shows the response of bare thermocouple of maximum wire size ?
(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*.

59. For platinum thermocouples, lead wires are made of
(*a*) iron and copper
(*b*) copper and copper-nickel alloy
(*c*) nickel and iron
(*d*) tin and nickel.

60. Invar is a
(*a*) iron-nickel alloy containing about 36% nickel
(*b*) copper-nickel alloy containing about 36% nickel
(*c*) zinc-nickel alloy containing about 36% nickel
(*d*) tin-nickel alloy containing about 36% nickel.

61. Monel is an alloy of
(*a*) Ni (69%) and Cu (28%) (*b*) Ni (69%) and Cr (31%)
(*c*) Cu (55%) and Sn (45%) (*d*) Fe (90%) and Cr (10%).

62. Constantan is an alloy of
(*a*) Cu (55%) and Sn (45%) (*b*) Cu (55%) and Ni (44%)
(*c*) Fe (55%) and Ni (44%) (*d*) Pt (90%) and Rh (10%).

63. Thermocouple in a well behaves as a true
(*a*) first-order system
(*b*) multiple first-order system
(*c*) underdamped second-order system
(*d*) overdamped second-order system.

64. The e.m.f. generated in thermocouples is of the order of
(*a*) volts (*b*) millivolts
(*c*) microvolts (*d*) kilovolts.

65. Thermopile is used for the measurement of
(*a*) current (*b*) e.m.f.
(*c*) temperature (*d*) flow rate.

66. Bolometer works on the principle of
(*a*) change of electrical resistance with change in temperature
(*b*) volumetric expansion of mercury with increase in temperature
(*c*) increase of vapour pressure with increase in temperature
(*d*) linear expansion with increase in temperature.

67. Bolometer is used for the measurement of
(*a*) temperature (*b*) flow rate
(*c*) current (*d*) e.m.f.

68. Resistance thermometers work on the principle of
(*a*) increase of electrical resistance with increase in temperature
(*b*) increase in vapour pressure with increase in temperature

(*c*) linear expansion of metal with increase in temperature
(*d*) e.m.f. generated in a single homogeneous wire with increase in temperature.

69. A mercury-in-glass thermometer and a platinum resistance thermometer are calibrated from measurements on ice and steam points. The two thermometers then necessarily agree
(*a*) at every temperature
(*b*) only at the calibrated points
(*c*) at temperature midway between the calibrated points
(*d*) at temperatures near zero kelvin.

70. The resistance of platinum
(*a*) increases with increase in temperature
(*b*) decreases with increase in temperature
(*c*) remains constant with change in temperature
(*d*) decreases linearly with increase in temperature.

71. Resistivity is minium for
(*a*) Ni (*b*) Pt
(*c*) Cu.

72. Conductivity of platinum
(*a*) remains constant with change in temperature
(*b*) increases with increase in temperature
(*c*) decreases with increase in temperature
(*d*) increases linearly with increase in temperature

73. The temperature coefficient of resistance of a wire is 0·00125 per °C. At 300 K its resistance is 1 ohm. The resistance of the wire will be 2 ohms at
(*a*) 1154 K (*b*) 1100 K
(*c*) 1400 K (*d*) 1127 K.

74. On increasing temperature, the resistance will decrease for
(*a*) platinum (*b*) carbon
(*c*) copper (*d*) constantan.

75. In the thermistors resistance
(*a*) remains unaffected with change in temperature
(*b*) increases with increase in temperature
(*c*) increases linearly with increase in temperature
(*d*) decreases with increase in temperature.

76. Thermistor is made of
(*a*) oxides or salts of metals
(*b*) metals

(*c*) two different metals
(*d*) two similar metal wires.

77. Radiation pyrometer works on the principle of
(*a*) Stefan-Boltzmann law (*b*) Ohm's law
(*c*) Seebeck effect (*d*) Curie's law.

78. The refractive index of a gas
(*a*) is inversely proportional to temperature
(*b*) is directly proportional to temperature
(*c*) is independent of temperature
(*d*) varies as the square root of temperature.

79. Refractometer works on the principle of
(*a*) polarisation of light
(*b*) change of angle of refraction with composition
(*c*) change of the electrical conductivity of solution with composition
(*d*) change of the electrical conductivity of solution with temperature.

80. Polarimeter works on the principle of
(*a*) polarisation of light
(*b*) change of the electrical conductivity of solution with composition.
(*c*) change of angle of refraction with composition
(*d*) change of electrical conductivity of solution with temperature.

81. Polarimeter is used for the analysis of
(*a*) any liquid solution
(*b*) sugars and chemicals having symmetrical structures
(*c*) any solid
(*d*) any gaseous mixture.

82. Conductivity meter works on the principle of
(*a*) change of angle of refraction with composition
(*b*) polarisation of light
(*c*) change of electrical conductivtiy of solution with composition
(*d*) change of electrical resistance with temperature.

83. Specific conductance in conductivity meter is defined as
(*a*) $\frac{1}{AR}$ (*b*) $\frac{R}{A}$
(*c*) $\frac{A}{R}$ (*d*) AR
where R = resistance of the liquid
$1/A$ = cell constant.

84. The units of specific conductance are
(*a*) ohm/cm (*b*) mho/cm
(*c*) ohm-cm (*d*) mho-cm.

85. Specific conductance in micro-mho/cm of a good quality distilled water is

(*a*) 0·01 (*b*) 0·1
(*c*) 1 (*d*) 10.

86. Specific conductance in micro-mho/cm of a excellent quality raw water is

(*a*) 100 (*b*) 1000
(*c*) 10 (*d*) 0·01.

87. Select the correct expression for pH

(*a*) $pH = -\log_e [H^+]$ (*b*) $pH = -\log_{10} [H^+]$

(*c*) $pH = \log_{10} [H^+]$ (*d*) $pH = -\frac{1}{\log_{10}[H^+]}$

where $[H^+]$ is the hydrogen ion concentration of a solution in moles per litre.

88. If a solution has pH = 2, it is

(*a*) highly acidic (*b*) weakly acidic
(*c*) neutral (*d*) alkaline.

89. At room temperature $[H^+][OH^-]$ is equal to

(*a*) 10^{-7} moles/litre (*b*) 10^{-14} moles/litre
(*c*) 10^{-10} moles/litre (*d*) 10^{-16} moles/litre.

90. If $[OH^-] = 10^{-6}$ moles/litre, its pH is

(*a*) 6 (*b*) 8
(*c*) 12 (*d*) 3.

91. If pH = 5, then $[H^+]$, in moles/litre, is

(*a*) 5×10^{-1} (*b*) 0·0005
(*c*) 6×10^{-5} (*d*) 0·00001.

92. The solution will be alkaline when pH is

(*a*) less than 7 (*b*) equal to 7
(*c*) greater than 7 (*d*) less than or equal to 7.

93. The solution will be acidic when

(*a*) pH > 7 (*b*) pH = 7
(*c*) pH ≥ 7 (*d*) pH < 7.

94. Which of the following expressions is correct for perfect neutral solution ?

(*a*) $\frac{[H^+]}{[OH^-]} > 1$ (*b*) $\frac{[H^+]}{[OH^-]} = 1$

(*c*) $\frac{[H^+]}{[OH^-]} < 1$ (*d*) $[H^+] + [OH^-] = 0$.

95. pH of perfect neutral solution is

(*a*) 7 (*b*) 5
(*c*) 0 (*d*) 1.

96. If the pH of a solution changes by 1 unit, the corresponding change in the hydrogen ion concentration of the solution is

(*a*) 2·3 times (*b*) 10 times
(*c*) 23 times (*d*) 100 times.

97. Polarograph is used for the analysis of

(*a*) solids (*b*) liquids
(*c*) gases (*d*) liquids and gases.

98. Composition of CO_2 in the flue gas is determined by

(*a*) polarograph (*b*) mass spectrometer
(*c*) thermal conductivity cell (*d*) polarimeter.

99. Amount of moisture in air is determined by

(*a*) refractometer (*b*) polarimeter
(*c*) hygrometer (*d*) polarograph.

100. Composition of alloys is commonly determined by

(*a*) thermal conductivity cell (*b*) mass spectrometer
(*c*) polarograph (*d*) polarimeter.

101. Flow rate of sludge is commonly determined by

(*a*) orifice meter (*b*) venturi meter
(*c*) open weir. (*d*) rotameter.

102. A convenient unit for expressing very low pressures is the micron. A micron, abbreviated μ is

(*a*) 0·1 mm of Hg column absolute pressure at 0°C
(*b*) 1 mm of Hg column absolute pressure at 0°C
(*c*) 0·01 mm of Hg column absolute pressure at 0°C
(*d*) 0·001 mm of Hg column absolute pressure at 0°C.

103. Mercury used as manometer liquid has the disadvantage(s) that it

(*a*) amalgamates or corrodes many metals
(*b*) is expensive
(*c*) is poisonous
(*d*) all of the above.

104. A disadvantage of using water as manometer liquid is its

(*a*) high vapour pressure (*b*) corrosive nature
(*c*) high boiling point (*d*) low vapour pressure.

105. Which of the following manometer liquids has maximum capillary rise relative to mercury ?

(*a*) Water (*b*) Mercury
(*c*) Carbon tetrachloride (*d*) Ethyl alcohol.

106. Which of the following manometer liquids has minimum capillary rise relative to mercury ?

(*a*) Water (*b*) Mercury
(*c*) Ethyl alcohol (*d*) Carbon tetrachloride.

107. Liquid column manometers are used to measure

(*a*) differential pressures of greater than 30 psi
(*b*) differential pressures of less than 30 psi
(*c*) high vacuums
(*d*) atmospheric pressure.

108. Bourdon gauges are used to measure pressures

(*a*) above 30 psia (*b*) below 30 psia
(*c*) below 3 microns (*d*) below 14·7 psia.

109. Ionisation gauge is used to measure

(*a*) pressure (*b*) vacuum
(*c*) flow rate (*d*) composition.

110. Mcleoid gauge is used to measure

(*a*) pressures of greater than 30 psia
(*b*) pressures of less than 30 psia
(*c*) high vacuums
(*d*) atmospheric pressure.

111. Tachometer is used to measure

(*a*) speed (*b*) pressure
(*c*) composition (*d*) speed.

112. Stroboscope is used to measure

(*a*) speed (*b*) flow rate
(*c*) pressure (*d*) composition.

113. Rapid moisture meter works on the principle of

(*a*) loss of moisture by heat
(*b*) electrical conductivity of sample
(*c*) reaction of moisture with CaC_2.

114. The process reaction rate is

(*a*) directly proportional to its capacity
(*b*) inversely proportional to its capacity
(*c*) inversely proportional to the square root of its capacity
(*d*) directly proportional to the square of its capacity.

115. The proportional band

(*a*) is always more than 100% (*b*) may be more than 100%
(*c*) is always less than 10% (*d*) is always zero.

116. Control valves are normally provided with radiating fins if the fluid temperature exceeds

(*a*) 100°F (*b*) 200°F
(*c*) 50°F (*d*) 450°F.

117. A symbol for instrumentation diagram shown in Fig. 9·2 stands for

(*a*) pneumatic control valve
(*b*) electrically operated control valve
(*c*) hydraulically operated control valve
(*d*) safety valve.

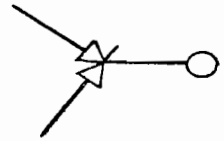


Fig. 9·2.

118. A symbol for instrumentation diagram shown in Fig. 9·3 stands for

(*a*) safety valve
(*b*) hydraulically operated control valve
(*c*) pneumatic control valve
(*d*) electrically operated control valve.

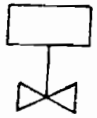


Fig. 9·3.

119. A symbol for instrumentation diagram shown in Fig. 9·4 stands for

(*a*) safety valve
(*b*) electrically operated control valve
(*c*) pneumatic control valve
(*d*) hydraulically operated control valve.

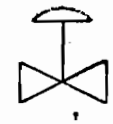


Fig. 9·4.

120. A symbol for instrumentation diagram shown in Fig. 9·5 stands for

(*a*) hydraulically operated control valve
(*b*) pneumatic control valve
(*c*) safety valve
(*d*) electrically operated control valve.

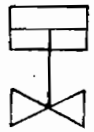
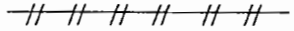
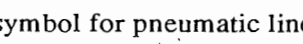
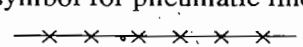
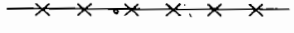
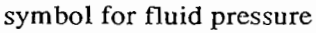


Fig. 9·5.

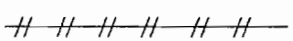
121. A symbol for electrical line in instrumentation diagram is

(*a*)  (*b*)
(*c*)  (*d*) 

122. A symbol for pneumatic line in instrumentation diagram is

(*a*)  (*b*)
(*c*)  (*d*)

123. A symbol for fluid pressure line in instrumentation diagram is

(*a*)  (*b*)
(*c*) (*d*)

124. The Laplace transform of a function $f(t)$ is defined to be $f(s)$ according to the equation

(a) $f(s) = \int_0^\infty f(t)\, e^{st}\, dt$ (b) $f(s) = \int_0^\infty f(t)\, e^{-st}\, dt$

(c) $f(s) = \int_0^1 f(t)\, e^{-st}\, dt$ (d) $f(s) = \int_0^1 f(t)\, e^{st}\, dt$.

125. The Laplace transform of unit-step change is

(a) 1 (b) $1/s$
(c) s (d) $1/(s+1)$.

126. The Laplace transform of e^{-at} is

(a) $1/(s + a)$ (b) $1/(s-a)$
(c) $a/(s + a)$ (d) $a/(s-a)$.

127. The Laplace transform of a ramp input of slope A is

(a) A/s (b) A
(c) A/s^2 (d) A/s^3.

128. The Laplace transform of $\sin kt$ is

(a) $k/(s^2 + k^2)$ (b) $s/(s^2 + k^2)$
(c) $k/(s^2-k^2)$ (d) $s/(s^2-k^2)$.

129. The Laplace transform of $\cos kt$ is

(a) $k/(s^2-k^2)$ (b) $s/(s^2 + k^2)$
(c) $k/(s^2 + k^2)$ (d) $s/(s^2-k^2)$.

130. The Laplace transform of $d f(t)/dt$ is

(a) $sf(s)$ (b) $sf(s) - f(o)$
(c) $sf(s) + f(o)$ (d) $f(s) - f(o)$.

where $f(s) = L\{f(t)\}$ and $f(o)$ is $f(t)$ evaluated at $t = 0$

131. The Laplace transform of $\dfrac{d^2 f(t)}{dt^2}$ is

(a) $s^2 f(s) - sf(o) - f'(o)$ (b) $s^2 f(s) - f(o) - f'(o)$
(c) $s^2 f(s) - sf'(o) - f(o)$ (d) $s^2 f(s) - sf(o) - sf'(o)$

where $f(s) = L\{f(t)\}$.

$$f'(0) = \left.\frac{df(t)}{dt}\right|_{t=0}$$

$f(o) = f(t)$ at $t = 0$.

132. If $f(s)$ is the Laplace transform of $f(t)$, then the Laplace transform of $e^{-at} f(t)$ is

(a) $f(s-a)$ (b) $f(s + a)$
(c) $e^{-as} f(s)$ (d) $e^{-as} f(s + a)$.

133. The Laplace transform of impulse function of magnitude A is

(a) A (b) A/s
(c) A/s^2 (d) $1/(s + A)$.

134. If $f(s)$ is the Laplace transform of $f(t)$, then the Laplace transform of $\int_0^t f(t)\, dt$ is

(a) $sf(s)$ (b) $f(s)/s$
(c) $s/f(s)$ (d) $f(s) + s$.

135. The Laplace transforms of t^n is

(a) $n!/s^n$ (b) $n!/s^{n+1}$
(c) n/s^{n+1} (d) $(n + 1)!/s^{n+1}$

136. The Laplace transform of

$$f(t) = \begin{cases} 0\,;\ t < 0 \\ 1/h\,;\ 0 \le t \le h \\ 0\,;\ t > h \end{cases}$$

is

(a) $\dfrac{1}{hs}$ (b) $\dfrac{1-e^{-hs}}{hs}$

(c) $\dfrac{e^{-hs}}{hs}$ (d) $\dfrac{1 + e^{-hs}}{hs}$.

137. The inverse Laplace transform of $s/(s^2-k^2)$ is

(a) $\sin kt$ (b) $\cos kt$
(c) $\sinh kt$ (d) $\cosh kt$.

138. The inverse Laplace transform of $1/(s + a)^N$ is

(a) $\int_0^t \dfrac{t^{N-1} e^{-at}}{(N-1)}\, dt$ (b) $\int_0^t \dfrac{t^N e^{-at}}{N!}\, dt$

(c) $\int_0^t \dfrac{t^{N-1} e^{-at}}{(N-1)!}\, dt$ (d) $\int_0^t \dfrac{t^{N-1} e^{at}}{(N-1)!}\, dt$.

139. The inverse Laplace transform of $1/(Ts + 1)$ is

(a) $e^{-t/T}$ (b) $\dfrac{1}{T} e^{-t/T}$

(c) $\dfrac{1}{T} e^{t/T}$ (d) $T e^{t/T}$.

140. The magnitude of a complex number $x + jy$ is

(a) $x^2 + y^2$ (b) $\sqrt{x^2 + y^2}$
(c) $(x + y)^2$ (d) $x + y$.

141. Phase angle of a complex number $x + jy$ is

(a) $\tan^{-1}(x/y)$ (b) $\tan^{-1}(x + y)$

(*c*) $\tan^{-1}(y/x)$ (*d*) $\tan^{-1}(x-y)$.

142. Controlled variable in a water heater is

(*a*) the outlet water temperature
(*b*) the water flow rate
(*c*) the heat input rate
(*d*) the inlet water temperature.

143. Manipulated variable in water heater is

(*a*) the outlet water temperature
(*b*) the inlet water temperature
(*c*) the heat input rate
(*d*) the water flow rate.

144. Load variable in water heater is

(*a*) the outlet water temperature
(*b*) the inlet water temperature
(*c*) the heat input rate
(*d*) none of these answers.

145. Controlled vairable in an exothermic CSTR is

(*a*) the inlet temperature of reactants
(*b*) the inlet concentrations of reactants
(*c*) the temperature in the reactor
(*d*) the flow rate of coolant.

146. Manipulated variable in an exothermic CSTR is

(*a*) the inlet temperature of reactants
(*b*) the temperature of reaction mixture
(*c*) the inlet concentrations of reactants
(*d*) the flow rate of coolant.

147. Load variable in an exothermic CSTR is

(*a*) the inlet temperature of reactants
(*b*) the flow rate of coolant
(*c*) the temperature of reaction mixture
(*d*) none of these answers.

148. Controlled variable in an endothermic CSTR is

(*a*) the temperature in the reactor
(*b*) the inlet temperature of reactants
(*c*) the heat input rate
(*d*) the inlet concentrations of reactants.

149. Manipulated variable in an endothermic CSTR is

(*a*) the inlet temperature of reactants
(*b*) the inlet concentrations of reactants
(*c*) the temperature in the reactor
(*d*) the heat input rate.

150. Load variable in an endothermic CSTR is

(*a*) the inlet temperature of reactants
(*b*) the temperature of reaction mixture
(*c*) the heat input rate
(*d*) none of these answers.

151. Controlled variable in a heat exchanger is

(*a*) the outlet temperature of cooling or heating fluid
(*b*) the flow rate of heating or cooling fluid
(*c*) the inlet temperature of heating fluid or cooling.

152. Manipulated variable in a heat exchanger is

(*a*) the inlet temperature of heating or cooling fluid
(*b*) the outlet temperature of cooling or heating fluid
(*c*) the flow rate of heating or cooling fluid.

153. Load variable in a heat exchanger is

(*a*) the inlet temperature of heating or cooling fluid
(*b*) the flow rate of heating or cooling fluid
(*c*) the outlet temperature of cooling or heating fluid.

154. An input which increases linearly with time is known as

(*a*) step-input (*b*) impulse-input
(*c*) sinusoidal-input (*d*) ramp-input.

155. The general transfer function of a first-order system is

(*a*) $1/(Ts-1)$ (*b*) $A/(Ts+1)$
(*c*) $A/(Ts-1)$ (*d*) $Ts+1$.

156. Time constant of a system has

(*a*) no units (*b*) has the units of time
(*c*) the units of $(\text{time})^{-1}$ (*d*) the units of linear velocity.

157. Time constant of a first-order system is numerically equal to

(*a*) (resistance)/(capacitance) (*b*) (capacitance)/(resistance)
(*c*) (capacitance)(resistance) (*d*) (resistance) $(\sqrt{\text{capacitance}})$.

158. Resistance of a first-order system is defined as the ratio of the change in

(*a*) driving force to the change in flow
(*b*) storage of a quantity to the change in driving force
(*c*) storage of a quantity to the change in flow
(*d*) driving force to the change in storage of a quantity.

159. Capacitance of a first order-system is defined as the ratio of the change in

(*a*) driving force to the change in flow

(*b*) storage of a quantity to the change in driving force
(*c*) storage of a quantity to the change in flow
(*d*) driving force to the change in storage of a quantity.

160. Time constant of a first-order system is defined as the time taken for the system's output to reach 63·2 per cent of its ultimate value after
(*a*) a step change in input (*b*) an impulse change in input
(*c*) a ramp change in input (*d*) a sinusoidal change in input.

161. Time constant of a mixer is equal to
(*a*) volume of mixture/volumetric flow rate of solution
(*b*) volumetric flow rate of solution/volume of mixture
(*c*) volumetric flow rate of solution/cross-sectional area of mixture
(*d*) cross-sectional area of mixture/volumetric flow rate of solution.

162. Time constant of mercury-in-glass thermometer (without covering or air gap) is equal to

(*a*) $\frac{hA}{mC}$ (*b*) $\frac{mC}{hA}$
(*c*) $\frac{m}{hA}$ (*d*) $\frac{mC}{h}$

where m = mass of mercury in bulb
C = heat capacity of mercury
h = film coefficient of heat transfer
A = surface area of bulb for heat transfer.

163. The rate of response of the first-order system is
(*a*) independent of time constant.
(*b*) directly proportional to the time constant
(*c*) inversely proportional to the time constant
(*d*) inversely proportional to the square of time constant.

164. The response of a first-order system $[G(s) = 1/(Ts + 1)]$ to an unit-step change in input is given by
(*a*) $(1-e^{-t/T})/T$ (*b*) $1-e^{-t/T}$
(*c*) $\frac{e^{-t/T}}{T}$ (*d*) $1 + e^{-t/T}$.

165. The response of a first-order system $[G(s) = 1/(Ts + 1)]$ to an unit-impulse change in input is given by
(*a*) $1-e^{-t/T}$ (*b*) $(1-e^{-t/T})/T$
(*c*) $\frac{e^{-t/T}}{T}$ (*d*) $T_e^{-t/T}$.

166. The steady-state response of a first-order system $[G(s) = 1/(Ts + 1)]$ to a sinusoidal forcing function is given by

(*a*) $\frac{A}{T^2\omega^2 + 1}\sin(\omega t + \phi)$ (*b*) $\frac{A}{\sqrt{T^2\omega^2 + 1}}\sin(\omega t)$
(*c*) $\frac{1}{T^2\omega^2 + 1}\sin(\omega t + \phi)$ (*d*) $\frac{A}{\sqrt{T^2\omega^2 + 1}}\sin(\omega t + \phi)$

where A = input amplitude
ω = radian frequency
$\phi = \tan^{-1}(-\omega T)$.

167. In the steady-state response of a first-order system $[G(s) = 1/(Ts + 1)]$ to a sinusoidal forcing function, the ratio of output amplitude to input amplitude is

(*a*) $\frac{1}{T^2\omega^2 + 1}$ (*b*) $\frac{A}{\sqrt{T^2\omega^2 + 1}}$
(*c*) $\frac{1}{\sqrt{T^2\omega^2 + 1}}$ (*d*) $\frac{1}{(T\omega + 1)^2}$

where A = input amplitude
ω = radian frequency.

168. Phase angle (ϕ) of the sinusoidal response of a first-order system is given by
(*a*) $\phi = \tan(\omega T)$ (*b*) $\phi = \tan^{-1}(-\omega T)$
(*c*) $\phi = \tan^{-1}(\omega T)$ (*d*) $\phi = \sin^{-1}(-\omega T)$.

169. Phase lag of a sinusoidal response to a first-order system is always
(*a*) $\leq 90°$ (*b*) 180°
(*c*) 120° (*d*) 135°.

170. Step response of a first-order system is
(*a*) underdamped (*b*) critically damped
(*c*) overdamped (*d*) undamped.

171. Time required for a first-order system's output to reach 90% of its ultimate value after a step change in input is
(*a*) 2 T (*b*) 4·606 T
(*c*) 3 T (*d*) 2·303 T
where T = time constant.

172. If y is the fractional response of a first-order system to a step change in input at any time t, the time-constant is given by

(*a*) $\left.\frac{dy}{dt}\right|_{t=0}$ (*b*) $\left.\frac{1}{\frac{dy}{dt}}\right|_{t=0}$
(*c*) $\left.\frac{dy}{dt}\right|_{t=\infty}$ (*d*) $\left.\frac{1}{\frac{dy}{dt}}\right|_{t=\infty}$

173. If y is the fractional response of a first-order system $\left[G(s) = \frac{1}{Ts + 1}\right]$ to a step-change in input at any time t, a plot of ln $(1-y)$ versus t gives a straight line of slope

(a) T (b) $1/T$
(c) $-1/T$ (d) $-T$.

174. The time required to achieve the fractional response of 0·5 of a first-order system to a step-change in input is

(a) (ln 2) T (b) (ln 4) T
(c) (ln 5) T (d) (ln 10) T
where T = time constant of system.

175. The time required to achieve a fractional response of 0·75 of a first-order system to a step-change in input is

(a) (ln 2) T (b) (ln 4) T
(c) (ln 5) T (d) (ln 10) T
where T = time constant of system.

176. The fractional response of a first-order system $\left[G(s) = \frac{1}{Ts + 1}\right]$ to a step-change in input after time t = (ln 10) T is

(a) 80 per cent (b) 90 per cent
(c) 99 per cent (d) 99·9 per cent.

177. For a first-order system to a step-change in input, the time required for the response to go from 0 to 50 per cent is the same as the time to go from

(a) 50 to 100 per cent (b) 50 to 75 per cent
(c) 50 to 90 per cent (d) 50 to 80 per cent.

178. For a first-order system to a step-change in input, the time required for the response to go from 0 to 90 per cent is the same as the time to go from

(a) 90 to 95 per cent (b) 90 to 99 per cent
(c) 90 to 99·9 per cent (d) 90 to 96 per cent.

179. Time constant of a mixer is

(a) equal to the hold up time
(b) less than the hold up time
(c) greater than the hold up time
(d) zero.

180. A first-order unimolecular irreversible reaction $A \xrightarrow{k} P$ is occurring in a CSTR. The time constant of the system is

(a) equal to the hold up time
(b) less than the hold up time
(c) greater than the hold up time
(d) $(1/k)$ times the hold up time.

181. In problem 180, as the rate constant (k) becomes very large, the time-constant approaches

(a) k (b) $1/k$
(c) $\frac{1}{k+1}$ (d) infinity.

182. If the reaction $A \xrightarrow{k} P$ occuring in a CSTR is zero-order, the time-constant is

(a) equal to the hold up time
(b) $1/k$
(c) k times the hold up time
(d) $(1/k)$ times the hold up time.

183. Gases A and B are fed continuously to a tank with a volume of 30 ft^3. The normal tank conditions are 40 psia and 80°F and the normal flow rates of A and B are 40 and 10 cfm, respectively, measured at tank conditions. What is the time-constant of the system ?

(a) 0·75 min. (b) 3 min.
(c) 0·60 min. (d) 1·67 min.

184. For an open tank discharging water into the air, the time-constant is

(a) equal to the hold up time
(b) twice the hold up time
(c) four times the hold up time
(d) half of the hold up time.

185. The time constant for the pressure system shown in Fig. 9·6 is equal to the hold up time when

(a) the input is independent of tank pressure and the output is directly proportional to tank pressure
(b) the output and input are independent of tank pressure
(c) the output is independent of tank pressure and the input is directly proportional to tank pressure
(d) the input and output are directly proportional to the tank pressure.

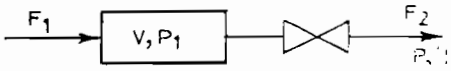


Fig. 9·2.

186. The general transfer function of a second-order system is

(*a*) $\dfrac{1}{(T^2s^2 + 4\xi Ts + 1)}$ (*b*) $\dfrac{R}{(T^2s^2 + 2\xi Ts + 1)}$

(*c*) $R(T^2s^2 + 2\xi Ts + 1)$ (*d*) $\dfrac{R}{(T^2s^2 + 1)}$

187. The general transfer function of a second order system is $R/(T^2s^2 + 2\xi Ts + 1)$, where ξ

(*a*) is a measure of the degree of damping
(*b*) is a measure of the period of response
(*c*) has the units of time
(*d*) all of the these answers.

188. For underdamped second-order response, damping coefficient (ξ) is

(*a*) equal to 1 (*b*) less than 1
(*c*) greater than 1 (*d*) equal to zero.

189. For overdamped second-order response, damping coefficient (ξ) is

(*a*) equal to zero (*b*) equal to 1
(*c*) greater than 1 (*d*) less than 1.

190. For critically damped second-order response, damping coefficient (ξ) is

(*a*) equal to zero (*b*) equal to 1
(*c*) less than 1 (*d*) greater than 1.

191. In underdamped second-order response

(*a*) overshoot = decay ratio (*b*) overshoot = (decay ratio)^2
(*c*) overshoot = $\sqrt{\text{decay ratio}}$ (*d*) overshoot = (decay ratio)^3.

192. With a damping coefficient of zero, the system is

(*a*) undamped (*b*) critically damped
(*c*) underdamped (*d*) overdamped.

193. U-tube manometer filled with mercury is an example of

(*a*) undamped second-order system
(*b*) overdamped second-order system
(*c*) underdamped second-order system
(*d*) critically damped second-order system.

194. The radian frequency ω is related to the period of oscillation T_p (time/cycle) by

(*a*) $\omega = T_p$ (*b*) $T_p = 2\pi/\omega$
(*c*) $T_p = 2\pi\omega$ (*d*) $\omega = 2\pi T_p$.

195. If the unit-step response of a second-order response oscillates continuously without attenuation in amplitude, the radian frequency is

(*a*) $\dfrac{1}{2\pi T_p}$ (*b*) $\dfrac{2\pi}{T_p}$

(*c*) $\dfrac{1}{T_p}$ (*d*) $\dfrac{1}{2T_p}$

where T_p = period of oscillation (time/cycle).

196. The steady-state response of a second-order system $\left[G(s) = \dfrac{1}{(T^2s^2 + 2\xi Ts + 1)}\right]$ to a sinusoidal forcing function is given by

(*a*) $\dfrac{A}{\sqrt{\left[1-(\omega T)^2\right]^2 + (2\xi\omega T)^2}} \sin(\omega t + \phi)$.

(*b*) $\dfrac{A}{\sqrt{\left[1-(\omega T)\right]^2 + (2\xi\omega T)^2}} \sin(\omega t + \phi)$

(*c*) $\dfrac{A}{\sqrt{\left[1 + (\omega T)^2\right]^2 + (2\xi\omega T)^2}} \sin(\omega t + \phi)$

(*d*) $\dfrac{A}{\left[1-(\omega T)^2\right]^2 + (2\xi\omega T)^2} \sin(\omega t + \phi)$.

where ω = radian frequency
A = input amplitude

$$\phi = -\tan^{-1}\left[\frac{2\xi\omega T}{1-(\omega T)^2}\right].$$

197. In the steady-state response of a second-order system [$G(s) = 1/T^2s^2 + 2\xi Ts + 1$) to a sinusoidal forcing function, the ratio of the output amplitude to the input amplitude is

(*a*) $[1-(\omega T)^2]^2 + (2\xi\omega T)^2$ (*b*) $\dfrac{1}{\sqrt{\left[1-(\omega T)^2\right]^2 + (2\xi\omega T)^2}}$

(*c*) $\sqrt{\left[1-(\omega T)^2\right]^2 + (2\xi\omega T)^2}$ (*d*) $\dfrac{1}{\left[1-(\omega T)^2\right]^2 + (2\xi\omega T)^2}$

where ω = radian frequency.

198. In the steady-state response of a second-order system

$[G(s) = 1/(T^2s^2 + 2\xi Ts + 1)]$ to a sinusoidal forcing function, the output lags the input by phase angle $|\phi|$ which is equal to

(*a*) $\tan^{-1}\dfrac{2\xi\omega T}{1-(\omega T)^2}$ (*b*) $\tan^{-1}\dfrac{2\omega T}{1-(\omega T)^2}$

(*c*) $\tan^{-1}(\omega T)$ (*d*) $\tan^{-1}\dfrac{2\xi\omega T}{1+(\omega T)^2}$

where ω = radian frequency.

199. The phase lag of a second-order system is always
(*a*) $\leq 180°$ (*b*) $\leq 90°$
(*c*) $45°$ (*d*) $135°$.

200. The transfer function of a transportation lag of T time units is
(*a*) e^{-Ts} (*b*) e^{Ts}
(*c*) $\dfrac{1}{(Ts+1)}$ (*d*) $\dfrac{1}{Ts}$.

201. For the liquid-level system shown in Fig. 9·7, the time constant is
(*a*) A/R (*b*) R/A
(*c*) AR (*d*) $1/AR$
where A = the cross-sectional area of tank.

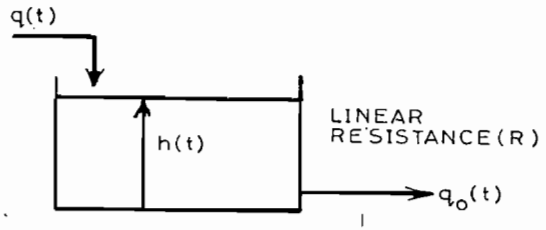


Fig. 9·7.

202. If the transfer functions of the two non-interacting first-order systems connected in series are $G_1(s)$ and $G_2(s)$, the overall transfer function is
(*a*) $\dfrac{G_1(s)}{G_2(s)}$ (*b*) $G_1(s)\,G_2(s)$
(*c*) $G_1(s) + G_2(s)$ (*d*) $G_1(s) - G_2(s)$.

203. If the transfer functions of the two interacting first-order systems connected in series are $G_1(s)$ and $G_2(s)$, the overall transfer function is
(*a*) $\dfrac{G_1(s)}{G_2(s)}$ (*b*) $G_1(s)\,G_2(s)$
(*c*) $G_1(s) + G_2(s)$ (*d*) none of these answers.

204. Select the wrong statement
(*a*) For a single first-order system, there is no transfer lag
(*b*) Transfer lag is always present when two or more first-order systems are connected in series
(*c*) Interacting system is more sluggish than the non-interacting system
(*d*) Transfer lag decreases as the number of stages increases.

205. Transfer lag is a characteristic of
(*a*) first-order systems only
(*b*) second-order systems only
(*c*) all higher order other than first-order systems
(*d*) all higher order than first and second order systems.

206. Step-response of a second-order system is shown in Fig. 9·8. The damping coefficient is maximum for curve

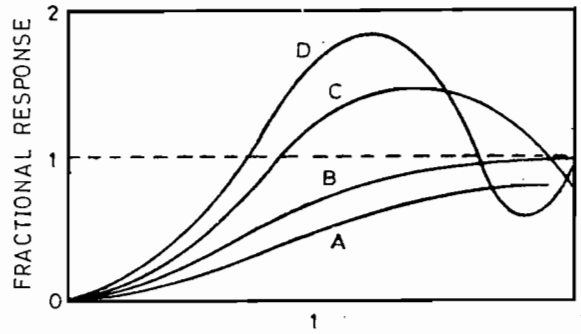


Fig. 9·8.

(*a*) B (*b*) C
(*c*) D (*d*) A.

207. Two interacting first-order systems connected in series will behave as
(*a*) a overdamped second-order system
(*b*) an underdamped second order system
(*c*) a critically damped second-order system
(*d*) a first-order system

208. The ratio of the geometric mean to the arithmetic mean of time-constants T_1 and T_2 is 1 if
(*a*) $T_1 = 2T_2$ (*b*) $T_1 = 3T_2$
(*c*) $T_1 = T_2$ (*d*) $T_1 = 4T_2$.

209. Pressure tanks in series are non-interacting
(*a*) only if there is sub-sonic flow from one tank to the next
(*b*) only if there is super sonic flow from one tank to the next

(*c*) only if there is sonic flow from one tank to the next
(*d*) always whether the flow from one tank to the next is subsonic, sonic, or super sonic.

210. Which one of the following is an example of interacting system ?
(*a*) Series of stirred tank reactors for which temperature or concentration is the pertinent variable
(*b*) Distillation tower
(*c*) Stirred tank with a water jacket
(*d*) Pressure tanks a series in which there is super sonic flow from one tank to the next.

211. The transfer function of an ideal proportional controller is
(*a*) K_C (*b*) $1/K_C$
(*c*) $1 + K_C$ (*d*) $1/(K_C + 1)$
where K_C = gain or sensitivity.

212. The transfer function of a *P-I* controller is
(*a*) $K_C/T_I s$ (*b*) $K_C\left(1 + \frac{1}{T_I s}\right)$
(*c*) $K_C\,(1 + T_I s)$ (*d*) $K_C\left(1 + \frac{s}{T_I}\right)$
where K_C = gain or sensitivity
T_I = integral time.

213. The transfer function of a *P-D* controller is
(*a*) $K_C\,T_D s$ (*b*) $K_C\left(1 + \frac{1}{T_D s}\right)$
(*c*) $K_C\,(1 + T_D s)$ (*d*) $K_C\left(1 + \frac{T_D}{s}\right)$
where K_C = gain
T_D = derivative time.

214. The transfer function of a *P-I-D* controller is
(*a*) $K_C\,[1 + (T_I + T_D)s]$ (*b*) $K_C\left(1 + \frac{1}{T_D s} + T_I s\right)$
(*c*) $K_C\left(1 + \frac{1}{T_D s} + \frac{1}{T_I s}\right)$ (*d*) $K_C\left(1 + \frac{1}{T_I s} + T_D s\right)$
where K_C = gain
T_I = integral time
T_D = derivative time.

215. On-Off control is a special case of
(*a*) proportional control
(*b*) proportional-integral control
(*c*) proportional-derivative control
(*d*) proportional-integral-derivative control.

216. The bandwidth of an-off controller is approximately
(*a*) zero (*b*) 100%
(*c*) 50% (*d*) 85%.

217. Offset is defined as
(*a*) steady-state error in controlled variable
(*b*) unsteady-state error in controlled variable
(*c*) highest maximum deviation in controlled variable
(*d*) lowest maximum deviation in controlled variable.

218. Offset
(*a*) does not vary with time
(*b*) varies linearly with time
(*c*) varies as the square root of the time
(*d*) varies exponentially with time.

219. Which of the following controllers has maximum offset ?
(*a*) *P*-controller (*b*) *P-I* controller
(*c*) *P-D* controller (*d*) *P-I-D* controller.

220. Offset is zero for
(*a*) *P*-controller only (*b*) *P-D* controller only
(*c*) *P*- and *P-D* controllers (*d*) *P-I* and *P-I-D* controllers.

221. Which of the following controllers has highest maximum deviation ?
(*a*) *P*-controller (*b*) *P-I* controller
(*c*) *P-D* controller (*d*) *P-I-D* controller.

222. Which of the following controllers has smallest maximum deviation ?
(*a*) *P*-controller (*b*) *P-I* controller
(*c*) *P-D* controller (*d*) *P-I-D* controller.

223. Stabilizing time
(*a*) is the time required for the response to first reach its ultimate value
(*b*) is the time required for the response to reach 95% of its ultimate value
(*c*) is the time required for the response to reach 63·2% of its ultimate value
(*d*) none of these answers.

224. Which of the following controllers requires minimum stabilizing time ?

(*a*) *P*-controller (*b*) *P-D* controller
(*c*) *P-I-D* controller (*d*) *P-I* controller.

225. Which of the following controllers requires maximum stabilizing time ?

(*a*) *P*-controller (*b*) *P-I* controller
(*c*) *P-D* controller (*d*) *P-I-D* controller.

226. Which of the following controllers is the least expensive ?

(*a*) *P-I* controller (*b*) *P-I-D* controller
(*c*) *P*-controller (*d*) *P-D* controller.

227. Which of the following controllers is the most expensive ?

(*a*) *P*-controller (*b*) *P-D* controller
(*c*) *P-I* controller (*d*) *P-I-D* controller.

228. Pneumatic controllers are used to control upto a distance of

(*a*) 100 ft (*b*) 1000 ft
(*c*) 5000 ft.

229. Hydraulic controllers are used to control upto a distance of

(*a*) 100 ft (*b*) 1000 ft
(*c*) 500 ft.

230. Electronic controllers are used to control upto a distance of

(*a*) 100 ft (*b*) 1000 ft
(*c*) 5000 ft.

231. Solenoid valve works like

(*a*) proportional controller
(*b*) on-off controller
(*c*) proportional-derivative controller
(*d*) proportional-integral-derivative controller.

232. Pneumatic controllers are most suited to

(*a*) pharmaceutical industries
(*b*) petroleum refineries
(*c*) steel industries.

233. Find the transfer function *C/R* for the block diagram shown in Fig. 9·9.

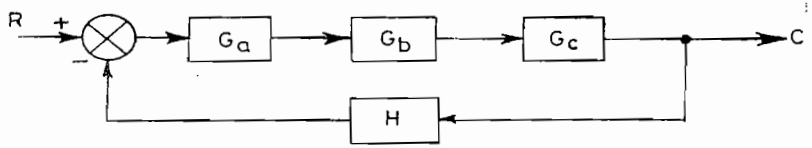


Fig. 9·9.

(*a*) $\dfrac{G_a G_b G_c}{1 + G_a G_b G_c H}$ (*b*) $\dfrac{G_a G_b G_c}{1 - G_a G_b G_c H}$

(*c*) $\dfrac{G_a G_b G_c}{1 + H}$ (*d*) $\dfrac{H}{1 + G_a G_b G_c H}$.

234. The open-loop transfer function for the block diagram shown in Fig. 9·9 is

(*a*) $G_a\, G_b\, G_c$ (*b*) $G_a\, G_b\, G_c H$

(*c*) H (*d*) $\dfrac{G_a\, G_b\, G_c}{H}$.

235. Find the transfer function *C/R* for the block diagram shown in Fig. 9·10.

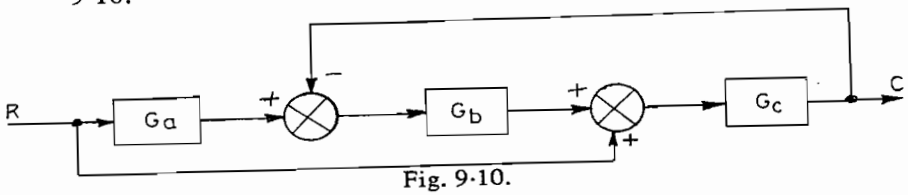


Fig. 9·10.

(*a*) $\dfrac{G_a + G_a G_b G_c}{1 + G_b G_c}$ (*b*) $\dfrac{G_c + G_a G_b G_c}{1 + G_b G_c}$

(*c*) $\dfrac{G_a G_b G_c}{1 + G_a G_b G_c}$ (*d*) $\dfrac{G_a G_b G_c}{1 + G_b G_c}$.

236. Find the transfer function *C/R* for the block diagram shown in Fig. 9·11.

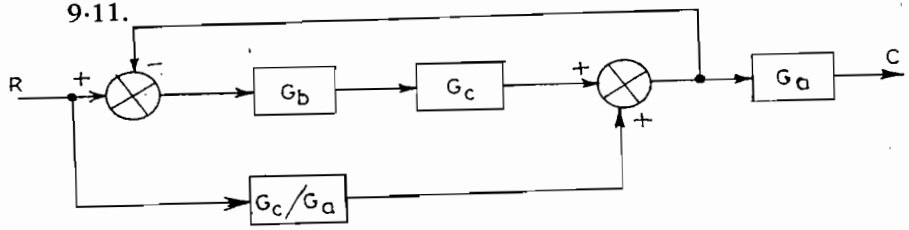


Fig. 9·11.

(*a*) $\dfrac{G_a G_b G_c + G_c}{1 + G_b G_c}$ (*b*) $\dfrac{G_a G_b G_c - G_c}{1 + G_b G_c}$

(*c*) $\dfrac{G_a G_b G_c}{1 + G_a G_b G_c}$ (*d*) $\dfrac{G_a G_b G_c + G_c}{1 - G_b G_c}$.

237. Find the transfer function *C/R* for the block diagram shown in Fig. 9·12.

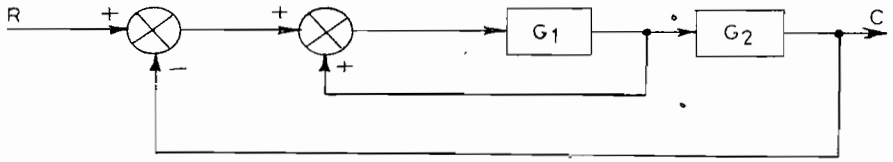


Fig. 9·12.

(a) $\dfrac{G_1 G_2}{1 + G_1 G_2}$ (b) $\dfrac{G_1 G_2}{1 - G_1 + G_1 G_2}$

(c) $\dfrac{G_1 G_2}{1 - G_2 + G_1 G_2}$ (d) $\dfrac{G_1 G_2}{1 - G_1 - G_1 G_2}$.

238. The open-loop transfer function for the block diagram shown in Fig. 9·13 is

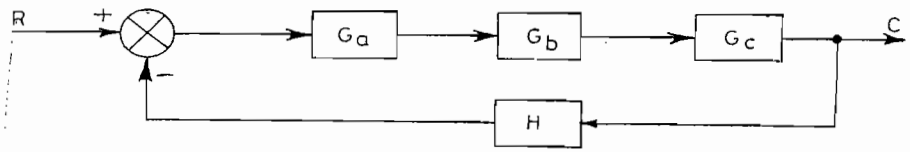


Fig. 9·13.

(a) $G_a G_b G_c$ (b) $G_a G_b G_c H$

(c) H (d) $\dfrac{G_a G_b G_c}{H}$.

239. The amplitude ratio (AR) for the sinusoidal response of a transportation lag is always

(a) < 1 (b) 1

(c) > 1 (d) 0.

240. Phase angle (ϕ) in degree for the sinusoidal response of a transportation lag is

(a) $\tan^{-1}(-\omega T)$ (b) $-\omega T$

(c) $\tan^{-1}(\omega T)$ (d) $-\dfrac{180}{\pi}\,\omega T$.

241. The amplitude ratio (AR) for the sinusoidal response of a first-order system is always

(a) < 1 (b) > 1

(c) 1 (d) 0.

242. The amplitude ratio (AR) for the sinssoidal response of a second-order system is always

(a) < 1 (b) > 1

(c) 1 (d) none of these answers.

243. The amplitude ratio (AR) for the sinusoidal response of a second-order system with a transfer function

$$G(s) = \frac{1}{T^2 s^2 + 2\xi T s + 1}$$

is always greater than unity for ξ less than

(a) $1/\sqrt{2}$ (b) 1

(c) 2 (d) $\sqrt{2}$

244. Bode diagram consists of two graphs which are plots of

(a) logarithm of AR versus frequency, and phase angle versus logarithm of frequency

(b) logarithm of AR versus logarithm of frequency and phase angle versus logarithm of frequency

(c) AR versus frequency, and phase angle versus frequency

(d) logarithm of AR versus frequency, and logarithm of phase angle versus logarithm of frequency.

245. For the first order system, the corner frequency (ω_c) is the frequency corresponding to

(a) $\omega T = 1$ (b) $\omega T = 0$

(c) $\omega T = 1/\sqrt{2}$ (d) $\omega T = \sqrt{2}$.

246. At the corner frequency, the amplitude ratio (AR) for the sinusoidal response of a first-order system is

(a) $1/\sqrt{2}$ (b) 1

(c) $\sqrt{2}$ (d) $1/\sqrt{5}$.

247. At the corner frequency, the phase angle for the sinusoidal response of a first-order system is

(a) $-90°$ (b) $-45°$

(c) $0°$ (d) $-60°$.

248. The amplitude ratio (AR) is expressed in decibels and the decibel is defined by

(a) Decibel $= \log_{10}(AR)$ (b) Decibel $= 20 \log_{10}(AR)$

(c) Decibel $= 10 \log_{10}(AR)$ (d) Decibel $= \log_e(AR)$

249. An amplitude ratio (AR) of unity corresponds to

(a) zero decibel (b) 20 decibels

(c) 46·06 decibels (d) 1 decibel.

250. An amplitude ratio (AR) of 0·1 corresponds to

(a) −10 decibels (b) −20 decibels

(c) −1 decibel (d) −0·23 decibel.

251. For n first-order non-interacting systems connected in series, the overall amplitude ratio (AR) is obtained by

(a) $(AR) = (AR)_1 + (AR)_2 + (AR)_3 + \ldots\ldots\ldots + (AR)_n$
(b) $(AR) = (AR)_1 \,.\, (AR)_2 \,.\, (AR)_3 \,.\, \ldots\ldots\ldots .(AR)_n$
(c) $(AR) = [(AR)_1 + (AR)_2 + (AR)_3 + \ldots\ldots\ldots + (AR)_n]/n$
(d) $(AR) = [(AR)_1 \,.\, (AR)_2 \,.\, (AR)_3 \,.\, \ldots\ldots\ldots .(AR)_n]^{1/n}$.

252. For n first-order non-interacting systems connected in series, the overall phase angle (ϕ) is obtained by

(a) $\phi = \phi_1 + \phi_2 + \phi_3 + \ldots\ldots\ldots + \phi_n$
(b) $\phi = \phi_1.\phi_2.\phi_3.\ldots\ldots\ldots.\phi_n$
(c) $\phi = (\phi_1 + \phi_2 + \phi_3 + \ldots\ldots\ldots + \phi_n)/n$
(d) $\phi = (\phi_1.\phi_2.\phi_3 \,.\, \ldots\ldots\ldots \,.\, \phi_n)^{1/n}$.

253. The amplitude ratio (AR) for the sinusoidal response of a proportional controller with a transfer function K_c is

(a) $1/K_c$ (b) K_c
(c) 1 (d) $K_c/2$.

254. Phase angle (ϕ) for the sinusoidal response of a proportional controller with a transfer function K_c is

(a) 0° (b) –30°
(c) – 45° (d) –90°.

255. The amplitude ratio (AR) for the sinuosidal response of P-I controller with a transfer function $K_c\left(1 + \dfrac{1}{T_I s}\right)$ is

(a) $K_c\sqrt{1 + \dfrac{1}{(\omega T_I)^2}}$ (b) $K_c\sqrt{1 + (\omega T_I)^2}$

(c) $\dfrac{1}{K_c\sqrt{1 + (\omega T_I)^2}}$ (d) $\sqrt{1 + \dfrac{1}{(\omega T_I)^2}}$.

256. Phase angle (ϕ) for the sinusoidal response of P-I controller with a transfer function $K_c\left(1 + \dfrac{1}{T_I s}\right)$ is

(a) $\tan^{-1}(-\omega T_I)$ (b) $\tan^{-1}\left(\dfrac{-1}{\omega T_I}\right)$

(c) $\tan^{-1}(\omega T_I)$ (d) $-\dfrac{180}{\pi} \cdot \dfrac{1}{\omega T_I}$.

257. In the sinusoidal response of a second-order system with a transfer function

$$G(s) = \frac{1}{T^2 s^2 + 2\xi T s + 1};$$

the frequency at which maximum amplitude ratio (AR) is obtained is called

(a) natural frequency (b) corner frequency
(c) resonant frequency (d) crossover frequency.

258. The resonant frequency (ω_r) for the sinusoidal response of a second-order system with a transfer function

$$G(s) = \frac{1}{T^2 s^2 + 2\xi T s + 1};$$

is obtained by

(a) $\omega_r = \dfrac{1}{T}\sqrt{1-\xi^2}$ (b) $\omega_r = \dfrac{1}{T}\sqrt{1-2\xi^2}$

(c) $\omega_r = \dfrac{1}{T}\sqrt{1-4\xi^2}$ (d) $\omega_r = \dfrac{2}{T}\sqrt{1-\xi^2}$.

259. Root-locus method for stability of control systems

(a) is a graphical procedure
(b) is difficult to apply to system containing transportation lag
(c) provides the roots of the characteristic equation
(d) all of these answers.

260. A pole of the open-loop transfer function, $G(s)$, is any value of s for which $G(s)$ approaches

(a) zero (b) unity
(c) infinity.

261. A zero of the open-loop transfer function, $G(s)$, is any value of s for which $G(s)$ equals

(a) zero (b) infinite
(c) one.

262. The number of poles in the open-loop transfer function

$$G(s) = \frac{1}{(s^3 + 6s^2 + 11s + 6)}$$

are

(a) 1 (b) 2
(c) 3 (d) 0.

263. The characteristic equation for the control system with a closed-lop transfer function $G_1/1 + G$ is

(a) $\dfrac{G_1}{1+G} = 0$ (b) $1 + G = 0$

(c) $G = 0$ (d) $G_1 = 1 + G$.

264. The characteristics equation for the control system
(*a*) determines its stability
(*b*) is the same for set-point or load changes
(*c*) depends only upon the open-loop transfer function
(*d*) all of these answers.

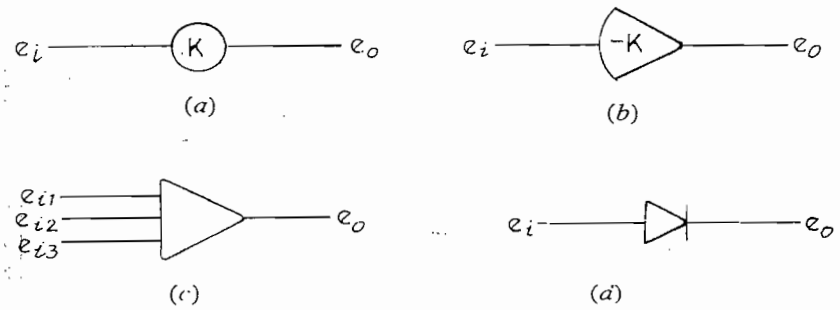
265. Routh test for stability of control systems uses
(*a*) open-loop transfer function
(*b*) closed-loop transfer function
(*c*) characteristic equation.

266. Select the wrong statement.
Routh test for stability of control systems
(*a*) is a simple algebraic method for detecting roots of a polynomial lying in the right half of the complex plane
(*b*) is applicable only to systems with polynomial characteristic equations
(*c*) can be used to test the stability of a control system containing a transportation lag
(*d*) does not give any idea of degree of stability or the roots of the characteristic equation.

267. In an analog computer a device that changes the sign and amplifies any voltage signal fed into it is known as
(*a*) pot (*b*) high-gain amplifier
(*c*) diode (*d*) function generator.

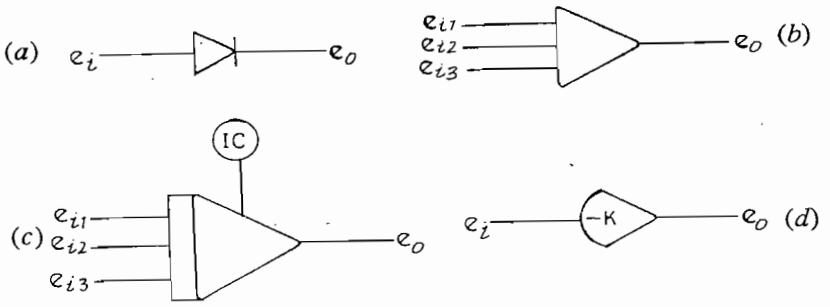
268. The amplification factor (K) of the high-gain amplifier is of the order of
(*a*) 10^{-5} to 10^{-8} (*b*) 10^{-1} to 10^{-4}
(*c*) 10 (*d*) 10^{5} to 10^{8}.

269. Which of the following is a symbol for the high-gain amplifier used in an analog computer diagram ?



270. A pot is a resistor with a movable contact. In this the output voltage (e_o) and input voltage (e_i) are related as $e_o = Kei$, where K varies in the range
(*a*) $K \geq 1$ (*b*) $K \geq 10$
(*c*) $K \leq 0$ (*d*) $0 \leq K \leq 1$.

271. Which is the symbol for integrator used in an analog computer diagram ?



272. Local atmospheric pressure is measured by
(*a*) a bourdon gauge (*b*) a mercury barometer
(*c*) a manometer (*d*) a hot-wire anemometer.

273. Absolute pressure is measured by
(*a*) a bourdon gauge (*b*) an aneroid barometer
(*c*) a differential manometer (*d*) a vacuum gauge.

274. Gauge pressures in flow systems are measured by
(*a*) aneroid barometer
(*b*) bourdon gauge and manometers
(*c*) vacuum gauge
(*d*) mercury barometer.

275. Humidity is most commonly measured by means of
(*a*) parital vapour pressure determination
(*b*) evaporation
(*c*) dry and wet bulb temperature measurement
(*d*) physical expansion.

276. The periodic temperature reading of a thermometer dipped in a constant temperature bath is given by the formula

$$T = T' (1-e^{-tL})$$

where L is
(*a*) the latent heat of the bath liquid
(*b*) the latent heat of mercury at temperature T

(*c*) the difference between the latent heats of the fluid and mercury
(*d*) none of the above.

277. Pneumatic transmission equipment is considered if
(*a*) the extreme accuracy is not necessary
(*b*) the extreme speed is not necessary
(*c*) the transmission distances are short
(*d*) all of the above.

278. Controller characteristics consist of
(*a*) mode of control (*b*) lag
(*c*) dead zone (*d*) all of the above.

279. Overdamping
(*a*) is too bad (*b*) is acceptable
(*c*) is highly desirable (*d*) decreases dynamic error.

280. Dead zone must be
(*a*) less than 0·2% of the scale
(*b*) between 1 and 5% of the scale
(*c*) more than 5% of the scale
(*d*) less than 10% of the scale.

281. Two response curves for a controlled system are shown in Fig. 9-14. Whereas the curve *B* depicts the response with dead time, curve *A* depicts without it. Then, dead time
(*a*) will diminish with time
(*b*) will widen with time
(*c*) will remain unchanged with time
(*d*) will diminish exponentially with time.

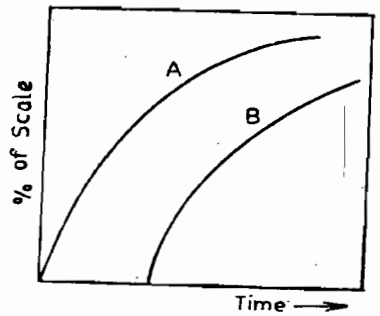


Fig. 9-14

282. Decreasing the proportional band
(*a*) decreases the decay ratio
(*b*) increases the decay ratio
(*c*) does not affect the decay ratio
(*d*) ensures more stable system.

283. When the reset time is increased
(*a*) the decay ratio is increased
(*b*) the decay ratio remains constant
(*c*) the decay ratio is decreased
(*d*) the system becomes less stable.

284. Mercury in glass thermometer works on the principle of ..... mercury with increase in temperature.

285. In a bimetallic thermometer, a bimetal consists of two strips of metals welded together having different coefficient of ..... .

286. Vapour pressure thermometer works on the principle of increase of ..... with increase in temperature.

287. The generation of emf in thermocouples is fundamentally explained by ..... .

288. Resistance thermometer works on the principle of change of ..... resistance with temperature.

289. The functioning of radiation pyrometers is based on the ..... law.

290. Polorimeter works on the principle of ..... .

291. Conductivity meter is based on the principle that electrical conductivity of a solution changes with ..... .

292. Specific conductance is defined as the ..... of resistance in ohms of 1 cm^3 of liquid at a specified temperature.

293. The units of specific conductance are ..... .

294. In the equation $p^H = -\log_{10}(H^+)$, H^+ is the hydrogen ion concentration of a solution in ..... .

295. An acidic solution has a p^H value ..... 7.

296. A change of 1 p^H unit corresponds to a ..... change of hydrogen ion concentration of the solution.

297.
(*a*) Mercury-in-glass thermometer	(*I*) Affinity of different constituents to an adsorbent
(*b*) Gas chromatograph	(*II*) Cubical expansion of liquids
(*c*) Optical pyrometer	(*III*) Faraday's law
(*d*) Magneto-hydrodynamic flowmeter	(*IV*) Wien's law

298.
(*a*) Composition of carbon dioxide in a flue gas	(*I*) Polorimeter
(*b*) Acid content in a waste stream	(*II*) Tachometer
(*c*) Analysis of sugars	(*III*) Thermal conductivity gas analyser
(*d*) Speed of big shafts	(*IV*) p^H meter

299.
(*a*) Amount of moisture in air	(*I*) Refractometer
(*b*) Alkalinity of a solution	(*II*) Hygrometer
(*c*) Composition of miscible liquids	(*III*) Hydrometer
(*d*) Specific gravity of petroleum	(*IV*) p^H meter

300.
(*a*) $1/s$	(*I*) $\sin at$
(*b*) $1/(s-a)$	(*II*) t

(*c*) $1/s^2$ (*III*) e^{at}
(*d*) $a/(s^2 + a^2)$ (*IV*) 1

301. (*a*) $R/(Ts + 1)$ (*I*) Laplace form of transportation lag
(*b*) $e^{-L/S}$ (*II*) Transfer function of a first-order system
(*c*) 1 (*III*) Laplace transform of unit impulse function
(*d*) $1/s$ (*IV*) Laplace transform of unit step function

302. (*a*) Step input (*I*) A sin ωT
(*b*) Impulse input (*II*) At
(*c*) Ramp input (*III*) $\delta(t-\tau) = \infty$ at $t = \tau$ and $\delta(t-\tau) = 0$ elsewhere
(*d*) Sinusoidal input (*IV*) $u(t) = 0$ for $t < 0$ and $u(t) = 1$ for $t \geq 0$

ANSWERS

1. (*d*)	2. (*a*)	3. (*d*)	4. (*c*)	5. (*c*)
6. (*a*)	7. (*b*)	8. (*d*)	9. (*d*)	10. (*a*)
11. (*a*)	12. (*c*)	13. (*a*)	14. (*c*)	15. (*b*)
16. (*b*)	17. (*b*)	18. (*c*)	19. (*d*)	20 (*a*)
21. (*b*)	22. (*b*)	23. (*d*)	24. (*b*)	25. (*a*)
26. (*b*)	27. (*d*)	28. (*c*)	29. (*b*)	30. (*a*)
31. (*b*)	32. (*a*)	33. (*c*)	34. (*a*)	35. (*c*)
36. (*b*)	37. (*c*)	38. (*d*)	39. (*a*)	40. (*a*)
41. (*b*)	42. (*c*)	43. (*a*)	44. (*b*)	45. (*c*)
46. (*c*)	47. (*a*)	48. (*b*)	49. (*a*)	50. (*c*)
51. (*d*)	52. (*a*)	53. (*c*)	54. (*c*)	55. (*d*)
56. (*c*)	57. (*a*)	58. (*d*)	59. (*b*)	60. (*a*)
61. (*a*)	62. (*b*)	63. (*b*)	64. (*b*)	65. (*c*)
66. (*a*)	67. (*a*)	68. (*a*)	69. (*b*)	70. (*a*)
71. (*c*)	72. (*c*)	73. (*b*)	74. (*b*)	75. (*d*)
76. (*a*)	77. (*a*)	78. (*a*)	79. (*b*)	80. (*a*)
81. (*b*)	82. (*c*)	83. (*a*)	84. (*b*)	85. (*c*)
86. (*a*)	87. (*b*)	88. (*a*)	89. (*b*)	90. (*b*)
91. (*d*)	92. (*c*)	93. (*d*)	94. (*b*)	95. (*a*)
96. (*b*)	97. (*a*)	98. (*c*)	99. (*c*)	100. (*c*)
101. (*c*)	102. (*d*)	103. (*d*)	104. (*a*)	105. (*a*)
106. (*d*)	107. (*b*)	108. (*a*)	109. (*b*)	110. (*c*)
111. (*d*)	112. (*a*)	113. (*a*)	114. (*b*)	115. (*b*)
116. (*d*)	117. (*d*)	118. (*d*)	119. (*c*)	120. (*a*)
121. (*b*)	122. (*d*)	123. (*a*)	124. (*b*)	125. (*b*)
126. (*a*)	127. (*c*)	128. (*a*)	129. (*b*)	130. (*b*)
131. (*a*)	132. (*b*)	133. (*a*)	134. (*b*)	135. (*b*)
136. (*b*)	137. (*d*)	138. (*c*)	139. (*b*)	140. (*b*)
141. (*c*)	142. (*a*)	143. (*c*)	144. (*b*)	145. (*c*)

146. (*d*)	147. (*a*)	148. (*a*)	149. (*d*)	150. (*a*)
151. (*a*)	152. (*c*)	153. (*a*)	154. (*d*)	155. (*b*)
156. (*b*)	157. (*c*)	158. (*a*)	159. (*b*)	160. (*a*)
161. (*a*)	162. (*b*)	163. (*c*)	164. (*b*)	165. (*c*)
166. (*d*)	167. (*c*)	168. (*b*)	169. (*a*)	170. (*c*)
171. (*d*)	172. (*b*)	173. (*c*)	174. (*a*)	175. (*b*)
176. (*b*)	177. (*b*)	178. (*b*)	179. (*a*)	180. (*b*)
181. (*b*)	182. (*a*)	183. (*c*)	184. (*b*)	185. (*a*)
186. (*b*)	187. (*a*)	188. (*b*)	189. (*c*)	190. (*b*)
191. (*c*)	192. (*a*)	193. (*c*)	194. (*b*)	195. (*c*)
196. (*a*)	197. (*b*)	198. (*a*)	199. (*a*)	200. (*a*)
201. (*c*)	202. (*b*)	203. (*d*)	204. (*d*)	205. (*c*)
206. (*d*)	207. (*a*)	208. (*c*)	209. (*c*)	210. (*c*)
211. (*a*)	212. (*b*)	213. (*c*)	214. (*d*)	215. (*a*)
216. (*a*)	217. (*a*)	218. (*a*)	219. (*a*)	220. (*d*)
221. (*b*)	222. (*c*)	223. (*b*)	224. (*b*)	225. (*b*)
226. (*c*)	227. (*d*)	228. (*b*)	229. (*a*)	230. (*c*)
231. (*b*)	232. (*b*)	233. (*a*)	234. (*b*)	235. (*b*)
236. (*a*)	237. (*b*)	238. (*b*)	239. (*b*)	240. (*d*)
241. (*a*)	242. (*d*)	243. (*a*)	244. (*b*)	245. (*a*)
246. (*a*)	247. (*b*)	248. (*b*)	249. (*a*)	250. (*b*)
251. (*b*)	252. (*a*)	253. (*b*)	254. (*a*)	255. (*a*)
256. (*b*)	257. (*c*)	258. (*b*)	259. (*d*)	260. (*c*)
261. (*a*)	262. (*c*)	263. (*b*)	264. (*d*)	265. (*c*)
266. (*c*)	267. (*b*)	268. (*d*)	269. (*b*)	270. (*d*)
271. (*c*)	272. (*b*)	273. (*b*)	274. (*b*)	275. (*c*)
276. (*d*)	277. (*d*)	278. (*d*)	279. (*a*)	280. (*a*)
281. (*c*)	282. (*b*)	283. (*c*)		

284. volumetric expansion
285. thermal expansion
286. vapour pressure
287. Seebeck effect
288. electrical
289. Stefan-Boltzmann
290. polarisation of light
291. composition
292. reciprocal
293. mho/cm
294. mols per litre
295. less than
296. 10 fold

297. (*a*) - (II)
(*b*) - (I)
(*c*) - (IV)
(*d*) - (III)

298. (*a*) - (III)
(*b*) - (IV)
(*c*) - (I)
(*d*) - (II)

299. (*a*) - (II)
(*b*) - (IV)
(*c*) - (I)
(*d*) - (III)

300. (*a*) - (IV)
(*b*) - (III)
(*c*) - (II)
(*d*) - (I)

301. (*a*) - (II)
(*b*) - (I)
(*c*) - (III)
(*d*) - (IV)

302. (*a*) - (IV)
(*b*) - (III)
(*c*) - (II)
(*d*) - (I)

10

Chemical Engineering Economics

1. If P represents the principal, n the number of interest periods, and i the interest rate based on the length of one interest period, the amount of simple interest during n interest periods is

   (*a*) $P(1 + i\,n)$ (*b*) $P(1 + i)^n$
   (*c*) $P\,i\,n$ (*d*) $P[(1 + i)^n - 1]$.

2. If P represents the principal, n the number of interest periods, and i the intererst rate based on the length of one interest period, the amount of compounded interest during n interest periods is

   (*a*) $P(1 + i\,n)$ (*b*) $P(1 + i)^n$
   (*c*) $P\,i\,n$ (*d*) $P[(1 + i)^n - 1]$.

3. If the interest rate i is expressed on the regular yearly basis and d represents the number of days in an interest period, the amount of exact simple interest is

   (*a*) $P\,i\,d$ (*b*) $\frac{P\,i\,d}{360}$
   (*c*) $\frac{P\,i\,d}{365}$ (*d*) $\frac{i\,d}{365}$.

4. The nominal and effective interest rates are equal when the interest is compounded

   (*a*) monthly (*b*) continuously
   (*c*) semi-annually (*d*) annually.

5. If the interest rate is 5 per cent per period and the interest is compounded at half-year periods, the actual annual return on the principal would be

   (*a*) exactly 5 per cent
   (*b*) exactly 10 per cent
   (*c*) somewhat larger than 10 per cent
   (*d*) greater than 5 per cent but less than 10 per cent.

6. Someone desires to borrow Rs. 2000 to meet his financial obligation. This money can be borrowed from a loan agency at a monthly interest rate of 3 per cent. What is the total amount of principal plus simple interest due after 3 years if no intermediate payments are made ?

   (*a*) Rs. 2180 (*b*) Rs. 2160
   (*c*) Rs. 4160 (*d*) Rs. 20,000.

7. A bound has a maturity value of Rs. 2420 and is paying discrete compound interest at an effective annual rate of 10 per cent. Determine the discount if the bond reaches maturity value in two years time.

   (*a*) Rs. 242 (*b*) Rs. 420
   (*c*) Rs. 2000 (*d*) Rs. 508.

8. If S represents the amount available after n interest periods for an initial principal P with the discrete compound interest rate i, the present worth can be determined by

   (*a*) Present worth $= S/(1 + i)^n$
   (*b*) Present worth $= S/e^{in}$
   (*c*) Present worth $= S/(1 + i\,n)$
   (*d*) Present worth $= S/(1 + n)^i$.

9. What will be the total amount available 10 years from now if Re. 1 is deposited at the present time with nominal interest at the rate of 11 per cent compounded continuously ?

   (*a*) e^{110} (*b*) $10\,e^{0.11}$
   (*c*) $10 \ln 11$ (*d*) $e^{1.1}$.

10. The effective annual interest rate i_{eff} is expressed in terms of the nominal interest rate r compounded continuously as

    (*a*) $i_{eff} = \ln (r + 1)$ (*b*) $i_{eff} = e^r - 1$
    (*c*) $i_{eff} = \ln r - 1$ (*d*) $i_{eff} = e^r$.

11. For a nominal interest rate of 20 per cent compounded continuously, the effective annual interest rate will be

    (*a*) equal to 20 per cent
    (*b*) more than 20 per cent
    (*c*) less than 20 per cent
    (*d*) equal to or less than 20 per cent.

12. The decision by a company management to implement a project is based entirely on

    (*a*) obligation (*b*) commitments
    (*c*) economic evaluations (*d*) none of the above.

13. Which of the following is a component of working capital investment ?

    (*a*) Process equipment
    (*b*) Maintenance and repair inventory

(*c*) Utilities plants
(*d*) Depreciation.

14. If the cost of an equipment of the desired capacity is not available, it may be estimated from the cost of another equipment using the formula

(*a*) $(\text{cost})_1 = (\text{cost})_2\ [(\text{capacity})_2/(\text{capacity})_1]$
(*b*) $(\text{cost})_1 = (\text{cost})_2\ [(\text{capacity})_1/(\text{capacity})_2]$
(*c*) $(\text{cost})_1 = (\text{cost})_2\ [(\text{capacity})_1/(\text{capacity})_2]^{0.6}$
(*d*) $(\text{cost})_1 = (\text{cost})_2\ [(\text{capacity})_2/(\text{capacity})_1]^{0.6}$.

15. If the cost of a shell and tube heat exchanger of $A\ m^2$ is Rs. x, then the cost of two numbers of shell and tube heat exchangers of $A/2\ m^2$ each will be about

(*a*) Rs. $\frac{3x}{4}$ (*b*) Rs. x
(*c*) Rs. $\frac{4x}{3}$ (*d*) Rs. $\frac{5x}{3}$.

16. The economic life of a small chemical plant is

(*a*) usually more than a large chemical plant
(*b*) usually much more than a large chemical plant
(*c*) usually much less than a large chemical plant
(*d*) always equal to a large chemical plant.

17. Which of the following is a correct formula to calculate the after-tax cash receipts 'C_{at}' ?

(*a*) $C_{at} = (1-t_r)\ (R-e-d) + d$ (*b*) $C_{at} = (1-t_r)\ (R-e) + t_r\ d$
(*c*) $C_{at} = (1-t_r)\ (R-E)\ t_r\ d$ (*d*) $C_{at} = (1-t_r)\ (R-E) + t_r\ d$.

where t_r is the tax rebate, R the revenues, E the expenses including depreciation, e the expenses other than depreciation, and d the depreciation.

18. Select the correct expression.

(*a*) Profit = revenue–operating cost
(*b*) Profit = revenue–fixed cost
(*c*) Profit = revenue–total cost
(*d*) Profit = revenue–book value.

19. At Rs. x per kWh, how much will it cost to maintain a temperature of 35°C for 24 hours in a box 0·5 m square on each side if the outside temperature is 20°C and the overall heat transfer coefficient for the box is 0·6 W/(m², K).

(*a*) Re. 0·162 x (*b*) Re. 0·324 x
(*c*) Re. 0·054 x (*d*) Rs. 324 x.

20. Rs. 10,000 is invested now at 10% interest per annum on a compound basis. What will be the accumulated sum at the end of 5 years ?

(*a*) Rs. 15,000 (*b*) Rs. 16,105·10
(*c*) Rs. 15,105·10 (*d*) Rs. 17,105·10.

21. Which curve in Fig. 10·1 will give the total amount accumulated at an annual interest rate of i with simple interest ?

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*.

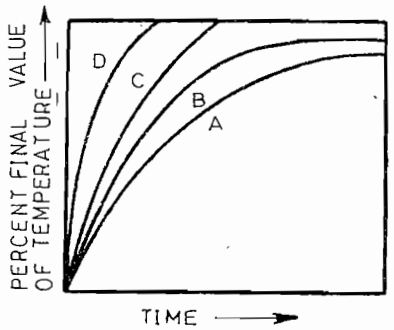


Fig. 10·1.

22. Which curve in Fig. 10·1 will give the total amount accumulated at an annual interest rate i if the interest is compounded annually ?

(*a*) *D* (*b*) *B*
(*c*) *C* (*d*) *A*.

23. Which curve in Fig. 10·1 will give the total amount accumulated at an annual interest rate i if the interest rate i is compounded semi-annually ?

(*a*) *B* (*b*) *C*
(*c*) *D* (*d*) *A*.

24. Which curve in Fig. 10·1 will give the total amount accumulated at an annual interest rate i if the interest is compounded continuously ?

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*.

25. Total installed cost of a centrifugal pump coupled with drive and capable of developing 1000 ft head at 500 gpm is to be calculated using Rs. 55,000 as the cost of a pump of 500 ft head at 1000 gpm. The cost estimation method involves the term 'capacity' which will be taken as $(\text{gpm})^x\ (\text{head})^y$, where

(*a*) $x = 1, y = 2$ (*b*) $x = 1/2, y = 1$
(*c*) $x = 2, y = 1$ (*d*) $x = 1, y = 1$.

26. The co-ordinates of break-even point (Fig. 10·2) are

(*a*) $x = F/(p-v)$, $y = F/(1-v/p)$
(*b*) $x = F/(1-v/p)$, $y = F/(p-v)$
(*c*) $x = F/(1-p/v)$, $y = F/(1+v/p)$
(*d*) $x = F/(1+vp)$, $y = F/(1-vp)$

where F = total fixed cost
v = variable cost per unit
p = selling price per unit.

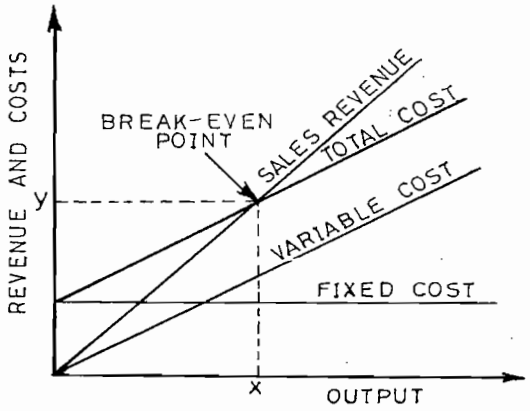


Fig. 10·2.

27. Select the correct statement.

(*a*) Payout period is the length of time over which the earnings on a project equal the investment
(*b*) Payout period is not important for business decision making
(*c*) Payout period is affected by the variations in earnings after the recovery of the investment
(*d*) Payout period and the economic life of a project are the same.

28. The payback method for the measurement of return on investment

(*a*) does not measure the discounted rate of return
(*b*) takes into account the cash inflows after the recovery of investment
(*c*) gives a correct picture of profitability
(*d*) underemphasizes liquidity.

29. A sum P is to be repaid in n years in equal annual investments of value R which includes the interest i on all unpaid balances. Which of the following is a correct formula to calculate R ?

(*a*) $R = P\left[\dfrac{i(1+i)^n}{(1+i)^n-1}\right]$ (*b*) $R = P\left[\dfrac{i(1+i)^n-1}{(1+i)^n}\right]$

(*c*) $R = P\left[\dfrac{i}{(1+i)^n-1}\right]$ (*d*) $R = P\left[\dfrac{(1+i)^n-1}{i(1+i)^n}\right]$.

30. Select the wrong statement.

(*a*) Depreciation is the unavoidable loss in the value of plant, equipment and materials with lapse in time
(*b*) Depreciation is a cash expense
(*c*) Depreciation does figure in the computation of the income tax liability on cash flows from an investment
(*d*) Annual depreciation costs are constant when the straight-line method is used.

31. In the straight-line method for determining depreciation, it is assumed that the value of the property

(*a*) decreases exponentially with time
(*b*) decreases logarithmically with time
(*c*) decreases linearly with time
(*d*) remains constant with time.

32. A property has an initial value of Rs. 10,000, service life of 10 years and final salvage value of Rs. 2,000. What is the annual depreciation cost if straight-line depreciation is used ?

(*a*) Rs. 1,000 (*b*) Rs. 1,200
(*c*) Rs. 200 (*d*) Rs. 800.

33. When the declining-balance method is used

(*a*) the annual depreciation cost is a fixed percentage of the property value at the beginning of the particular year
(*b*) the annual cost for depreciation is same each year
(*c*) the value of the asset can decrease to zero at the end of the service life
(*d*) the value of the asset decreases linearly with time.

34. Depreciation for year a by the sum-of-the-years-digits method is calculated by

(*a*) $d_a = \dfrac{V-V_s}{a}$ (*b*) $d_a = \dfrac{2(n-a+1)}{n(n+1)}(V-V_s)$

(*c*) $d_a = 1-(V_s/V)^{1/a}$ (*d*) $d_a = \dfrac{2(n-a-1)}{(n+1)}(V-V_s)$.

where d_a = depreciation for year a
n = service life, years
V = original value of the property at start of the service life.

35. Annual depreciation costs are constant

(*a*) when the straight-line method is used
(*b*) when the sum-of-the-years-digits method is used
(*c*) when the declining-balance method is used
(*d*) none of the above.

36. Which of the following methods results in book values greater than those obtained with the straight-line method ?

(*a*) Declining-balance method
(*b*) Sum-of-the-years-digits method
(*c*) Sinking-fund method
(*d*) Multiple straight-line method.

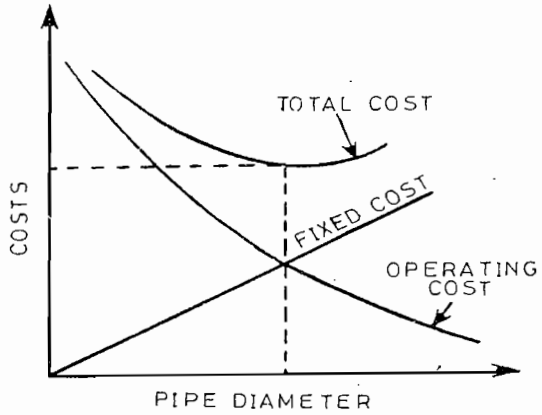


Fig. 10·3.

37. A plot of costs *versus* pipe diameter is shown in Fig. 10·3. The optimum pipe diameter will

(*a*) remain unchanged if the ratio of investment per year to operating cost per year is decreased
(*b*) remain unchanged if the ratio of investment per year to operating cost per year is kept constant
(*c*) decrease if the operating cost is increased
(*d*) remain unchanged if the operating cost is increased.

38. The ratio of the total present value to the initial investment of a given project

(*a*) remains constant with change in the discounted-cash-flow rate of return
(*b*) increases with increase in the discounted-cash flow rate of return
(*c*) decreases with increase in the discounted-cash-flow rate of return
(*d*) increases exponentially with increase in the discounted cash flow rate of return.

39. For most chemical plants the ratio of working capital to total capital investment varies from

(*a*) 10 to 20 per cent (*b*) from 80 to 90 per cent
(*c*) from 51 to 65 per cent (*d*) from 1 to 2 per cent.

ANSWERS

1. (*c*)	2. (*d*)	3. (*c*)	4. (*d*)	5. (*c*)
6. (*c*)	7. (*b*)	8. (*a*)	9. (*d*)	10. (*b*)
11. (*b*)	12. (*c*)	13. (*b*)	14. (*c*)	15. (*c*)
16. (*c*)	17. (*a*)	18. (*c*)	19. (*b*)	20 (*b*)
21. (*a*)	22. (*b*)	23. (*b*)	24. (*d*)	25. (*d*)
26. (*a*)	27. (*a*)	28. (*a*)	29. (*a*)	30. (*b*)
31. (*c*)	32. (*d*)	33. (*a*)	34. (*b*)	35. (*a*)
36. (*c*)	37. (*b*)	38. (*c*)	39. (*a*).	

11

Fertilizer Technology

1. Nitrogenous fertilizer is required
   (*a*) during early stages of plant growth to promote development of stems and leaves
   (*b*) to accelerate seeding or fruit formation in later stages of growth
   (*c*) for the development of the starches of potatoes and grains
   (*d*) for the development of the sugar of fruits and vegetables and the fibrous material of plants.
2. Phosphatic fertilizer is required
   (*a*) during early stages of plant growth to promote development of stems and leaves
   (*b*) to stimulate early growth and accelerate seeding or fruit formation in later stages of growth
   (*c*) for the development of the starches of potatoes and grains
   (*d*) for the development of the sugar of fruits and vegetables and the fibrous material of plants.
3. Potassic fertilizer is required
   (*a*) for the development of the starches of potatoes and grains
   (*b*) for the development of the sugar of fruits and vegetables
   (*c*) for the development of the fibrous material of plants
   (*d*) all of these answers.
4. Excessive application of synthetic fertilizers often causes shrivelling of the roots and wilting of the plant. This is because
   (*a*) the soil becomes too acidic
   (*b*) the soil becomes too alkaline
   (*c*) the osmotic pressure of the soil water becomes higher than that of the plant sap
   (*d*) the osmotic pressure of the soil water becomes less than that of the plant sap.
5. Fertilizer value of a nitrogenous fertilizer is expressed in terms of its
   (*a*) N content (*b*) NH_3 content
   (*c*) HNO_3 content (*d*) NO content.

6. Phosphatic fertilizer is graded based on its
   (*a*) P_2O_5 content (*b*) P content
   (*c*) PCl_3 content (*d*) H_3PO_4 content.
7. Potassic fertilizer is graded based on its
   (*a*) K_2O content (*b*) KOH content
   (*c*) KNO_3 content (*d*) K content.
8. Mixed fertilizers contain three principal elements (nitrogen, phosphorus and potassium). 5–10–5 mixed fertilizer contains
   (*a*) 5 wt. % P_2O_5, 10% N, 5% K_2O
   (*b*) 5 wt. % N, 10% P_2O_5, 5% K_2O
   (*c*) 5 wt. % N, 10% P_2O_5, 85% K_2O
   (*d*) 10 wt. % N, 10% P_2O_5, 5% K_2O.
9. NPK fertilizer is a
   (*a*) nitrogenous fertilizer (*b*) phosphatic fertilizer
   (*c*) potassic fertilizer (*d*) mixed fertilizer.
10. The nitrogenous fertilizer with the highest percentage of nitrogen is
    (*a*) urea (*b*) ammonium sulphate
    (*c*) ammonium nitrate (*d*) calcium nitrate.
11. Which one of the following substances is used as a nitrogenous fertilizer, as a weed killer in the onion fields, and for correcting acidic soils ?
    (*a*) Urea (*b*) Basic slag
    (*c*) Superphosphate of lime (*d*) Calcium cyanamide.
12. The best fertilizer for rice paddies is
    (*a*) urea (*b*) ammonium sulphate
    (*c*) superphosphate (*d*) calcium ammonium nitrate.
13. Which one of the following compounds is not used as fertilizer ?
    (*a*) Urea (*b*) Diammonium phosphate
    (*c*) Ammonium nitrate (*d*) Calcium phosphate.
14. In the Haber's process for the manufacture of ammonia
    (*a*) finely divided iron is used as a catalyst
    (*b*) finely divided molybdenum is used as a catalyst
    (*c*) finely divided nickel is used as a catalyst
    (*d*) no catalyst is required.
15. If a mixture containing 3 moles of hydrogen and 1 mole of nitrogen is converted completely in ammonia, the ratio of initial and final volumes at the same temperature and pressure would be
    (*a*) 3 : 1 (*b*) 2 : 1
    (*c*) 1 : 3 (*d*) 1 : 2.

16. The favourable conditions for the maximum yield of ammonia by Haber's process are

(*a*) high pressure, high temperature, high concentrations of reactants
(*b*) low pressure, low temperature, low concentrations of reactants
(*c*) high pressure, low temperature, high concentrations of reactants
(*d*) high pressure, low temperature, low concentrations of reactants.

17. All NH_3 synthesis catalysts are based on iron oxide promoted by

(*a*) SiO_2 (*b*) K_2O (1–2%)
(*c*) ZnO (*d*) V_2O_5.

18. Synthetic ammonia is produced by reacting nitrogen and hydrogen gases. The reaction is

(*a*) endothermic (*b*) exothermic
(*c*) irreversible (*d*) catalyzed by enzymes.

19. The nutrient which makes the plant stems stronger and increases branching is

(*a*) N (*b*) P
(*c*) K (*d*) Zn.

20. Nitric acid is generally light yellow in colour due to the presence of

(*a*) NH_3 (*b*) NO
(*c*) NO_2 (*d*) N_2O_5.

21. Which of the following process is used for the commercial production of nitric acid ?

(*a*) $NaNO_3 + H_2SO_4$ process
(*b*) Ammonia oxidatioin process
(*c*) Passing air through an electric arc
(*d*) None of these answers.

22. Raw materials for the manufacture of nitric acid are

(*a*) anhydrous ammonia and air
(*b*) air and water
(*c*) air and steam
(*d*) anhydrous ammonia and water.

23. The catalyst used in the manufacture of nitric acid by ammonia oxidation process is

(*a*) Ni (*b*) Fe
(*c*) V_2O_5 (*d*) Pt-Rh alloy.

24. The concentration of the nitric acid produced by the oxidation of ammonia and absorption of nitrogen oxides with water is about

(*a*) 95 wt. % (*b*) 57–60 wt. %
(*c*) 100 wt. % (*d*) 75 wt. %.

25. Concentration of the nitric acid from 60 to 95% can be done by

(*a*) rectification with 93% HCl
(*b*) adding 70–75% Mg $(NO_3)_2$ solution with 60% HNO_3
(*c*) distilling at 1 atm
(*d*) all of the above.

26. Fuming nitric acid is

(*a*) hot concentrated HNO_3
(*b*) concentrated HNO_3 containing dissolved NO_2
(*c*) the purest form of HNO_3
(*d*) a mixture of concentrated HNO_3 and concentrated HCl.

27. Urea is a

(*a*) nitrogenous fertilizer (*b*) Phosphatic fertilizer
(*c*) potassic fertilizer (*d*) mixed fertilizer.

28. The percentage of nitrogen in urea is about

(*a*) 38·4 wt. % (*b*) 46 wt. %
(*c*) 59·1 wt. % (*d*) 61·3 wt. %.

29. The chemical formula of urea is

(*a*) $NH_4.COO.NH_2$ (*b*) $NH_2.CO.NH_2$
(*c*) $NH_3.CO_2.NH_3$ (*d*) $NH_2.CO.NH.CO.NH_2$.

30. The principal raw materials for the manufacture of urea are

(*a*) CO_2 and NH_3 (*b*) CO_2 and HNO_3
(*c*) CO and NH_3 (*d*) CO_2 and N_2.

31. The operating temperature and pressure in urea autoclave are

(*a*) 550°C and 1000 atm respectively
(*b*) 100°C and 1000 atm respectively
(*c*) 185°C and 180 atm respectively
(*d*) 25°C and 1 atm respectively.

32. Urea is formed in a low-pressure stripping operation by dehydration of

(*a*) ammonium bicarbonate (*b*) ammonium carbamate
(*c*) biuret (*d*) ammonium nitrate.

33. In the manufacture of urea from ammonia and carbon dioxide

(*a*) aluminium oxide is used as catalyst
(*b*) platinum is used as catalyst
(*c*) silica-alumina mixture is used as catalyst
(*d*) no catalyst is required.

34. Ammonium carbamate is formed by reacting ammonia and carbon dioxide at 180 atm and 185°C. The reaction is

(*a*) endothermic (*b*) exothermic
(*c*) reversible (*d*) catalytic.

35. Urea is formed by dehydration of ammonium carbamate in a low-pressure stripping operation. The reaction is
(*a*) reversible (*b*) endothermic
(*c*) catalytic (*d*) exothermic

36. For given NH_3/CO_2 ratio, temperature, urea production rate
(*a*) decreases with increasing pressure
(*b*) increases with increasing pressure
(*c*) remains constant with change in pressure
(*d*) decreases linearly with increasing pressure.

37. For given NH_3/CO_2 ratio, pressure (more than the dissociation pressure for the carbamate) urea production rate
(*a*) decreases with increase in temperature from 140°C to 175°C
(*b*) increases with increase in temperature to maximum at 175–180°C, then falls off sharply
(*c*) decreases linearly with increase in temperature
(*d*) is independent of temperature.

38. For given pressure, temperature and total feed rate, urea yield
(*a*) increases with increase in NH_3/CO_2 ratio
(*b*) decreases with increase in NH_3/CO_2 ratio
(*c*) remains unaffected with change in NH_3/CO_2 ratio
(*d*) may increase, decrease, remains unaffected with change in NH_3/CO_2 ratio.

39. In the manufacture of urea, biuret ($NH_2CONHCONH_2$) formation is kept at minimum (< 1%) because
(*a*) it is an explosive
(*b*) it is a compound which is detrimental to germinating seeds and toxic to animals
(*c*) it decomposes urea into carbon dioxide, nitrogen and water
(*d*) its nitrogen content is only 4 wt %.

40. Ammonium nitrate which is used as fertilizer contains about
(*a*) 35% N (*b*) 25% N
(*c*) 46% N (*d*) 82% N.

41. Nitrolime is
(*a*) calcium cyanamide
(*b*) calcium ammonium nitrate
(*c*) a mixture of urea and ammonium nitrate
(*d*) a mixture of ammonium nitrate and ammonium chloride.

42. The nitrogen content of calcium ammonium nitrate (CAN) is about
(*a*) 25% N (*b*) 35% N
(*c*) 46% N (*d*) 82% N.

43. Raw materials for the manufacture of ammonium nitrate are
(*a*) liquid ammonia and air
(*b*) liquid ammonia, 60% nitric acid and clay (diatomaceous earth, kieselgur)
(*c*) anhydrous ammonia and nitrous acid
(*d*) liquid ammonia and 98% sulphuric acid.

44. Ammonium nitrate is manufactured by
(*a*) the oxidation of ammonia
(*b*) reacting liquid ammonia and 60% nitric acid
(*c*) the oxidation of 60% nitric acid
(*d*) reacting liquid ammonia and 98% sulphuric acid.

45. Ammonium nitrate is made by reacting liquid ammonia and 60% nitric acid. The reaction is
(*a*) endothermic (*b*) exothermic
(*c*) catalytic (*d*) reversible.

46. Select the wrong statement
(*a*) Ammonia nitrate is hygroscopic
(*b*) Ammonia nitrate is extremely reactive with combustible materials
(*c*) Ammonium nitrate is insensitive to explosive decomposition
(*d*) Ammonium nitrate product is coated with clay such as diatomaceous earth, kieselgur.

47. The nitrogen content is minimum in
(*a*) ammonium sulphate (*b*) nitrolime
(*c*) ammonium chloride (*d*) ammonium nitrate.

48. When calcium carbide is heated with nitrogen, the product obtained is
(*a*) Ca_3N_2 (*b*) $Ca(CN)_2$
(*c*) $CaCN_2$ (*d*) $Ca(CNO)_2$.

49. Nitrolime is used as nitrogenous fertilizer. Its composition is
(*a*) Ca_3N_2 (*b*) $Ca(CN)_2$
(*c*) $CaCN_2$ (*d*) $CaCN_2 + C$.

50. Which of the following is used as a micronutrient in agriculture ?
(*a*) Zinc sulphate (*b*) Magnesium sulphate
(*c*) Sodium sulphate (*d*) Copper sulphate.

51. The most reactive allotropic form of phosphorus is
(*a*) red phosphorus (*b*) yellow phosphorus
(*c*) black phosphorus (*d*) violet phosphorus.

52. The phosphorus vapours are composed of
(*a*) P (*b*) P_2
(*c*) P_3 (*d*) P_4.

53. Red phosphorus is chemically unreactive because
(*a*) it does not contain P-P bonds
(*b*) it does not contain tetrahedral P_4 molecules
(*c*) it does not catch fire in air even upto 200°C
(*d*) it has a polymeric structure.

54. Red phosphorus may be changed to white phosphorus by
(*a*) vapourization followed by condensation
(*b*) heating in the presence of light
(*c*) heating under high pressure
(*d*) melting under pressure.

55. White phosphorus is most stable
(*a*) at ordinary temperature (*b*) at atmospheric pressure
(*c*) above 600°C (*d*) under high pressure.

56. Which of the following properties of white phosphorus are common to red phosphorus ?
(*a*) It is soluble in carbon disulphide
(*b*) It phosphoresces in air
(*c*) It reacts with hot caustic soda solution to give phosphine
(*d*) It burns when heated in air.

57. Which of the following allotropic forms of phosphorus is used in the manufacture of safety matches ?
(*a*) White phosphorus (*b*) Red phosphorus
(*c*) Black phosphorus (*d*) all forms of phosphorus.

58. Phosphate rock constitutes mainly of
(*a*) calcium phosphate (*b*) calcium fluoride
(*c*) fluorapatite (*d*) ammonium phosphate.

59. Phosphorus is manufactured by heating in electric furnace a mixture of
(*a*) phosphate rock and coke
(*b*) phosphate rock and sand
(*c*) phosphate rock, coke and sand
(*d*) phosphate rock, coke and common salt.

60. Chemically bone ash is mainly
(*a*) calcium phosphate (*b*) crude phosphorus
(*c*) animal charcoal (*d*) ammonium phosphate.

61. The electric furnace is used for the manufacture of elemental phosphorus from a phosphate rock. The fused section of the furnace where the reduction to elemental phosphorus takes place is maintained at
(*a*) 500–600°C (*b*) 800–900°C
(*c*) 1400–1450°C (*d*) 2000–2100°C.

62. Yellow phosphorus is converted to red phosphorus in covered retorts at a temperature of
(*a*) 250–450°C in absence of air
(*b*) 100–150°C in absence of air
(*c*) 1400–1450°C in absence of air
(*d*) 800–1000°C in absence of air.

63. Yellow phosphorus is transported under
(*a*) air (*b*) nitrogen
(*c*) water (*d*) all of these answers.

64. The electric furnace is used for the manufacture of elemental phosphorus from phosphate rock. The electrodes are made of
(*a*) carbon (*b*) aluminium
(*c*) zinc (*d*) copper.

65. The chemical formula of othophosphoric acid is
(*a*) H_3PO_3 (*b*) H_3PO_4
(*c*) $H_4P_2O_7$ (*d*) HPO_3.

66. The chemical formula of pyrophosphoric acid is
(*a*) $H_4P_2O_7$ (*b*) H_3PO_4
(*c*) HPO_3 (*d*) H_3PO_3.

67. The chemical formula of metaphosphoric acid is
(*a*) $H_4P_2O_7$ (*b*) HPO_3
(*c*) H_3PO_3 (*d*) H_3PO_4.

68. Which one of the following oxy-acids of phosphorus is derived from oxide different from the one from which the other three acids are derived ?
(*a*) H_3PO_4 (*b*) $H_4P_2O_7$
(*c*) HPO_3 (*d*) H_3PO_3.

69. Raw materials for the manufacture of orthophosphoric acid by wet process are phosphate rock and
(*a*) coke (*b*) 98% H_2SO_4
(*c*) sand (*d*) 60% HNO_3.

70. In wet process (strong sulphuric acid leaching) for the manufacture of orthophosphoric acid, the reactor temperature is maintained at
(*a*) 80°C (*b*) 200°C
(*c*) 250°C (*d*) 900°C.

71. Grinding cost is maximum when
(*a*) phosphate rock is ground to –200 mesh
(*b*) phosphate rock is ground to –150 mesh

(*c*) phosphate rock is ground to –100 mesh
(*d*) phosphate rock is ground to –20 mesh.

72. If the reactor temperature in wet process (strong sulphuric acid leaching) for the manufacture of orthophosphoric acid is kept about 100°C

(*a*) undesirable $CaSO_4.½H_2O$ and $CaSO_4$ crystals are formed
(*b*) pyrophosphoric acid is formed
(*c*) metaphosphoric acid is formed
(*d*) none of these answers.

73. In wet process (strong sulphuric acid leaching) for the manufacture of orthophosphoric acid, the dilute orthophosphoric acid (40%) is obtained from travelling pan vacuum filter. The dilute orthophosphoric acid (50%) is concentrated economically 75% orthophosphoric acid by using

(*a*) an evaporator (*b*) a distillation column
(*c*) an extractor (*d*) an adsorption column.

74. Pyrophosphoric acid can be made by heating the orthophosphoric acid to

(*a*) 100°C (*b*) 250°C
(*c*) 900°C (*d*) 1400°C.

75. Metaphosphoric acid can be made by heating the orthophosphoric acid to about

(*a*) 250°C (*b*) 500°C
(*c*) 900°C (*d*) 1500°C.

76. In wet process (strong sulphuric acid leaching) for the manufacture of orthophosphoric acid, a by-product obtained is

(*a*) $CaSO_4.1½\ H_2O$ (*b*) $CaSO_4.2H_2O$
(*c*) $CaSO_4.½H_2O$ (*d*) $CaSO_4$.

77. The chemical formula of gypsum is

(*a*) $CaSO_4$ (*b*) $CaSO_4.H_2O$
(*c*) $CaSO_4.2H_2O$ (*d*) $CaSO_4.½H_2O$.

78. Gypsum can be converted to ammonium sulphate by reacting with

(*a*) ammonium carbonate (*b*) ammonia
(*c*) nitric acid (*d*) soda ash.

79. In wet process (Hydrochloric acid leaching) for the manufacture of orthophosphoric acid, solvent used for the extraction of H_3PO_4 from $CaCl_2$ solution is

(*a*) benzene (*b*) butanol
(*c*) methyl ethyl ketone (*d*) hexane.

80. Select the wrong statement.

(*a*) For the manufacture of H_3PO_4 wet process (strong sulphuric acid leaching) uses high grade phosphate rock whereas in electric furnace process low grade phosphate rock can also be used
(*b*) For the manufacture of H_3PO_4, the capital investment of the plant in electric furnace process is higher as compared to wet process (strong sulphuric acid leaching)
(*c*) For the manufacture of H_3PO_4, electric furnace process produces high purity acid
(*d*) For the manufacture of H_3PO_4, electric furnace process is economical only in those places where electricity is quite cheap
(*e*) Gypsum is a by-product of wet process (Hydrochloric acid leaching) for the manufacture of H_3PO_4.

81. Superphosphate is made by reacting phosphate rock with

(*a*) dilute sulphuric acid (*b*) orthophosphoric acid
(*c*) hydrochloric acid (*d*) gypsum.

82. Triple superphosphate is made by reacting phosphate rock with

(*a*) dilute sulphuric acid (*b*) orthophosphoric acid
(*c*) hydrochloric acid (*d*) nitric acid
(*e*) 65% oleum.

83. Triple superphosphate is made by reacting phosphate rock with orthophosphoric acid. It is represented by

(*a*) $CaH_4(PO_4)_2$ (*b*) $CaH_2(PO_4)_2$
(*c*) $Ca_3H_4(PO_4)_2$ (*d*) $Ca_3(PO_4)_2$.

84. Orthophosphoric acid forms

(*a*) $H_3PO_4.H_2O$ in water solutions
(*b*) $(H_3PO_4)_2.H_2O$ in water solutions
(*c*) $(H_3PO_4)_4.H_2O$ in water solutions
(*d*) $(H_3PO_4)_3.H_2O$ in water solutions.

85. Superphosphate contains

(*a*) 16–20% P_2O_5 (*b*) 30–35% P_2O_5
(*c*) 42–50% P_2O_5 (*d*) 70–75% P_2O_5.

86. Triple superphosphate contains

(*a*) 16–20% P_2O_5 (*b*) 42–50% P_2O_5
(*c*) 70–75% P_2O_5 (*d*) 90–92% P_2O_5.

87. The chemical formula of monoammonium phosphate is

(*a*) NH_4HPO_4 (*b*) $NH_4H_2PO_4$
(*c*) $NH_4H_2HPO_4$ (*d*) $(NH_4)_2HPO_4$.

88. The chemical formula of diammonium phosphate is

(*a*) $(NH_4)_2HPO_4$ (*b*) $(NH_4)_2H_2PO_4$
(*c*) $NH_4H_2PO_4$ (*d*) $(NH_4)_2PO_4$.

89. Ammonium phosphates are made by reacting anhydrous liquid ammonia with

(*a*) nitric acid (*b*) orthophosphoric acid
(*c*) strong sulphuric acid (*d*) metaphosphoric acid.

90. The chemical formula of sodium tripolyphosphate (STPP) is

(*a*) $Na_5P_3O_{10}$ (*b*) $Na_3P_5O_{10}$
(*c*) $Na_3P_3O_{10}$ (*d*) $Na_5P_2O_5$.

91. Sodium tripolyphosphate (STPP) is made by reacting orthophosphoric acid with

(*a*) limestone (*b*) quick lime
(*c*) slaked lime (*d*) soda ash.

92. Sodium tripolyphosphate (STPP) is made by reacting saturated soda ash solution and orthophosphoric acid. To form one mole of monosodium to two moles of disodium phosphate, ratio of Na_2O/P_2O_5 must be

(*a*) ·167 (*b*) 16·7
(*c*) 17·6 (*d*) 1·67.

93. Tricresyl phosphate (TCP) is made by reacting cresylic acid ($CH_3.C_6H_4.OH$) with

(*a*) phosphorus oxychloride (*b*) phosphorus trichloride
(*c*) orthophosphoric acid (*d*) phosphorus pentoxide.

94. Tricresyl phosphate is used

(*a*) as an additive and antiknock supplement compound for petrol
(*b*) in extraction of uranium, plutonium and thorium nitrates
(*c*) in nuclear reactor fuel reprocessing
(*d*) as fertilizer.

95. Tributyl phosphate is used

(*a*) in extraction of uranium, plutonium and thorium nitrates
(*b*) as fertilizer
(*c*) as plasticizer
(*d*) as an additive and antiknock supplement compound for petrol.

96. Sodium tripolyphosphate (STPP) is mainly used

(*a*) in detergents formulation
(*b*) in machine industries
(*c*) as fertilizer
(*d*) in plastics and coatings.

97. Nitrophosphates are mixtures of

(*a*) ammonium nitrate and various phosphates made available by action of nitric acid and sulphuric acid on phosphate rock
(*b*) gypsum and ammonium sulphate

(*c*) calcium phosphate and ammonium bicarbonate
(*d*) ammonium bicarbonate and phosphorus oxychloride.

98. The overall steam reformation of naphtha is

(*a*) endothermic process
(*b*) slightly exothermic process
(*c*) highly exothermic process
(*d*) autocatalytic process.

99. Ammonia synthesis gas is manufactured by

(*a*) steam reforming of light naphtha
(*b*) partial oxidation of fuel oil
(*c*) partial oxidation of coal
(*d*) all of the above.

100. C/H ratio (by weight) of natural gas is about

(*a*) 15-25 (*b*) 7-8
(*c*) 3-4 (*d*) 1.

101. C/H ratio (by weight) of light naphtha is about

(*a*) 1 (*b*) 6
(*c*) 25 (*d*) 12.

102. Which one of the following is used to manufacture ammonia synthesis gas from natural gas ?

(*a*) Steam reforming (*b*) Partial oxidation
(*c*) Electrolysis (*d*) Thermal pyrolysis.

103. Which one of the following is used to manufacture ammonia synthesis gas from fuel oil ?

(*a*) Electrolysis (*b*) Steam reforming
(*c*) Partial oxidation (*d*) Hydrocracking.

104. Ammonia synthesis gas is manufactured from coal by low pressure coal

(*a*) gasification (*b*) dehydrogenation
(*c*) hydrogenation (*d*) hydration.

105. The feedstock (s) for the manufacture of ammonia synthesis gas is/are

(*a*) light naphtha (*b*) water
(*c*) coal (*d*) all of the above.

106. The steam/carbon ratio is defined as the mols of steam fed per atom of carbon present as hydrocarbon in the feed. The usual steam/carbon ratio used in the steam reforming of naphtha in industry is about

(*a*) 1 (*b*) 3·5
(*c*) 15 (*d*) 25.

107. In the steam-naphtha reforming process, the reaction temperature must be maintained in the range of

(*a*) 150–250°C (*b*) 250–450°C
(*c*) 700–1000°C (*d*) 1800–2000°C.

108. The catalyst used in the steam-naphtha reforming process is
(*a*) vanadium pentaoxide on an alumina support
(*b*) nickel oxide on an alumina support, with MgO or Cr_2O_3 as promoters
(*c*) zeolite
(*d*) aluminium oxide.

109. Triplesuperphosphate is manufactured by reacting phosphate rock and ..... .

110. Undesirable by-product in urea synthesis is ..... .

111. 5–10–5 mixed fertilizer means it contains 5 wt. % ....., 10 wt. % ....., and 5 wt. % ..... .

112. Ammonia synthesis gas consists of 3 mols of ..... and 1 mol of .....

113. The principal raw materials for the manufacture of urea are ..... and ..... .

114. The urea production rate ..... with increasing pressure.

115. Phosphoric acid is manufactured by strong sulphuric acid leaching or hydrochloric acid leaching of ..... .

116. Superphosphate is manufactured by reacting phosphate rock with ..... .

117. Tricresyl phosphate is manufactured by reacting cresylic acid and ..... .

118. The raw materials for the manufacture of sodium tripoly phosphate are ..... and phosphoric acid.

119. The formation of 1 mol of sodium tripoly phosphate requires a ratio of Na_2O/P_2O_5 to be ..... .

120. Chemically nitrolime is ..... .

Match the items in the left column with the appropriate item in the right column :

121.
(*a*) NH_2CONH_2 (*I*) Ammonium carbamate
(*b*) NH_4COONH_2 (*II*) Biuret
(*c*) $NH_2CONHCONH_2$ (*III*) Urea
(*d*) NH_4NO_3 (*IV*) Ammonium nitrate

122.
(*a*) H_3PO_4 (*I*) Pyrophosphoric acid
(*b*) $H_4P_2O_7$ (*II*) Metaphosphoric acid
(*c*) HPO_3 (*III*) Phosphoric acid
(*d*) P_2O_5 (*IV*) Phosphorous pentoxide

123.
(*a*) $Na_5P_3O_{10}$ (*I*) Diammonium phosphate
(*b*) $(CH_3C_6H_4)_3PO_4$ (*II*) Monoammonium phosphate
(*c*) $NH_4H_2PO_4$ (*III*) Tricresyl phosphate
(*d*) $(NH_4)_2HPO_4$ (*IV*) STPP

124.
(*a*) $Ca_{10}(PO_4)_6F_2$ (*I*) Gypsum
(*b*) $CaSO_42H_2O$ (*II*) Fluorapatite
(*c*) $3CaH_4(PO_4)_27CaSO_4$ (*III*) Triple superphosphate
(*d*) $CaH_4(PO_4)_2$ (*IV*) Superphosphate

ANSWERS

1. (*a*)	2. (*b*)	3. (*d*)	4. (*c*)	5. (*a*)
6. (*a*)	7. (*a*)	8. (*b*)	9. (*d*)	10. (*a*)
11. (*d*)	12. (*b*)	13. (*d*)	14. (*a*)	15. (*b*)
16. (*c*)	17. (*b*)	18. (*b*)	19. (*b*)	20 (*c*)
21. (*b*)	22. (*a*)	23. (*d*)	24. (*b*)	25. (*b*)
26. (*b*)	27. (*a*)	28. (*b*)	29. (*b*)	30. (*a*)
31. (*c*)	32. (*b*)	33. (*d*)	34. (*b*)	35. (*b*)
36. (*b*)	37. (*b*)	38. (*b*)	39. (*b*)	40. (*a*)
41. (*b*)	42. (*a*)	43. (*b*)	44. (*b*)	45. (*b*)
46. (*c*)	47. (*a*)	48. (*c*)	49. (*d*)	50. (*a*)
51. (*b*)	52. (*d*)	53. (*d*)	54. (*a*)	55. (*c*)
56. (*d*)	57. (*b*)	58. (*c*)	59. (*c*)	60. (*a*)
61. (*c*)	62. (*a*)	63. (*c*)	64. (*a*)	65. (*b*)
66. (*a*)	67. (*b*)	68. (*d*)	69. (*b*)	70. (*a*)
71. (*a*)	72. (*a*)	73. (*a*)	74. (*b*)	75. (*c*)
76. (*b*)	77. (*c*)	78. (*a*)	79. (*b*)	80. (*e*)
81. (*a*)	82. (*b*)	83. (*a*)	84. (*b*)	85. (*a*)
86. (*b*)	87. (*b*)	88. (*a*)	89. (*b*)	90. (*a*)
91. (*d*)	92. (*d*)	93. (*a*)	94. (*a*)	95. (*a*)
96. (*a*)	97. (*a*)	98. (*a*)	99. (*d*)	100. (*c*)
101. (*b*)	102. (*a*)	103. (*c*)	104. (*a*)	105. (*d*)
106. (*b*)	107. (*c*)	108. (*b*).		

109. phosphoric acid
110. biuret
111. N, P_2O_5, K_2O
112. hydrogen, nitrogen
113. ammonia, carbon dioxide
114. increases
115. phosphate rock
116. sulphuric acid
117. phosphorous oxychloride
118. sodium carbonate
119. 5/3
120. calcium ammonium nitrate

121. (*a*) - (III)
(*b*) - (I)
(*c*) - (II)
(*d*) - (IV)

122. (*a*) - (III)
(*b*) - (I)
(*c*) - (II)
(*d*) - (IV)

123. (*a*) - (IV)
(*b*) - (III)
(*c*) - (II)
(*d*) - (I)

124. (*a*) - (II)
(*b*) - (I)
(*c*) - (IV)
(*d*) - (III)

12

Petroleum Refining Engineering

DEFINITIONS

Aniline point. The lowest temperature at which oil is completely miscible with an equal volume of aniline.

API gravity. An arbitrary figure related to the specific gravity of petroleum products in accordance with the formula :

$$\text{Degree API} = \frac{141{\cdot}5}{\text{Specific gravity at } 15{\cdot}5°C/15{\cdot}5°C} - 131{\cdot}5$$

Ash. The residue remaining after a fuel sample has been heated in a crucible to a temperature of 775°C.

Calorific value, gross. The quantity of heat released by unit quantity of fuel, when it is burned completely with oxygen, and the products of combustion returned to ambient temperature. It is also called the ''higher calorific value''.

Calorific value, net. It is obtained by subtracting heat of condensation (latent heat) of the water vapour formed by the combustion of the hydrogen in the fuel from the gross calorific value.

Characterization factor (K_{UOP}). Defined by

$$K_{UOP} = \frac{T_B^{1/3}}{G}$$

where T_B is the mean average boiling point, °R and G is the specific gravity at 15·56°C/15·56°C.

Cetane number. Determined in a single cylinder CFR engine by comparing the ignition delay characteristics of the fuel with that of reference blends of known cetane number. The reference fuels used for this purpose are normal cetane (cetane number = 100) and heptamethyl nonane (cetane number = 15). It is calculated by

Cetane number = % n-cetane

+ 0·15x% heptamethyl nonane

It can also be roughly assessed by the following formula :

Cetane Number = 0·72 Diesel Index + 10

Cloud point. The temperature at which a cloud or haze of wax crystals appears at the bottom of the test jar when the oil is cooled under prescribed conditions.

Diesel index. It is an indication of the ignition quality of a diesel fuel and is calculated as follows :

(*a*) $$\text{Diesel index} = \frac{\text{Aniline point, °F} \times \text{°API}}{100}$$

(*b*) $$\text{Diesel index} = \frac{\text{Aniline gravity constant}}{100}$$

(*c*) $$\text{Diesel index} = \frac{\text{Cetane number} - 10}{0{\cdot}72}$$

Drop point of greases. The temperature at which the thickener is so soluble in the base oil that the grease becomes substantially fluid.

Fire point. The lowest temperature at which the oil ignites and continues to burn for 5 second.

Flash point. The lowest temperature at which application of test flame causes the vapour above the oil to ignite.

Freezing point. The temperature at which crystals of hydrocarbons formed on cooling disappear when temperature of fuel is allowed to rise.

Kauri-butanol number. It is a measure of the tolerance to added hydrocarbon diluent of a standard solution of kauri resin dissolved in n-butanol. Standards are toluene (KB = 105) and 75 vol.% n-heptane plus 25 percent toluene (KB = 40).

Melting and setting point of wax. Molten wax is allowed to cool in a specified apparatus while the temperature is recorded at frequent intervals, the point at which the temperature remains within a range of 0·1°C for one minute being taken as the setting point.

The congealing point of a petroleum wax or petrolatum is determined by applying a drop of molten wax to a thermometer bulb, and noting the temperature at which it congeals when the thermometer is rotated under standardised cooling conditions. The drop melting point of wax or petrolatum is determined by recording the temperature at which a drop of the sample falls from the bulb of a thermometer when heated under standard conditions.

Octane number. The volume percentage of iso-octane (2, 2, 4-trimethyl pentane) in a blend with n-heptane that has the same anti-knock performance under standard test conditions as the fuel under test. It is a measure of the anti-knock quality of gasolines. For octane values above 100 the mixtures of iso-octane and tetraethyl lead are used as the standard.

Penetration. The distance in tenths of a millimeter that a standard needle, with a total load of 100 g, will penetrate at the end of 5 seconds interval into a specially prepared sample of bitumen controlled at 25°C.

Penetration index (*PI*). Defined by

$$\frac{\log 800 - \log (\text{PEN } 25°\text{C})}{T_{R\&B} - 25} = \left(\frac{20 - PI}{10 + PI}\right)\left(\frac{1}{50}\right)$$

where $T_{R\&B}$ is the ring and ball softening point of the bitumen in °C.

Performance number. It is given by

$$\text{Octane number} = 100 + \frac{(\text{Performance number} - 100)}{3}$$

This is used to estimate knocking characteristics of aviation gasolines.

Pour point. The lowest temperature expressed in multiple of 3°C at which the oil is observed to flow when cooled and examined under prescribed conditions.

Sediment. The insoluble residues remaining after extraction by toluene.

Smoke point. The maximum flame height in millimeter at which the fuel will burn without smoking when determined in a smoke point apparatus under specified conditions.

Softening point of bitumens. The temperature at which a substance attains a particular degree of softness under specified condition of test. The softening point (Ring & Ball) test measures the temperature in °C at which a standard disc of bitumen confined in a metal ring softens to such an extent, when heated at a rate of 5°C per minute, that it deforms under the loading imposed by a small steel ball which falls a distance of 2·54 cm.

Vapour pressure. The pressure exerted by the vapour above the free surface of the liquid at the given temperature.

Viscosity index (*VI*). It is a measure of change of viscosity with temperature. It can be calculated from the equation

$$VI = \frac{L - U}{L - H} \times 100$$

where U is kinematic viscosity at 100°F of oil whose *VI* is to calculated, L is kinematic viscosity at 100°F of an oil of 0 *VI* having the same kinematic viscosity at 210°F as the oil U and H is kinematic viscosity at 100°F of an oil of 100 *VI* having the same viscosity at 210°F as the oil U.

1. Crude petroleum consists of
(*a*) 84–87 per cent carbon and 11–14 per cent hydrogen
(*b*) 11–14 per cent carbon and 84–87 per cent hydrogen
(*c*) 54 per cent carbon and 25 per cent hydrogen
(*d*) 70–72 per cent carbon and 5–7 per cent hydrogen.

2. The general formula of paraffins is
(*a*) C_nH_{2n} (*b*) C_nH_{2n-2}
(*c*) C_nH_{2n+2} (*d*) C_nH_{2n+1}.

3. The general formula of naphthenes is
(*a*) C_nH_{2n+2} (*b*) C_nH_{2n-2}
(*c*) C_nH_{2n-6} (*d*) C_nH_{2n}.

4. The general formula of olefins is
(*a*) C_nH_{2n-2} (*b*) C_nH_{2n-4}
(*c*) C_nH_{2n+2} (*d*) C_nH_{2n}.

5. The general formula of aromatics is
(*a*) C_nH_{2n} (*b*) C_nH_{2n+2}
(*c*) C_nH_{2n-6} (*d*) C_nH_{2n-4}.

6. The general formula of mercaptans is
(*a*) R–S–R (*b*) R′–S–R
(*c*) R–S–H (*d*) R–SOOH.
where R and R′ are alkyl groups

7. Which of the following is a sulphur compound ?
(*a*) Ethyl mercaptan (*b*) Pyridine
(*c*) Naphthenic acid (*d*) Cumene.

8. The nitrogen compounds in the petroleum products are responsible for
(*a*) loss in catalyst activity
(*b*) colour instability of the products
(*c*) formation of gums
(*d*) all of the above.

9. The general formula of naphthenic acids is
(*a*) $C_nH_{2n}O_2$ (*b*) $C_nH_{2n+2}O_2$
(*c*) $C_nH_{2n-2}O_{2n}$ (*d*) $C_nH_{2n-2}O_2$.

10. Naphthenes
(*a*) are unsaturated cyclic compounds
(*b*) are straight chain saturated compounds
(*c*) are saturated cyclic compounds
(*d*) and paraffins have the same general formula C_nH_{2n+2}.

11. Which of the following hydrocarbon series are almost absent in crude petroleum ?

(*a*) Paraffins (*b*) Naphthenes
(*c*) Aromatics (*d*) Olefins.

12. Which of the following is a nitrogen compound ?

(*a*) Quinoline (*b*) Ethyl mercaptan
(*c*) Naphthenic acid (*d*) Tetra ethyl lead.

13. Sedimentary rocks are

(*a*) porous (*b*) rough
(*c*) hard (*d*) brittle.

14. Aromatics are desirable in

(*a*) kerosine to improve smoke point
(*b*) high speed diesel oil to improve centane number
(*c*) gasoline to improve octane number
(*d*) none of the above.

15. Which of the following is an oxygen compound ?

(*a*) Naphthenic acid (*b*) Indole
(*c*) Pyrrole (*d*) Methyl mercaptan.

16. The nature of Bombay High crude oil is

(*a*) paraffinic (*b*) intermediate
(*c*) naphthenic (*d*) none of the above.

17. The characterization factor (*K*) for Ankleshwar crude oil is about

(*a*) 1·2 (*b*) 120
(*c*) 12 (*d*) 21.

18. Mercaptans are low boiling

(*a*) sulphur compounds (*b*) oxygen compounds
(*c*) nitrogen compounds (*d*) organometallic compounds.

19. Mercaptans

(*a*) are low boiling oxygen compounds
(*b*) are desirable in gasoline
(*c*) decrease the octane number of gasoline
(*d*) are not corrosive.

20. Which of the following products contains minimum sulphur ?

(*a*) Naphtha (*b*) Kerosine
(*c*) High speed diesel oil (*d*) Furnace oil.

21. Which of the following products contains maximum sulphur ?

(*a*) LPG (*b*) ATF
(*c*) LDO (*d*) Furnace oil.

22. In the atmospheric distillation of crude petroleum

(*a*) the content of sulphur increases from lighter fraction to heavier ones, with the residue having the highest concentration of sulphur
(*b*) the content of sulphur decreases from lighter fraction to heavier ones, with the residue having the lowest concentration of sulphur
(*c*) the content of nitrogen decreases from lighter fraction to heavier ones, with the residue having the lowest concentration of nitrogen
(*d*) none of the above.

23. Flash points below 50°C are determined by

(*a*) Pensky-Martens apparatus
(*b*) Abel apparatus
(*c*) Saybolt chromometer
(*d*) none of the above.

24. Flash points above 50°C are determined by

(*a*) Abel apparatus (*b*) Saybolt chromometer
(*c*) Pensky-Martens apparatus (*d*) Lovibond Tintometer.

25. Fire point of a given sample is

(*a*) equal to the flash point
(*b*) higher than the flash point
(*c*) less than the flash point
(*d*) equal to or less than the flash point.

26. The refractive index of naphthas varies

(*a*) inversely with both wave length and temperature
(*b*) directly with both wave length and temperature
(*c*) inversely with wave length and directly with temperature
(*d*) directly with wave length and inversely with temperature.

27. Sulphur content in heavier products is determined generally by

(*a*) lamp method (*b*) quartz tube method
(*c*) bomb method (*d*) none of the above.

28. Which of the following petroleum products has minimum flash point ?

(*a*) Gasoline (*b*) Kerosine
(*c*) High speed diesel oil (*d*) Fuel oil.

29. Which of the following petroleum products has maximum flash point ?

(*a*) Naphtha (*b*) Kerosine
(*c*) High speed diesel oil (*d*) Furnace oil.

30. Which of the following petroleum products has minimum °API ?

(*a*) Gasoline (*b*) Furnace oil
(*c*) Light diesel oil (*d*) High speed diesel oil.

31. Which of the following petroleum products has minimum °API ?

(*a*) Gasoline (*b*) Kerosine
(*c*) Furnace oil (*d*) High speed diesel oil.

32. For petroleum products, °API is given by

(*a*) $°API = \frac{131{\cdot}5}{S} - 141{\cdot}5$ (*b*) $°API = \frac{141{\cdot}5}{S} - 131{\cdot}5$

(*c*) $°API = \frac{145}{S} - 130$ (*d*) $°API = 141{\cdot}5 - \frac{131{\cdot}5}{S}$

where S = specifc gravity at 60°F/60°F.

33. The characterization factor (K) is defined by

(*a*) $K = T_B^{1/2}/S$ (*b*) $K = T_B^{1/3}/S$

(*c*) $K = T_B^{1/4}/S$ (*d*) $K = T_B^{2/3}/S$

where T_B = average molal boiling point, °R
S = specific gravity at 60°F/60°F.

34. Cleavland method is applicable for determining flash point of lubricating oils and other oils flashing below

(*a*) 190°F (*b*) 180°F
(*c*) 80°F (*d*) 175°F.

35. Pour point of Bombay High crude oil is

(*a*) 18°C (*b*) 30°C
(*c*) –15°C (*d*) –50°C.

36. Carbon residue of an oil is determined

(*a*) by conradson method only
(*b*) by ramsbottom method only
(*c*) either by conradson method or by ramsbottom method
(*d*) by Pensky-Martens (closed) method.

37. Corrosion in crude distillation unit column overhead system is caused by

(*a*) the presence of naphthenic acid in crude oils
(*b*) the presence of HCl formed by dissociation of chloride salts
(*c*) the sulphur compounds in crude oils
(*d*) all of the above.

38. Which of the following petroleum products has maximum C/H ratio (by weight) ?

(*a*) Naphtha (*b*) Kerosine
(*c*) Light diesel oil (*d*) Fuel oil.

39. Which of the following petroleum products has minimum C/H ratio (by weight) ?

(*a*) Gasoline (*b*) Aviation turbine fuel
(*c*) High speed diesel oil (*d*) Furnace oil.

40. Which of the following petroleum products has maximum kinematic viscosity at a given temperature ?

(*a*) Gasoline (*b*) Aviation turbine fuel
(*c*) Light diesel oil (*d*) Furnace oil.

41. Which of the following petroleum products has minimum viscosity at a given temperature ?

(*a*) Motor spirit (*b*) Light diesel oil
(*c*) Aviation turbine fuel (*d*) High speed diesel oil

42. Which of the following petroleum products has maximum viscosity at a given temperature ?

(*a*) Motor spirit (*b*) Furnace oil
(*c*) High speed diesel oil (*d*) Kerosine.

43. Which of the following petroleum products has minimum viscosity at a given temperature ?

(*a*) Furnace oil (*b*) Kerosine
(*c*) Light diesel oil (*d*) Naphtha.

44. The viscosity of the hydrocarbon liquids

(*a*) remains unaffected with change in density
(*b*) decreases with increase in density
(*c*) increases with increase in density
(*d*) none of the above.

45. The density of the hydrocarbon liquids

(*a*) remains unaffected with change in the number of carbon and hydrogen atoms in hydrocarbon molecules
(*b*) decreases with increase in the number of carbon and hydrogen atoms in hydrocarbon molecules
(*c*) increases with increase in the number of carbon and hydrogen atoms in hydrocarbon molecules
(*d*) none of the above.

46. At sea level atmospheric pressure and room temperature

(*a*) methane through butane occur as liquids
(*b*) pentane and heavier hydrocarbons occur as liquids
(*c*) ethane and heavier hydrocarbons occur as liquids
(*d*) propane and heavier hydrocarbons occur as liquids.

47. Maximum vapor pressure at 65°C, in kgf/cm^2 gauge, of Indian LPG (commercial butane + propane mixture) is

(*a*) 10 (*b*) 16·87
(*c*) 26 (*d*) 36.

48. The evaporation temperature, in °C, of Indian LPG (commercial butane + propane mixture) for 95% by volume at 760 mm Hg is
(*a*) 25 (*b*) 30
(*c*) 2 (*d*) –38.

49. The yield of straight run LPG, in wt. %, from Bombay High crude oil is about
(*a*) 12 (*b*) 1
(*c*) 15 (*d*) 20.

50. The merox process is employed for LPG for the oxidation of mercaptans with air in alkaline medium in the presence of
(*a*) chelated iron compound (*b*) nickel
(*c*) platinum (*d*) vanadium pentaoxide.

51. LPG at normal atmospheric temperature and pressure is a
(*a*) liquid which is heavier than water
(*b*) gas which is heavier than air
(*c*) gas which is lighter than air
(*d*) liquid which is lighter than water.

52. LPG
(*a*) is a mixture of a saturated and unsaturated hydrocarbons in the C_3 and C_4 range
(*b*) is a mixture of methane and carbon dioxide
(*c*) is a mixture of methane and hydrogen
(*d*) is a mixture of saturated and unsaturated hydrocarbons in the C_6 and C_7 range.

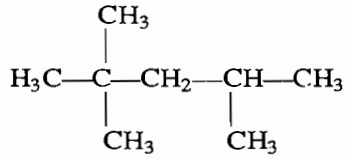
53. Which of the following compounds is added in LPG to impart a distinct odour ?
(*a*) Amyl nitrate (*b*) Ethyl mercaptan
(*c*) Tetra ethyl lead (*d*) Phenol.

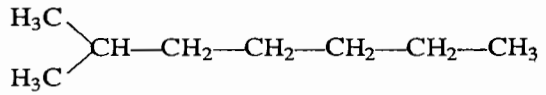
54. Motor fuel gasoline is composed of
(*a*) methane through decane (*b*) ethane through decane
(*c*) propane through decane (*d*) hexane through decane.

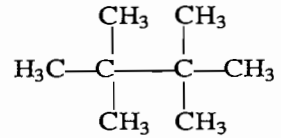
55. Select the correct statement
(*a*) Higher the indication period of gasoline, poorer is the stability of the gasoline
(*b*) Higher the induction period of gasoline, better is the stability of gasoline

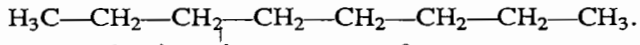
(*c*) The induction period of gasoline has no relation with the stability of gasoline
(*d*) The induction period of gasoline must be less than 36 min.

56. The structural formula of iso-octane is

(*a*) 

(*b*) 

(*c*) 

(*d*) 

57. Octane number is an important test for
(*a*) LPG (*b*) kerosine
(*c*) gasoline (*d*) light diesel oil.

58. The most popular antiknock agent is
(*a*) C_2H_5SH (*b*) $Pb(C_2H_5)_4$
(*c*) $Pb_4C_2H_5$ (*d*) CH_3SH.

59. Which of the following hydrocarbons are the most desirable in gasoline ?
(*a*) Paraffins (*b*) Isoparaffins
(*c*) Naphthenes (*d*) Aromatics

60. Octane number of *n*-heptane is taken to be
(*a*) 15 (*b*) 0
(*c*) 100 (*d*) 17.

61. Octane number of paraffins
(*a*) remains constant with change in number of carbon atoms
(*b*) increases with increase in number of carbon atoms
(*c*) decreases with increase in number of carbon atoms
(*d*) none of the above.

62. Which of the following hydrocarbons has maximum octane number ?
(*a*) Benzene (*b*) Cyclohexane
(*c*) Hexane (*d*) Iso-hexane.

63. Which of the following hydrocarbons has maximum octane number ?

(*a*) O-Xylene (*b*) Toluene
(*c*) Benzene (*d*) Iso-octane.

64. Select the wrong statement

(*a*) The aromatics have higher octane number than naphthenes with same number of carbon atoms
(*b*) Branched chain paraffins have higher octane number than straight chain paraffins with same number of carbon atoms
(*c*) Octane number of paraffins decreases with increasing number of carbon atoms
(*d*) Octane number of *n*-octane is 100.

65. Arrange the following hydrocarbons series in the increasing order of octane number for the same carbon atoms.

(*i*) Paraffins (P) (*ii*) Naphthenes (N) (*iii*) Aromatics (A)

(*a*) P, N, A (*b*) A, N, P
(*c*) A, P, N (*d*) N, A, P.

66. Arrange the following hydrocarbons series in the increasing order of knock rating for the same carbon atoms.

(*i*) Paraffins (P) (*ii*) Naphthenes (N) (*iii*) Aromatics (A)

(*a*) A, N, P (*b*) P, N, A
(*c*) N, A, P (*d*) A, P, N.

67. Antioxidants are added in gasoline

(*a*) to minimize gum formation
(*b*) to prevent icing of the carburettor
(*c*) to prevent the build-up of lead in engines
(*d*) for identification.

68. The dielectric constant of petroleum products is

(*a*) less than that of porcelain
(*b*) more than that of porcelain
(*c*) zero
(*d*) equal to or more than that of porcelain.

69. Select the correct order of increasing effect of TEL on octane number

(*a*) Olefins, aromatics, naphthenes, paraffins
(*b*) Aromatics, naphthenes, olefins, paraffins
(*c*) Paraffins, naphthenes, aromatics olefins
(*d*) Paraffins, olefins, naphthenes, aromatics.

70. Arrange the following hydrocarbons series in the increasing order of specific heat for the same carbon atoms.

1. Paraffins 2. Naphthenes 3. Aromatics

(*a*) Paraffins, Naphthenes, Aromatics
(*b*) Aromatics, Naphthenes, Paraffins
(*c*) Naphthenes, Paraffins, Aromatics
(*d*) Naphthenes, Aromatics, Paraffins.

71. Which of the following hydrocarbons are the most desirable in kerosine ?

(*a*) Paraffins (*b*) Isoparaffins
(*c*) Naphthenes (*d*) Aromatics.

72. Smoking tendency of hydrocarbons of same carbon atoms present in kerosine is maximum for

(*a*) Isoparaffins (*b*) Naphthenes
(*c*) Aromatics (*d*) Paraffins.

73. Smoking tendency of hydrocarbons of same carbon atoms present in kerosine is minimum for

(*a*) Isoparaffins (*b*) Paraffins
(*c*) Aromatics (*d*) Naphthenes.

74. Smoking tendency of paraffins present in kerosine

(*a*) remains constant with change in molecular weight
(*b*) increases with increase in molecular weight
(*c*) decreases with increase in molecular weight
(*d*) none of the above.

75. Smoke point is an important test for

(*a*) Gasoline (*b*) High speed diesel oil
(*c*) Kerosine (*d*) LPG.

76. Sulphur content in the kerosine is determined generally by

(*a*) quartz tube method (*b*) bomb method
(*c*) lamp method (*d*) none of the above.

77. Smoking tendency of aromatics present in kerosine

(*a*) remains constant with change in molecular weight
(*b*) increases with increase in molecular weight
(*c*) decreases with increase in molecular weight.

78. Aniline point of an oil is the lowest temperature at which the oil is completely miscible with an equal volume of aniline. High aniline point indicates that the fuel

(*a*) is highly paraffinic
(*b*) has a low diesel index
(*c*) has a very poor ignition quality
(*d*) is highly aromatic.

79. Colour of the petroleum products can be determined by

(*a*) Abel apparatus (*b*) Pensky-Martens apparatus
(*c*) Saybolt chromometer (*d*) all of the above.

80. The diesel index is an indication of the ignition quality of a diesel fuel. Diesel index is calculated by

(*a*) $\text{Diesel Index} = \dfrac{\text{Aniline point in °F} \times \text{°API}}{100}$

(*b*) $\text{Diesel Index} = \dfrac{\text{Aniline Gravity Constant}}{100}$

(*c*) $\text{Diesel Index} = \dfrac{\text{Cetane number} - 10}{0{\cdot}72}$

(*d*) all of these answers.

81. Select the correct statement.

(*a*) Higher the diesel index, better is the ignition quality of a diesel fuel
(*b*) Higher the diesel index, poorer is the ignition quality of a diesel fuel
(*c*) The ignition quality is independent of the diesel index of a diesel fuel
(*d*) The ignition quality is independent of the cetane number of a diesel fuel.

82. Which of the following compounds can improve the cetane number of diesel oils when added in small quantities ?

(*a*) Ethyl mercaptan
(*b*) Amyl nitrate
(*c*) Methyl tertiary butyl ether
(*d*) Tetra ethyl lead.

83. Cetane number is an important test for

(*a*) gasoline (*b*) kerosine
(*c*) high speed diesel oil (*d*) fuel oil.

84. Cetane number of hepta methyl nonane is taken to be

(*a*) 0 (*b*) 15
(*c*) 100 (*d*) 42.

85. Cetane number of normal cetane is taken to be

(*a*) 0 (*b*) 15
(*c*) 17 (*d*) 100.

86. The chemical formula of normal cetane is

(*a*) $C_{12}H_{26}$ (*b*) $C_{14}H_{30}$
(*c*) $C_{16}H_{34}$ (*d*) $C_{18}H_{38}$.

87. Which of the following hydrocarbons are the most desirable in high speed diesel oil ?

(*a*) Aromatics (*b*) Naphthenes
(*c*) Paraffins (*d*) Naphthenic acids.

88. Arrange the following hydrocarbons series in the increasing order of cetane number for the same number of carbon atoms :

1. Paraffins 2. Naphthenes 3. Aromatics

(*a*) Paraffins, Naphthenes, Aromatics
(*b*) Aromatics, Naphthenes, Paraffins
(*c*) Paraffins, Aromatics, Naphthenes
(*d*) Aromatics, Paraffins, Naphthenes.

89. Penetration index and softening point are the important tests for

(*a*) high speed diesel oil (*b*) light diesel oil
(*c*) kerosine (*d*) bitumen.

90. Viscosity index of an oil

(*a*) indicates the rate of change of viscosity with temperature
(*b*) indicates the viscosity at 100°F
(*c*) indicates the rate of change of viscosity with pressure
(*d*) indicates the rate of change of specific gravity with pressure

91. Low sulphur diesel fuels are advantageous because

(*a*) they are less corrosive
(*b*) they are less liable to carbonization
(*c*) they form exhaust gases low in sulphurous and sulphuric anhydrides
(*d*) all of the above.

92. Bitumen is produced by

(*a*) blowing air into vacuum residue
(*b*) hydrogenation of vacuum residue
(*c*) steam reforming of vacuum residue
(*d*) pyrolysis of vacuum residue.

93. Heavy vacuum gas oil obtained from vacuum distillation unit is mainly used as

(*a*) blending component for gasoline
(*b*) blending component for kerosine
(*c*) feedstock for fluid catalytic cracking unit
(*d*) blending component for aviation turbine fuel.

94. For middle distillate production, FCC reactors are usually operated between

(*a*) 175° and 185°C (*b*) 900° and 950°C
(*c*) 100° and 110° (*d*) 470° and 490°C.

95. The vacuum required in vacuum distillation of reduced crude oil is of the order of

(*a*) 1·2 mm Hg (*b*) 120 mm Hg
(*c*) 700 mm Hg (*d*) 740 mm Hg.

96. The primary purpose of visbreaking process is

(*a*) to increase viscosity and pour point
(*b*) to reduce viscosity and pour point
(*c*) to increase viscosity and reduce pour point
(*d*) to reduce viscosity and increase pour point.

97. Zeolite catalyst

(*a*) are crystalline alumino-silicates
(*b*) have high activity than synthetic amorphous catalyst
(*c*) are used in catalytic cracking of heavy vacuum gas oils
(*d*) all of the above.

98. Crude petroleum distillation is carried out at pressure

(*a*) slightly below atmospheric pressure
(*b*) slightly above atmospheric pressure
(*c*) above 5 atm
(*d*) above 15 atm.

99. Which of the following solvents is used to extract aromatics from lube distillates and deasphalted oil ?

(*a*) Methyl ethyl ketone (*b*) Methyl isobutyl ketone
(*c*) Furfural (*d*) Aluminium chloride.

100. The solvent used in the dewaxing of the waxy oil feed is

(*a*) liquid sulphur trioxide
(*b*) composed of methyl ethyl ketone and toluene
(*c*) composed of triethylene glycol and water
(*d*) platinum.

101. Sulfolane is

(*a*) ethyl mercaptan
(*b*) thiophene
(*c*) tetrahydrothiophene dioxide
(*d*) methyl mercaptan.

102. In sweetening MEROX process for kerosine the mercaptans are converted into

(*a*) disulphides (*b*) sulphur
(*c*) hydrogen sulphide (*d*) all of the above.

103. Sodium plumbite has the chemical formula

(*a*) $NaPbO_2$ (*b*) Na_2PbO
(*c*) Na_2PbO_2 (*d*) Na_4PbO.

104. The doctor solution consists of sodium plumbite in

(*a*) aqueous caustic soda (*b*) soda ash
(*c*) water (*d*) ethanol.

105. Which of the following types of crude petroleum is the most suitable for the manufacture of bitumen ?

(*a*) Naphthenic
(*b*) Intermediate
(*c*) Paraffinic
(*d*) Bitumen cannot be manufactured from crude petroleum.

106. Hydrocracking is a

(*a*) high pressure and low temperature process
(*b*) low pressure and high temperature process
(*c*) low pressure and low temperature process
(*d*) high pressure and high temperature process.

107. Which of the following processes consumes hydrogen ?

(*a*) Fluid catalytic cracking process
(*b*) Hydrocracking process
(*c*) Visbreaking process
(*d*) Propane deasphalting process.

108. Which of the following processes is used to manufacture petroleum coke ?

(*a*) Visbreaking (*b*) Delayed coking
(*c*) Hydrocracking (*d*) Fluid catalytic cracking.

109. GASOHOL is a mixture of petrol and

(*a*) water (*b*) ethyl alcohol
(*c*) kerosine (*d*) high speed diesel oil.

110. Ash forming constituents present in crude petroleum are

(*a*) sulphur compounds (*b*) nitrogen compounds
(*c*) oxygen compounds (*d*) organometallic compounds.

111. Which of the following compounds is used in antiknock compositions to prevent the deposition of oxides of lead on spark plug, combustion chamber and exhaust line ?

(*a*) Methyl tertiary butyl ether (*b*) Ethylene dibromide
(*c*) Ethyl mercaptan (*d*) Amyl nitrate.

112. Which of the following hydrocarbons present in gasoline are prone to gum formation ?

(*a*) Paraffins (*b*) Naphthenes
(*c*) Olefins (*d*) Isoparaffins.

113. Which of the following is/are used as antioxidant in gasoline ?

(*a*) Phenols (*b*) Alcohols
(*c*) Halogenated hydrocarbons (*d*) Amyl nitrate.

114. Which of the following is/are used as anticing compounds ?

(*a*) Alcohols (*b*) Amyl nitrate
(*c*) Tetra ethyl lead (*d*) Ethyl mercaptan.

115. Which of the following impurities in the crude petroleum is the most prolific producer of HCl during distillation ?

(*a*) Sodium chloride (*b*) Magnesium chloride
(*c*) Calcium chloride (*d*) Potassium chloride.

116. Which of the following impurities in the crude petroleum is an oleophobic ?

(*a*) Ethyl mercaptan (*b*) Naphthenic acid
(*c*) Pyridine (*d*) Sodium chloride.

117. Which of the following impurities in the crude petroleum is an oleophilic ?

(*a*) Sodium chloride (*b*) Naphthenic acid
(*c*) Sand (*d*) Finely dispersed water.

118. The presence of oleophilic impurities in the crude petroleum causes

(*a*) corrosion in the crude distillation unit column overhead system
(*b*) erosion of crude petroleum pumps
(*c*) fouling of heat transfer surfaces
(*d*) all of the above.

119. Salt content of the desalted crude oils may be

(*a*) 3 ptb (*b*) 50 ptb
(*c*) 100 ptb (*d*) 200 ptb.

where ptb stands for pounds of salts, measured as sodium chloride, per thousand barrel.

120. Electrical desalting of crude petroleum is done for

(*a*) the removal of oleophilic impurities only
(*b*) the removal of oleophobic impurities only
(*c*) the removal of both oleophilic and oleophobic impurities
(*d*) the purposes other than the removal of oleophobic or oleophilic impurities.

121. The operating pressure, in kgf/cm^2, of electrical desalters is about

(*a*) 10 (*b*) 1
(*c*) 0·7 (*d*) 50.

122. The voltage required for good desalting of curde petroleum is approximately

(*a*) 1000 volts per inch of distance between electrodes
(*b*) 2000 volts per inch of distance between electrodes

(*c*) 3000 volts per inch of distance between electrodes
(*d*) 4000 volts per inch of distance between electrodes.

123. The water, in volume per cent used in the electrical desalting of crude oils varies normally between

(*a*) 3 and 8 (*b*) 20 and 30
(*c*) 10 and 15 (*d*) 15 and 20.

124. The temperature maintained in the electrical desalters is normally in the range of

(*a*) 200 to 220°C (*b*) 120 to 130°C
(*c*) 40 to 50°C (*d*) 250 to 275°C.

125. The conductivity of a crude oil-water mixture depends on the

(*a*) temperature (*b*) percentage of water
(*c*) pH (*d*) all of the above.

126. The conductivity of a crude oil-water mixture

(*a*) remains unaffected with change in temperature
(*b*) increases with increase in temperature
(*c*) decreases with increase in temperature
(*d*) may decrease or increase with increase in temperature depending on the nature of crude oil.

127. The conductivity of a mixture of crude oil-water mixture

(*a*) is independent of the amount of water present
(*b*) decreases with increase in the amount of water
(*c*) increases with increase in the amount of water
(*d*) decreases linearly with increase in the amount of water.

128. The feedstock for the catalytic reforming unit is

(*a*) naphtha (*b*) high speed diesel oil
(*c*) kerosine (*d*) reduced crude oil.

129. The operation of reactors used in the catalytic reforming of naphtha is favoured at

(*a*) low pressure and low temperature
(*b*) high pressure and high temperature
(*c*) low pressure and high temperature
(*d*) high pressure and low temperature.

130. The monometallic catalyst used in the catalytic reforming of naphthas is

(*a*) Pt (*b*) Ni
(*c*) Fe (*d*) V_2O_5.

131. The bi-metallic catalysts used in the catalytic reforming of naphthas permit aromatics crerating reactions to occur with a minimum of

hydrocracking of paraffins and naphthenes. The bi-metallic catalysts contain

(*a*) platinum and nickel (*b*) nickel and vanadium
(*c*) platinum and rhenium (*d*) rhenium and rhodium.

132. In the catalytic reforming of naphtha, the dehydrogenation of naphthenes gives hydrogen and

(*a*) paraffins (*b*) aromatics
(*c*) branched chain paraffins (*d*) none of the above.

133. The desirable reactions in the catalytic reforming of naphtha are

(*a*) slightly exothermic (*b*) endothermic
(*c*) autocatalytic (*d*) highly exothermic.

134. Which of the following reactions is undesirable in the catalytic reforming of naphthas ?

(*a*) Hydrocracking of paraffins
(*b*) Dehydrogenation of naphthenes
(*c*) Isomerization of naphthenes
(*d*) Cyclization of paraffins.

135. In alkylation processes, olefins react with

(*a*) normal paraffins (*b*) isoparaffins
(*c*) naphthenes (*d*) aromatics.

136. The catalyst used in alkylation process is

(*a*) Ni (*b*) Al_2O_3
(*c*) HF (*d*) Pt.

137. HF alkylation units operate at

(*a*) 4°C (*b*) 180°C
(*c*) 480°C (*d*) 37°C.

138. In the Edeleanu process solvent used is

(*a*) furfural (*b*) hydrogen peroxide
(*c*) liquid sulphur dioxide (*d*) phenol.

139. Edeleanu process is used

(*a*) to reduce aromatic content of kerosine
(*b*) to reduce paraffinic content of kerosine
(*c*) to reduce naphthenic content of kerosine
(*d*) to increase aromatic content of kerosine.

140. The frequent fluctuation in crude distillation tower top pressure can be caused due to

(*a*) entry of water alongwith top reflux to the tower
(*b*) fluctuations in the tower bottom level

(*c*) fluctuation in the feed rate and feed temperature to the column
(*d*) all of the above.

141. Clay tratment is generally employed for

(*a*) the removal of olefins and diolefins from cracked gases/liquid streams
(*b*) the improvement of colour and odour
(*c*) the oxidation stability of lube base stocks
(*d*) all of the above.

142. In the UDEX process for the extraction of aromatics from reformed naphtha the solvent used is

(*a*) liquid sulphur dioxide
(*b*) a mixture of diethylene glycol and water
(*c*) a mixture of methyl ethyl ketone and benzene
(*d*) iron.

143. For the removal of asphaltic constituents from vacuum residue the most suitable solvent is

(*a*) liquid sulphur dioxide (*b*) vanadium pentacxide
(*c*) propane (*d*) triethylene glycol.

144. In propane deasphalting process the extractor pressure and temperature are

(*a*) 40 kgf/cm^2 g and 130°C (*b*) 1 kgf/cm^2 and 30°C
(*c*) 175 kgf/cm^2 g and 180°C (*d*) 120 mm Hg and 30°C.

145. Edeleanu process is used to extract aromatics from kerosine using liquid sulphur dioxide as solvent. In this process extractor temperature is maintained at about

(*a*) 80°C (*b*) 180°C
(*c*) –20°C (*d*) 470°C.

146. Paraffin waxes are graded by its

(*a*) melting point (*b*) specific gravity
(*c*) ductility (*d*) viscosity.

147. The calculation of the characterization factor, K_{UOP}, requires mean average boiling point and ..... .

148. For the paraffinic curde oil, the value of the characterization factor, K_{UOP}, must be greater than ..... .

149. The US Bureau of Mines method for the classification of crude oils is based on the characteristics of the two key fractions. These key fractions are 250–275°C at 1 atm and ..... °C at 40 mm Hg.

150. The flash point above ..... are determined by Pensky-Marten apparatus.

151. The density of LPG in its liquid form is about ..... that of water.

152. For determining the ignition quality of a diesel fuel used in compression ignition engine, the reference fuels used are normal cetane and ..... .

153. For determining the octane number of gasoline, the reference fuels used are iso-octane and ..... .

154. The process for conversion of straight run naphthas to obtain high octane gasoline is called ..... .

155. In the standard Reid apparatus for determining the absolute vapour pressure of liquid fuels, the ratio of the volume of air chamber to the volume of fuel chamber is ..... .

156. In the standard Reid apparatus the bomb is heated in a water bath controlled thermostatically to ..... °F.

157. The difference between gross and net calorific values of petroleum fuel oils is much greater than for coal tar fuels because of the high percentages of ..... in petroleum fuel oils.

158. Wax sweating operation is a ..... process.

159. Paraffin waxes consist largely of ..... .

160. Solvent deoiling is a preferred process for deoiling ..... wax.

161. Slack wax is considered to be made up of oil, ... and ..... .

162. The principle of solvent deoiling process is to separate oil and soft wax from ..... .

163. Methyl iso-butyl ketone is preferred as a deoiling solvent over mixed methyl ethyl ketone because the use of methyl iso-butyl ketone eliminates solvent drying facilities, requires lower solvent dilution ratios and requires ..... filtration temperatures.

164. Hydrofinishing process for waxes is preferred over the conventional processes of clay or bauxite treatment or a combination of acid and clay treatment because the hydrofinishing process gives ..... yields and requires low operating cost.

165. In the hydrofinishing process for waxes, the yield of treated wax is of the order of ..... wt. %.

166. For efficient and satisfactory wax sweating, the upper limit of an oil content is considered to be ..... .

167. In a soaker visbreaker the cracking reactions take place in the ..... .

168. In a soaker visbreaker a soaking drum is added between ..... and ..... .

169. Compared to conventional visbreaker, the visbreaker with a soaker requires ..... fuel consumption and operate for ..... onstream time.

170. The flash points below 50°C are determined by ..... apparatus.

171. One of the reference fuels used for the determination of cetane number of diesel fuels is heptamethyl nonane. Its cetane number is taken to be ..... .

172. Yield stress for waxy crude increases with ..... temperature.

173. The penetration of a bitumen at the softening point temperature is about ..... .

174. An oil with a minimum change in viscosity with temperature has ..... viscosity index.

175. An oil with a rapid change in viscosity with temperature has ..... viscosity index.

ANSWERS

1. (*a*)	2. (*c*)	3. (*d*)	4. (*d*)	5. (*c*)
6. (*c*)	7. (*a*)	8. (*d*)	9. (*d*)	10. (*c*)
11. (*d*)	12. (*a*)	13. (*a*)	14. (*c*)	15. (*a*)
16. (*b*)	17. (*c*)	18. (*a*)	19. (*c*)	20 (*a*)
21. (*d*)	22. (*a*)	23. (*b*)	24. (*c*)	25. (*b*)
26. (*a*)	27. (*c*)	28. (*a*)	29. (*d*)	30. (*a*)
31. (*c*)	32. (*b*)	33. (*b*)	34. (*d*)	35. (*b*)
36. (*c*)	37. (*d*)	38. (*d*)	39. (*a*)	40. (*d*)
41. (*a*)	42. (*b*)	43. (*d*)	44. (*c*)	45. (*c*)
46. (*b*)	47. (*b*)	48. (*c*)	49. (*b*)	50. (*a*)
51. (*b*)	52. (*a*)	53. (*b*)	54. (*d*)	55. (*b*)
56. (*a*)	57. (*c*)	58. (*b*)	59. (*d*)	60. (*b*)
61. (*c*)	62. (*a*)	63. (*a*)	64. (*d*)	65. (*a*)
66. (*a*)	67. (*a*)	68. (*a*)	69. (*c*)	70. (*b*)
71. (*a*)	72. (*c*)	73. (*b*)	74. (*b*)	75. (*c*)
76. (*c*)	77. (*c*)	78. (*a*)	79. (*c*)	80. (*d*)
81. (*a*)	82. (*b*)	83. (*c*)	84. (*b*)	85. (*d*)
86. (*c*)	87. (*c*)	88. (*b*)	89. (*d*)	90. (*a*)
91. (*d*)	92. (*a*)	93. (*c*)	94. (*d*)	95. (*b*)
96. (*b*)	97. (*d*)	98. (*b*)	99. (*c*)	100. (*b*)
101. (*c*)	102. (*a*)	103. (*c*)	104. (*a*)	105. (*a*)
106. (*d*)	107. (*b*)	108. (*b*)	109. (*b*)	110. (*d*)
111. (*b*)	112. (*c*)	113. (*a*)	114. (*a*)	115. (*b*)
116. (*d*)	117. (*b*)	118. (*d*)	119. (*a*)	120. (*b*)
121. (*a*)	122. (*c*)	123. (*a*)	124. (*b*)	125. (*d*)
126. (*b*)	127. (*c*)	128. (*a*)	129. (*c*)	130. (*a*)
131. (*c*)	132. (*b*)	133. (*b*)	134. (*a*)	135. (*b*)
136. (*c*)	137. (*d*)	138. (*c*)	139. (*a*)	140. (*d*)
141. (*d*)	142. (*b*)	143. (*c*)	144. (*a*)	145. (*c*)
146. (*a*).				

147. specific gravity
148. 12
149. 275-300
150. 50°C
151. half
152. heptamethyl nonane
153. n-heptane
154. catalytic reforming
155. 4
156. 100
157. hydrogen
158. batch
159. n-paraffins
160. slack
161. soft wax, hard wax
162. hard wax
163. higher
164. higher
165. 99
166. 40%
167. soaker drum
168. furnace, fractionator
169. lower, longer
170. Abel
171. 15
172. decreasing
173. 800
174. high
175. low

13

Environmental Engineering

1. The chemical most commonly used to speed sedimentation of sewage is

(*a*) sulphuric acid (*b*) copper sulphate
(*c*) lime (*d*) sodium permanganate.

2. The gas from sludge digestion tanks is mainly composed of

(*a*) nitrogen (*b*) hydrogen sulphide
(*c*) methane (*d*) carbon monoxide.

3. The quantity of chlorine in ppm required to satisfactorily chlorinate sewage is usually

(*a*) 125—150 (*b*) 95—120
(*c*) 60–90 (*d*) 0—25.

4. Most of the bacteria in sewage are

(*a*) pathogenic (*b*) anaerobic
(*c*) saprophytic (*d*) parasitic.

5. The ratio of oxygen available to the oxygen required for stabilization of sewage is called

(*a*) biochemical oxygen demand
(*b*) relative stability
(*c*) bacterial-stability factor
(*d*) oxygen-ion concentration.

6. In the design of grit chambers

(*a*) temperature is an important factor
(*b*) the maximum velocity of flow is 1 ft/s
(*c*) the detention period should be at least 30 min
(*d*) there should be a 5 to 1 ratio of length to depth.

7. The process of lagooning is primarily a means of

(*a*) increasing the capacity of storage reservoirs
(*b*) increasing flow of sewage through Imhoff tanks
(*c*) reducing the excessive flow in sewers
(*d*) disposing sludge.

8. The biochemical treatment of sewage effluents is essentially a process of

(*a*) reduction (*b*) oxidation
(*c*) dehydration (*d*) alkalinization.

9. In treating turbine water a popular coagulant is

(*a*) calcium sulphate (*b*) chlorine
(*c*) ferric sulphate (*d*) iodine.

10. Septic tanks are primarily used for

(*a*) the aerobic decomposition of deposited sewage solids
(*b*) separation of deposited solids
(*c*) anaerobic decomposition of deposited solids
(*d*) separation of oil and grease scums.

11. The per cent of total solids in most domestic sewage is approximately

(*a*) 0·01 (*b*) 0·1
(*c*) 1 (*d*) 10.

12. For protection of acquatic life in a fresh water stream, sewage effluent should never lower the dissolved oxygen content lower than

(*a*) 15 ppm (*b*) 10 ppm
(*c*) 5 ppm (*d*) 20 ppm.

13. Ecological system or ecosystem refers to

(*a*) a group of individuals of any one kind of organism
(*b*) all of the population occupying a given area
(*c*) the community and non-living environment working together
(*d*) a portion of the earth where living objects can be found.

14. Chloramines are used in water treatment

(*a*) for disinfection
(*b*) for taste and colour control
(*c*) as algicides
(*d*) for weed control in reservoirs.

15. The most suitable equipment for removing the fine dust particle (<1micron diameter) from air below its dew point will be

(*a*) bag filter (*b*) electrostatic precipitator
(*c*) cyclone separator (*d*) wet scrubber.

16. The most efficient equipment for removal of sub micron dust particles from blast furnace gas is

(*a*) venturi scrubber (*b*) gravity settling chamber
(*c*) electrostatic precipitator (*d*) cyclone separator.

17. Man dies in an atmosphere of carbon monoxide because

(*a*) it combines with oxygen present in the body to form carbon dioxide

(*b*) it reduces the organic matter of tissues
(*c*) it combines with the haemoglobin of the blood making it capable of absorbing oxygen
(*d*) it drives up the blood.

18. The lowest layer of atmosphere is called

(*a*) ionosphere (*b*) troposphere
(*c*) stratosphere (*d*) exosphere.

19. Which of the following nitrogen oxides is neutral in character ?

(1) N_2O_4 (2) N_2O_5
(3) N_2O (4) N_2O_3.

20. Arrange the following in ascending order of their occurrence in the atmosphere :

(1) oxygen (2) Nitrogen
(3) Carbon dioxide (4) Argon.
(*a*) Nitrogen, Oxygen, Carbon dioxide, Argon
(*b*) Argon, Carbon dioxide, Oxygen, Nitrogen
(*c*) Carbon dioxide, Argon, Oxygen, Nitrogen
(*d*) Nitrogen, Oxygen, Argon, Carbon dioxide.

21. The operation of a cyclone separator relies on

(*a*) centrifugal force acting on the particle
(*b*) producing an electric charge on the particle to be collected and then directing it, by electrostatic forces, to the collecting electrodes
(*c*) the creation of intimate contact between a stream of gas and a flow of scrubbing liquor
(*d*) diffusion of dust particles.

22. The collection efficiency of a cyclone separator

(*a*) is directly proportional to the mass of the dust particle
(*b*) is inversely proportional to the radius of the dust particle path
(*c*) increases with increase in gas flow rate
(*d*) all of the above.

23. For a given particle size, the collection efficiency of a cyclone separator

(*a*) will be increased at higher pressure drops
(*b*) will be decreased at higher pressure drops
(*c*) will not be affected by changing pressure drop
(*d*) none of the above.

24. In an aerosol

(*a*) some of the particles may be positively charged
(*b*) some of the particles may be negatively charged
(*c*) some of the particles may be uncharged
(*d*) all of the above.

25. High absolute humidity

(*a*) increases the explosibility of the aerosol
(*b*) decreases the explosibility of the aerosol
(*c*) does not change the explosibility of the aerosol.

26. The operation of electrostatic precipitator relies on

(*a*) producing an electric charge on the particle to be collected and then directing it, by electrostatic forces, to the collecting electrodes
(*b*) centrifugal force acting on the particle
(*c*) diffusion of dust particles
(*d*) the creation of intimate contact between a stream of gas and a flow of scrubbing liquor.

27. The operating pressure drop for the electrostatic precipitator, including perforated plates, varies in the range of

(*a*) 0·2 to 0·5 in. H_2O g (*b*) 3 to 60 in. H_2O g
(*c*) 2 to 6 in. H_2O g (*d*) 0·01 to 0·1 in. H_2O g

28. In the electrostatic precipitator

(*a*) high conductivity material is more easily collected
(*b*) low conductivity material is more easily collected
(*c*) electrical conductivity of material is not an important factor
(*d*) none of the above.

29. The electrostatic precipitators have an efficiency characteristic which is related primarily to exposure time, *i.e.*, the period during which a dust particle is exposed to the electrostatic field. Exposure time can be increased by

(*a*) increasing the cross-sectional area of the precipitator
(*b*) increasing its length in the direction of gas flow
(*c*) both *a* and *b*
(*d*) neither *a* nor *b*.

30. The collection efficiency of electrostatic precipitator depends on

(*a*) the electrode area (*b*) the particle drift velocity
(*c*) the gas flow rate (*d*) all of the above.

31. The collection efficiency of electrostatic precipitator

(*a*) increases with increase in the electrode area
(*b*) increases with increase in the particle drift velocity
(*c*) decreases with increase in the gas flow rate
(*d*) all of the above.

32. For most industrial electrostatic precipitator installations, particle drift velocity which is used to calculate the precipitation efficiency, varies from

(*a*) 3 to 8 ft/s (*b*) 0·1 to 1 ft/s
(*c*) 60 to 80 ft/s (*d*) 15 to 20 ft/s.

33. For heavy duty industrial type electrostatic precipitator

(*a*) from 30000 to 100000 volts dc is normally required
(*b*) from 240 to 440 volts dc is normally required
(*c*) from 13000 to 18000 volts dc is normally required
(*d*) from 1000 to 5000 volts dc is normally required.

34. For a fabric filter, gas-to-fabric ratio is expressed as cubic feet per minute per square foot fabric surface area. As the gas-to-fabric ratio becomes larger

(*a*) the size and cost of a fabric filter is correspondingly increased
(*b*) the size and cost of a fabric filter is correspondingly decreased
(*c*) the size and cost of a fabric filter remains unaffected.

35. Gas temperature is an important consideration in the design of fabric filter because it affects

(*a*) the gas viscosity (*b*) the gas density
(*c*) the selection of fabric (*d*) all of the above.

36. In a fabric filter the pressure drop

(*a*) increases directly as viscosity of the gas and inversely as density of the gas
(*b*) increases directly as density of the gas and inversely as viscosity of the gas
(*c*) increases directly as density of the gas and independent of the viscosity of the gas
(*d*) none of the above.

37. The resistance offered by filter used in a fabric filter

(*a*) varies inversely as the particle size and directly as the dust concentration
(*b*) varies inversely as the dust concentration and directly as the particle size
(*c*) varies directly as the particle size as well as the dust concentration
(*d*) varies inversely as the particle size as well as the dust concentration.

38. The operating pressure drops for a fabric filter are usually in the range of

(*a*) 0·2 to 0·5 in. H_2O g (*b*) 2 to 6 in. H_2O g
(*c*) 8 to 60 in. H_2O g (*d*) 0·01 to 0·1 in. H_2O g.

39. Depending on the size of the particles being collected, the wet scrubbers operate in a pressure drop range from

(*a*) 0·2 to 0·5 in. H_2O g (*b*) 3 to 60 in. H_2O g
(*c*) 0·01 to 0·1 in. H_2O g (*d*) 760 to 800 in. H_2O g.

40. Which of the following devices of particulate collection is the least efficient ?

(*a*) Cyclone separator (*b*) Electrostatic precipitator
(*c*) Fabric filter (*d*) Wet scrubber.

41. For any particular dust concentration in the feed stream to a fabric filter, increasing the gas-to-fabric ratio will

(*a*) result in an increased pressure drop
(*b*) result in decreased pressure drop
(*c*) not affect the pressure drop.

42. For continuous reverse air cleaning in a fabric filter, gas-to-fabric ratio normally varies from

(*a*) 8 to 15 cfm/sq ft (*b*) 0·2 to 0·5 cfm/sq ft
(*c*) 50 to 60 cfm/sq ft (*d*) 0·01 to 0·1 cfm/sq ft.

43. The fabric used in a fabric filter is selected on the basis of

(*a*) temperature (*b*) chemical resistance
(*c*) dust concentration (*d*) all of the above.

44. Which of the following devices of particulate collection from a stream of a gas does not discharge the particulates collected as a dry solid ?

(*a*) Cyclone separator (*b*) Electrostatic precipitator
(*c*) Wet scrubber (*d*) Fabric filter.

ANSWERS

1. (*c*)	2. (*c*)	3. (*d*)	4. (*c*)	5. (*b*)
6. (*b*)	7. (*d*)	8. (*b*)	9. (*c*)	10. (*c*)
11. (*b*)	12. (*c*)	13. (*c*)	14. (*a*)	15. (*b*)
16. (*c*)	17. (*c*)	18. (*b*)	19. (*c*)	20. (*c*)
21. (*a*)	22. (*d*)	23. (*a*)	24. (*d*)	25. (*b*)
26. (*a*)	27. (*a*)	28. (*a*)	29. (*c*)	30. (*d*)
31. (*d*)	32. (*b*)	33. (*a*)	34. (*b*)	35. (*d*)
36. (*a*)	37. (*a*)	38. (*b*)	39. (*b*)	40. (*a*)
41. (*a*)	42. (*a*)	43. (*d*)	44. (*c*)	

14

Nuclear Engineering

1. The nucleus of an atom consists of

(*a*) protons only (*b*) protons and electrons
(*c*) protons and neutrons (*d*) protons, neutrons, and electrons.

2. A proton is identical with

(*a*) ionised hydrogen molecule
(*b*) the nucleus of hydrogen atom
(*c*) the nucleus of deuterium
(*d*) an α-ray particle.

3. The electron is identical with

(*a*) hydrogen ion (*b*) positron
(*c*) an α-ray particle (*d*) a β-ray particle.

4. In an atom, the electrons

(*a*) move round the nucleus at random
(*b*) are embedded in space around the nucleus
(*c*) are distributed as three dimensional charge clouds around the nucleus
(*d*) are stationary in various energy levels.

5. The electron is a particle with a mass of about

(*a*) 1/18 of the lightest nucleus
(*b*) 1/180 of the lightest nucleus
(*c*) 1/1800 of the lightest nucleus
(*d*) 1/18000 of the lightest nucleus.

6. The positron is almost as heavy as

(*a*) an electron (*b*) a proton
(*c*) a neutron (*d*) a meson.

7. Positive ions are formed from neutral atoms by the loss of

(*a*) neutrons (*b*) protons
(*c*) electrons (*d*) mesons.

8. An electrovalent compound is made up of

(*a*) neutral atoms

(*b*) electrically charged atoms or groups of atoms
(*c*) electrically charged molecules
(*d*) neutral molecules.

9. The life of a meson is about

(*a*) 10^{-8} sec (*b*) 10^{-2} sec
(*c*) 10^{-18} sec (*d*) 1 sec.

10. The mass of a meson with charge $+e$ is

(*a*) equal to that of a proton
(*b*) equal to that of an electron
(*c*) 275 times that of an electron
(*d*) 1/1850 of the mass of an electron.

11. The antiparticle of electron is

(*a*) proton (*b*) positron
(*c*) antiproton (*d*) neutron.

12. The number of protons in the nucleus $_{92}U^{235}$ is

(*a*) 327 (*b*) 92
(*c*) 235 (*d*) 143.

13. The number of neutrons in the nucleus $_{92}U^{235}$ is

(*a*) 92 (*b*) 146
(*c*) 143 (*d*) 327.

14. Anions are formed from neutral atoms by

(*a*) loss of electrons (*b*) loss of protons
(*c*) gain of electrons (*d*) gain of protons.

15. The α-particle is identical with

(*a*) a helium atom (*b*) a doubly charged helium ion
(*c*) proton (*d*) fast moving neutron.

16. Which of the following particles is unstable ?

(*a*) neutron (*b*) proton
(*c*) electron (*d*) alpha particle.

17. The neutron carries

(*a*) no electric charge (*b*) a single positive charge
(*c*) a single negative charge (*d*) double negative charge.

18. The mass of helium is about

(*a*) half of the mass of neutron
(*b*) one-fourth of the mass of proton
(*c*) twice the mass of deuterium
(*d*) same as the mass of tritium.

19. An atom can be considered as having a dense nucleus of neutrons and protons and a surrounding distribution of electrons. If there are x neutrons, y protons and z electrons, what sort of relationship exists between x, y and z in a small neutral atom ?

(*a*) $x = y \cong z$ (*b*) $x \cong y = z$
(*c*) $x = y = z$ (*d*) $x = y-1 = z$

where $\cong$ means "approximately equals".

20. Select the correct statement

(*a*) The nucleus is an elementary particle
(*b*) The nucleus has a structure
(*c*) The nucleus cannot have different states of energy
(*d*) Some radioactive nuclei emit only α-rays and γ-rays.

21. In radioactive disintegration, β-ray emission is always accompanied by

(*a*) α-ray emission (*b*) γ-ray emission
(*c*) neutron emission (*d*) none of the above.

22. A radioactive substance gives off γ-rays when

(*a*) its nucleus goes from a higher energy state to a lower one
(*b*) one of the orbital electrons jumps from a higher orbit to one of a lower energy
(*c*) an orbital electron jumps from a lower orbit to a higher one
(*d*) its nucleus goes from a lower energy state to a higher one.

23. Atomic size is of the order of

(*a*) 10^{-12} cm (*b*) 10^{-10} cm
(*c*) 10^{-8} cm (*d*) 10^{-6} cm.

24. The radius of nucleus is of the order of

(*a*) 10^{-10} cm (*b*) 10^{-8} cm
(*c*) 10^{-14} cm (*d*) 10^{-12} cm.

25. The volume of nucleus is about

(*a*) 10^{-12} times the volume of atom
(*b*) 10^{12} times the volume of atom
(*c*) 10^{-10} times the volume of atom
(*d*) 10^{-8} times the volume of atom.

26. The density of nucleus is about

(*a*) 10^{-10} times the density of atom
(*b*) 10^{12} times the density of atom
(*c*) 10^{-8} times the density of atom
(*d*) 10^{10} times the density of atom.

27. The distance between nucleons in atomic nucleus is of the order of

(*a*) 200 Fermi (*b*) 2 Fermi
(*c*) 50 Fermi (*d*) 1000 Fermi.

28. The particle mainly responsible for the stability of nucleus is

(*a*) electron (*b*) proton
(*c*) neutron (*d*) positron.

29. Stability of nucleus depends upon the ratio of

(*a*) electron to proton (*b*) neutron to proton
(*c*) neutron to electron (*d*) none of the above.

30. The neutron to proton ratio in a stable nucleus is about

(*a*) 2 : 1 (*b*) 1 : 1
(*c*) 1 : 2 (*d*) 1·6 : 1

31. The nucleus is very dense and rigid because

(*a*) nucleus is positively charged
(*b*) nucleus is the centre of atom
(*c*) α-rays are deflected by nucleus
(*d*) almost whole of the mass is concentrated in nucleus.

32. In a most stable element the number of protons and the number of neutron is

(*a*) even-even (*b*) even-odd
(*c*) odd-even (*d*) odd-odd

33. Gamma rays are

(*a*) high energy electrons
(*b*) high energy electromagnetic waves
(*c*) low energy electrons
(*d*) low energy electromagnetic waves.

34. Radioactive decay is

(*a*) a physical change (*b*) a chemical change
(*c*) a nuclear change (*d*) none of the above.

35. During radioactive decay Beta particles are ejected from

(*a*) nucleus (*b*) outer nuclear region
(*c*) outermost shell (*d*) innermost shell.

36. In an α-decay the ratio of neutron to proton

(*a*) decreases (*b*) increases
(*c*) remains unchanged (*d*) may decrease or increase.

37. In β-decay the ratio of neutron to proton

(*a*) remains unchanged (*b*) decreases
(*c*) increases (*d*) may decrease or increase.

38. Select the correct statement.

(*a*) Ionising power of α-rays is higher than that of β-rays
(*b*) Penetrating power of β-rays is higher than that of γ-rays
(*c*) α-rays are composed of positively charged particles of mass 2
(*d*) α-rays travel faster than γ-rays.

39. The nuclide $_{91}X^{234}$ is the Beta decay product of

(*a*) $_{92}A^{234}$ (*b*) $_{91}B^{235}$
(*c*) $_{90}C^{234}$ (*d*) $_{93}D^{238}$.

40. Select the only correct statement out of the following :

(*a*) The mass of a nucleus is proportional to its density
(*b*) The mass of a nucleus is inversely proportional to its density
(*c*) The mass of a nucleus is proportional to its volume
(*d*) The mass of a nucleus is inversely proportional to its volume.

41. The ratio of the specific charge e/m of a proton to that of an alpha particle is

(*a*) 1 : 2 (*b*) 1 : 4
(*c*) 4 : 1 (*d*) 2 : 1.

42. The ratio of the diameter of atom to that of nucleus is about 10^4. Considering the density of ordinary matter to be of the order of 1 gm/cm^3, the density of the nuclear matter will be of the order of

(*a*) 10^4 gm/cm^3 (*b*) 10^7 gm/cm^3
(*c*) 10^{12} gm/cm^3 (*d*) 10^{64} gm/cm^3.

43. The ratio of the mass of an electron to the mass of a proton is

(*a*) 1837 (*b*) 1/1837
(*c*) 183·7 (*d*) 1/183·7.

44. The nucleus of any atom

(*a*) is positively charged (*b*) is negatively charged
(*c*) has no charge.

45. The specific charge of a charged body in motion

(*a*) increases
(*b*) decreases
(*c*) remains constant
(*d*) increases for positively charged bodies and decreases for negatively charged bodies.

46. The atomic number of an element is

(*a*) the number of neutrons present in an atomic nucleus
(*b*) the number of protons present in an atomic nucleus
(*c*) the sum of the number of protons and neutrons present in an atomic nucleus
(*d*) the difference in the number of protons and neutrons present in an atomic nucleus.

47. The mass number of an element is equal to

(*a*) the number of protons in the nucleus
(*b*) the number of neutrons in the nucleus
(*c*) the number of protons and neutrons in the nucleus
(*d*) the difference in the number of protons and neutrons in the nucleus.

48. Which of the following properties of elements is a whole number ?
(*a*) Atomic weight (*b*) Atomic radius
(*c*) Atomic volume (*d*) Atomic number.

49. The atomic number of an element corresponds to
(*a*) its atomic volume
(*b*) the number of electrons in its atom
(*c*) the number of neutrons in the nucleus of its atom
(*d*) its atomic weight.

50. The emission of an α-particle causes the resultant nucleus to have
(*a*) less atomic weight and less atomic number
(*b*) less atomic weight and more atomic number
(*c*) more atomic weight and more atomic number
(*d*) more atomic weight and less atomic number.

51. The emission of a β-particle causes the resultant nucleus to have
(*a*) less atomic weight (*b*) more atomic weight
(*c*) less atomic number (*d*) higher atomic number.

52. If the atomic weight of an element is A, the correct expression is
(*a*) $e = A-p$ (*b*) $p = A-n$
(*c*) $n = A + e$ (*d*) $A = n-e$.

53. The mass number of an element is 40 and atomic number 20. The ratio of neutrons to protons is
(*a*) 1 : 1 (*b*) 1 : 2
(*c*) 2 : 1 (*d*) none of the above.

54. The atomic weight of elements are usually fractional because
(*a*) these are mixtures of allotropes
(*b*) these are mixtures of isotopes
(*c*) these are mixtures of isobars
(*d*) element always contains some impurities.

55. A radioactive element A on radioactive disintegration gives two elements B and C. If B is helium and C is the element of atomic number 90 and atomic weight 234·1, the element A is
(*a*) $_{88}Ra^{226}$ (*b*) $_{91}Pa^{234}$
(*c*) $_{92}U^{238}$ (*d*) $_{90}Th^{234}$

56. A radioactive element X decays to give two inert gases. The element X is
(*a*) $_{92}U^{238}$ (*b*) $_{86}Ra^{226}$
(*c*) $_{90}Th^{234}$ (*d*) none of these.

57. Unit of radioactivity is
(*a*) Curie (*b*) Fermi
(*c*) Angstron (*d*) Candle.

58. Isotopes of an element have same
(*a*) mass number (*b*) number of neutrons
(*c*) atomic weight (*d*) electronic configuration.

59. Isotopes of an element have different
(*a*) chemical properties (*b*) nuclear charge
(*c*) electronic configuration (*d*) mass number.

60. Which one of the following characteristics is different for the neutral atoms of the isotopes of an element ?
(*a*) Atomic number (*b*) Atomic weight
(*c*) Number of protons (*d*) Number of electrons.

61. Elements have different nuclear charge but the same mass number are called
(*a*) isotones (*b*) isobars
(*c*) isotopes (*d*) isosteres.

62. The elements A and B which are isobaric have atomic number 18 and 20 respectively. If B contains 20 neutrons, the number of neutrons in A is
(*a*) 16 (*b*) 18
(*c*) 20 (*d*) 22.

63. The decay series of a radioactive element is

$$A \xrightarrow{-\alpha} B \xrightarrow{-\beta} C \xrightarrow{-\beta} D$$

In this series
(*a*) A and B are isobars (*b*) A and C are isobars
(*c*) A and D are isotopes (*d*) B and C are isotopes.

64. The increasing order (lowest first) for the values of e/m (charge/mass) for electron (e), proton (p), neutron (n) and alpha particle (a) is
(*a*) e, p, n, a (*b*) n, p, e, a
(*c*) n, p, a, e (*d*) n, a, p, e.

65. An element $_zM^A$ undergoes an α-emission followed by two successive β-emissions. The element formed is
(*a*) $_zM^{A-3}$ (*b*) $_zM^{A-4}$
(*c*) $_zM^{A-2}$ (*d*) $_zM^{A-6}$.

66. The radioactive isotope of hydrogen is called
(*a*) protium (*b*) deuterium
(*c*) tritium (*d*) ortho-hydrogen.

67. Unit negative charge and negligible mass are the characteristics of
(*a*) electrons (*b*) protons
(*c*) neutrons (*d*) mesons.

68. One amu is equal to

(*a*) $1{\cdot}66 \times 10^{-24}$ kg (*b*) $1{\cdot}66 \times 10^{-21}$ kg
(*c*) $1{\cdot}66 \times 10^{-27}$ kg (*d*) $1{\cdot}66 \times 10^{-26}$ kg.

69. Which one of the following elements is not radioactive ?

(*a*) Radium (*b*) Zirconium
(*c*) Uranium (*d*) Polonium.

70. One amu is equivalent to

(*a*) 931 J (*b*) 931 eV
(*c*) 931 MeV (*d*) 9·31 MeV.

71. When a radioactive element emits an α-particle, it becomes

(*a*) electrically negative (*b*) electrically positive
(*c*) neutral (*d*) none of the above.

72. When a radioactive element emits a β-particle, it becomes

(*a*) electrically positive (*b*) electrically negative
(*c*) neutral (*d*) none of the above.

73. The electron volt is the unit of

(*a*) energy (*b*) momentum
(*c*) potential difference (*d*) charge.

74. The mass defect is the mass lost in the synthesis of any nucleus from its component particles. This mass is lost in the form of energy. The amount of energy which is equivalent to the loss in mass is given by the Einstein relation

(*a*) $E = mc^2$ (*b*) $E = (mc)^2$
(*c*) $E = m^2c$ (*d*) $E = mc$.

where E= energy released, erg
m= mass defect, gm
c = velocity of light (3×10^{10} cm/sec).

75. Select the only correct statement

(*a*) Energy can be converted into matter, but matter cannot be converted into energy
(*b*) Matter can be converted into energy, but energy cannot be converted into matter
(*c*) Energy and matter both can be converted into each other
(*d*) Neither energy can be converted into matter, nor can matter be converted into energy.

76. Since the mass defect of the helium nucleus is $5{\cdot}045 \times 10^{-26}$ gm, its binding energy must be

(*a*) $5{\cdot}045 \times 10^{-26}$ erg (*b*) $4{\cdot}54 \times 10^{-5}$ erg
(*c*) $4{\cdot}54 \times 10^{-5}$ J (*d*) $5{\cdot}045 \times 10^{-26}$ J.

77. When combined in a nucleus the total mass of the protons and neutrons is less than the sum of their individual masses. This suggests that

(*a*) the mass defect is due to electrons revolving round the nucleus
(*b*) the mass defect accounts for the energy of the electrons revolving round the nucleus
(*c*) the mass defect accounts for the binding energy holding the particles together in the nucleus
(*d*) the experiments are not accurate enough.

78. Mass loss of 0·1364 amu is observed in the synthesis of O–16 nucleus from its components. The binding energy of O–16 nucleus is about

(*a*) 0·1364 MeV (*b*) 50 MeV
(*c*) 112 MeV (*d*) 127 MeV.

79. Binding energy of helium – 4 is 28·57 MeV. Its binding energy per nucleon is

(*a*) 19·24 MeV (*b*) 7·14 MeV
(*c*) 4·75 MeV (*d*) 57·14 MeV.

80. Nuclear forces are

(*a*) electrostatic (*b*) inter nuclear forces
(*c*) exchange forces (*d*) protonic forces.

81. The force holding the particles inside a nucleus is

(*a*) an electrostatic force (*b*) a gravitational force
(*c*) an exchange force (*d*) a magnetic force

82. The range of nuclear forces is

(*a*) 10^{-8} cm (*b*) 10^{-13} cm
(*c*) 10^{-16} cm (*d*) 100 angstron

83. The fuel used in nuclear reactor is

(*a*) graphite (*b*) heavy water
(*c*) cadmium (*d*) uranium.

84. Atoms of U-235 and U-238 differ in structure by

(*a*) three electrons
(*b*) three protons
(*c*) three neutrons
(*d*) three electrons and three protons.

85. The atom whose nucleus contains the largest number of neutrons is

(*a*) $_{92}U^{235}$ (*b*) $_{92}U^{238}$
(*c*) $_{92}U^{239}$ (*d*) $_{94}Pu^{239}$.

86. If $_{92}U^{238}$ emits one alpha particle, the remaining nucleus will contain

(*a*) 234N + 90P (*b*) 236N + 88P
(*c*) 144N + 90P (*d*) 145N + 93P.

87. In the final disintegration of $_{92}U^{238}$ to $_{82}Pb^{206}$, the number of α-particles ejected is

(*a*) 32 (*b*) 10
(*c*) 8 (*d*) 2.

88. The fertile fuels are those

(*a*) which by nuclear reactions give fission fuels
(*b*) which can be fissioned by thermal neutrons
(*c*) which can be fissioned by fast neutrons
(*d*) which cannot be converted into fission fuels.

89. Which of the following is not a fission fuel ?

(*a*) U-233 (*b*) U-235
(*c*) Pu-239 (*d*) U-238.

90. Which of the following is a fertile fuel ?

(*a*) Th-232 (*b*) Pu-241
(*c*) U-233 (*d*) U-235.

91. Pitchblende is an ore of

(*a*) radium (*b*) thorium
(*c*) polonium (*d*) uranium.

92. Monazite sand is a chief source of

(*a*) uranium (*b*) thorium
(*c*) radium (*d*) polonium.

93. In all naturally occurring uranium, the isotopic abundance of fission fuel as U-235 is

(*a*) 99·29% (*b*) 0·71%
(*c*) 10% (*d*) 0·1%.

94. The percentage of U-238 in all naturally occurring uranium is about

(*a*) 99·29% (*b*) 0·71%
(*c*) 10% (*d*) 99·99%.

95. The concentration of ThO_2 in Indian monazite sands is about

(*a*) 10-11% (*b*) 89-90%
(*c*) 70-71% (*d*) 29-30%.

96. In nuclear reactions

(*a*) only the mass number is conserved
(*b*) only the atomic number is conserved
(*c*) the mass number and the atomic number both are conserved
(*d*) neither the atomic number nor the mass number is conserved.

97. In the nuclear reaction given below

$$_4Be^9 + {}_2He^4 \longrightarrow {}_6C^x + {}_0n^1$$

the value of x should be

(*a*) 13 (*b*) 12
(*c*) 11 (*d*) 6.

98. In the nuclear reaction given below

$$_1H^2 + {}_{11}Na^{23} \longrightarrow {}_xNa^{24} + {}_1H^1$$

the value of x should be

(*a*) 11 (*b*) 10
(*c*) 12 (*d*) 13.

99. A certain nuclear reaction is represented by the equation

$$_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + x$$

in which x is a material particle. This particle is

(*a*) a deuterium (*b*) an alpha particle
(*c*) a proton (*d*) a neutron.

100. A possible nuclear reaction is

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{54}Xe^{140} + {}_{38}Sr^{94} + 2{}_0n^1 + \text{rays} + \text{energy}$$

This nuclear process is

(*a*) fusion (*b*) fission
(*c*) transmutation (*d*) none of the above.

101. In the nuclear reaction given below

$$_{92}U^{238} + {}_0n^1 \longrightarrow X + {}_{36}Kr^{88} - 3{}_0n^1$$

the element X is

(*a*) barium (*b*) calcium
(*c*) strontium (*d*) potassium.

102. The sum of masses of two nuclei produced in fission is

(*a*) less than the mass of the original nucleus
(*b*) more than the mass of the original nucleus
(*c*) equal to the mass of the original nucleus
(*d*) many times less than the mass of the original nucleus.

103. The reaction

$$_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + {}_0n^1 + \text{energy}$$

represents

(*a*) nuclear fission
(*b*) nuclear fusion
(*c*) transmutation of an element
(*d*) the laboratory method for the production of helium.

104. To induce fusion the temperature of reacting substances must be raised to millions of degrees so that

(*a*) the substance may burn more violently
(*b*) the base nuclei may possess sufficient kinetic energy to overcome their mutual electrostatic repulsion and thus they may come in bodily contact with other nuclei

(*c*) fusion of atoms may take place at a faster rate
(*d*) thermoelectric effect may be increased.

105. The nuclear fusion is a reverse process of

(*a*) nuclear fission (*b*) thermionic emission
(*c*) radioactive decay (*d*) none of the above.

106. The rate of disintegration of a radioactive element

(*a*) remains constant throughout
(*b*) progressively increases
(*c*) progressively decreases
(*d*) may increase or decrease or remain constant.

107. Select the correct statement

(*a*) The rate of disintegration of radioactive substances can be increased by applying intense heat to it.
(*b*) The half-life period depends upon the quantity of radioactive substance present.
(*c*) The rate of disintegration is proportional to the number of atoms of the radioactive substance present.
(*d*) If the half-life period is T, then after the elapse of time $2T$, all of the nuclei of the radioactive substances will have disintegrated.

108. The half-life period, $t_{1/2}$, of a radioactive element is N years. The period of its complete decay is

(*a*) $2N$ years (*b*) N^2 years
(*c*) $\frac{1}{2} N^2$ years (*d*) infinity.

109. The half-life period may be best determined by

(*a*) noting the weight loss over a period of time
(*b*) measuring the volume of helium liberated
(*c*) by counting the number of alpha particles emitted per second in a Geiger Muller Counter, from a known amount
(*d*) calculations based upon the chemical equation for the radioactive disintegration.

110. The value of disintegration constant (k) of a radioactive isotope

(*a*) decreases with increasing pressure
(*b*) increases with increasing temperature
(*c*) increases with increasing concentration
(*d*) is independent of temperature, concentration or pressure.

111. The disintegration constant of a radioactive element is $2{\cdot}31 \times 10^{-10}$ years. Its half-life period is about

(*a*) $1{\cdot}15 \times 10^{-10}$ years (*b*) 3×10^{9} years
(*c*) 4×10^{9} years (*d*) 4×10^{-9} years.

112. Select the false statement

(*a*) A definite fraction of a radioactive substance disintegrates in a definite time
(*b*) The half-life time is independent of initial concentration of substance
(*c*) Radioactive disintegration constant is independent of temperature
(*d*) If the half-life time is 1580 years, the complete disintegration will take place in 3160 years.

113. A certain nuclide has a half-life of 40 days. If a sample containing 800 atoms is allowed to decay for 120 days, how many atoms will remain undecayed ?

(*a*) 50 (*b*) 100
(*c*) 200 (*d*) 400.

114. The half-life period of a radioactive isotope is 24 days. It would be 75% decomposed in

(*a*) 12 days (*b*) 24 days
(*c*) 36 days (*d*) 48 days.

115. If the half-life period of a radioactive metal 1 month, then

(*a*) the metal will have completely disintegrated in two months
(*b*) 7/8th of the metal will have disintegrated at the end of 3 months
(*c*) 1/8th of the metal will remain intact at the end of 4 months
(*d*) the metal will have completely disintegrated in 4 months.

116. What percentage of the original radioactive nuclei are left after 5 half-lives ?

(*a*) 20 (*b*) 12·5
(*c*) 3·125 (*d*) 5·125.

117. The average life of a radioactive atom is

(*a*) $T/1{\cdot}44$ (*b*) $1{\cdot}44\ T$
(*c*) $0{\cdot}144\ T$ (*d*) $14{\cdot}4\ T$
where T = half-life period.

118. The half-life period of a radioactive element depends on

(*a*) pressure (*b*) temperature
(*c*) amount of element present (*d*) none of these.

119. The half-life period of a radioactive element is 10 years. How long it takes to reduce to 12·5% of its original weight ?

(*a*) 20 years (*b*) 30 years
(*c*) 40 years (*d*) 125 years.

120. Two grams of radioactive substance is reduced to 0·25 gm during a period of 60 days. The half-life period is

(*a*) 10 days (*b*) 15 days
(*c*) 20 days (*d*) 30 days.

121. The radioactive decay rate of a radioactive element is found to be 10^3 disintegrations/second at a certain time. If the half-life of the element is one second, the decay rate after one second is

(*a*) 10^3 (*b*) $10^3/2$
(*c*) 2×10^3 (*d*) $10^{3/2}$.

122. Which of the following statements is wrong for deuterium and tritium ?

(*a*) Both have same number of protons
(*b*) Both have same number of electrons
(*c*) Both have same number of neutrons
(*d*) Both form neutral oxides.

123. The number of neutrons in the nucleus of tritium is

(*a*) 1 (*b*) 2
(*c*) 3 (*d*) 4.

124. Tritium is Beta emitter. Its decay product is

(*a*) hydrogen (*b*) deuterium
(*c*) helium (*d*) lithium.

125. Deuterium differs from hydrogen in

(*a*) chemical properties
(*b*) physical properties
(*c*) both physical and chemical properties
(*d*) radioactive properties.

126. Tritium is

(*a*) radioactive deuterium
(*b*) obtained by bombardment of $_4Be^9$ particle
(*c*) prepared by the electrolysis of water
(*d*) prepared by the electrolysis of heavy water.

127. Deuterium atom has

(*a*) 2 electrons in the outermost orbit
(*b*) two protons in the nucleus
(*c*) two neutrons in the nucleus
(*d*) one proton and one neutron in the nucleus.

128. Heavy water used in nuclear reactors is

(*a*) a product of oxygen and deuterium
(*b*) an ordinary water containing dissolved salts of heavy metals
(*c*) water of mineral springs
(*d*) water produced by repeated distillation and condensation.

29. Heavy water is used in nuclear reactors to

(*a*) cool the reactor
(*b*) facilitate the release of neutrons
(*c*) control fission
(*d*) slow down the speed of neutrons.

130. The molecular weight of heavy water is

(*a*) 10 (*b*) 12
(*c*) 18 (*d*) 20.

131. The substance used as neutron moderator in nuclear reactors is

(*a*) ordinary water (*b*) heavy water
(*c*) liquid hydrogen (*d*) liquid ammonia.

132. Maximum density of heavy water is at

(*a*) 0°C (*b*) 4°C
(*c*) 11·6°C (*d*) 3·8°C.

133. Heavy water is qualified as heavy because it is

(*a*) a heavy liquid
(*b*) an oxide of a heavier isotope of oxygen
(*c*) denser than water
(*d*) an oxide of deuterium.

134. The material used for absorbing neutrons in a nuclear reactor is

(*a*) lead (*b*) uranium
(*c*) zinc (*d*) cadmium.

135. Graphite is used in nuclear reactors.

(*a*) as a lubricant
(*b*) as a fuel
(*c*) for lining the inside of the reactor
(*d*) for reducing the velocity of neutrons.

136. In slowing down neutrons in a reactor protons are most effective because

(*a*) the mass of a proton is almost equal to that of a neutron
(*b*) the proton has a change+e
(*c*) the proton is a constituent of all nuclei
(*d*) none of the above.

137. The critical mass of a fissionable material can be reduced by

(*a*) cooling the material
(*b*) heating the material
(*c*) surrounding it by neutron reflecting material
(*d*) surrounding it by neutron absorbing material.

138. Which is not a constituent of atomic pile ?

(*a*) core (*b*) Moderator
(*c*) Control rods (*d*) Ionization chamber.

139. Chain reaction in $_{92}U^{238}$ will decrease if
(*a*) its mass exceeds critical mass
(*b*) its mass is just equal to critical mass
(*c*) its mass is less than critical mass
(*d*) all of these answers.

140. Thermal neutrons are those which
(*a*) are at very high temperature
(*b*) move with high velocity
(*c*) are at rest
(*d*) have kinetic energies similar to those of surrounding molecules.

141. Fission is a process in which
(*a*) nucleus is split into two fragments
(*b*) two nuclei fuse together and decrease in mass appears in the form of energy
(*c*) atoms and molecules lose their identity
(*d*) matter appears in the fourth state called plasma.

142. The process in a nuclear reactor is
(*a*) controlled nuclear fission (*b*) uncontrolled nuclear fission
(*c*) controlled nuclear fusion (*d*) uncontrolled nuclear fusion.

143. The first atomic power plant in India was built at
(*a*) Narora (*b*) Kalapakkam
(*c*) Tarapur (*d*) Kota.

144. India entered the nuclear energy club as
(*a*) fourth nation of the world (*b*) fifth nation of the world
(*c*) sixth nation of the world (*d*) seventh nation of the world.

145. India conducted an underground nuclear test at
(*a*) Pushkar (*b*) Kalapakkam
(*c*) Narora (*d*) Pokharan.

146. Nuclear energy is due to conversion of
(*a*) light into heat (*b*) mass into energy
(*c*) protons into neutrons (*d*) helium into hydrogen.

147. Laser is an acronym for light amplification by
(*a*) stimulated emission of radiation
(*b*) spontaneous emission of radiation
(*c*) stimulated energetic radiation
(*d*) spontaneous emission of radio waves.

148. The surface tension of the nuclear fluid is
(*a*) more than that of water but less than that of mercury
(*b*) less than that of water
(*c*) much more than that of any liquid
(*d*) approximately equal to that of turpentine.

149. Energy in the sun is produced as a result of
(*a*) fission (*b*) thermonuclear reaction
(*c*) explosion (*d*) combustion.

150. Inside the sun
(*a*) four nuclei of hydrogen combine together to form one nucleus of helium
(*b*) four nuclei of hydrogen combine together to form two nuclei of helium
(*c*) four nuclei of hydrogen combine together to form four nuclei of helium
(*d*) one nucleus of hydrogen is transformed into one nucleus of helium.

151. Hydrogen bomb is based on the nuclear fusion of
(*a*) hydrogen (*b*) deuterium
(*c*) tritium (*d*) helium.

152. The phenomenon of nuclear fission is used in the construction of
(*a*) the hydrogen bomb (*b*) the atom bomb
(*c*) an ordinary bomb (*d*) incendiary bomb.

153. The phenomenon of fusion is responsible for the energy radiated by
(*a*) the sun (*b*) the atom bomb
(*c*) the firefly (*d*) lightning.

154. In a nuclear explosion the energy is released in the form of
(*a*) electrical energy (*b*) thermal energy
(*c*) kinetic energy (*d*) potential energy.

155. The large energy released in atomic bomb explosion is due to
(*a*) release of neutrons
(*b*) conversion of heavy atoms to lighter atoms
(*c*) appreciable mass loss
(*d*) higher mass of products than initial substance.

156. Which metal is most important in atomic research ?
(*a*) Cd (*b*) U
(*c*) Pb (*d*) Fe.

157. Laser is a device to produce
(*a*) a beam of white light (*b*) a beam of coherent light
(*c*) microwaves (*d*) gamma rays.

158. Which of the following is radioactive ?
(*a*) Deuterium (*b*) Tritium
(*c*) Hydrogen (*d*) Helium.

159. Radioactive decay is a
(*a*) zero-order reaction (*b*) first-order reaction
(*c*) second-order reaction (*d*) third-order reaction.

160. Nuclear fission was first experimentally observed by
(*a*) Fermi (*b*) Rutherford
(*c*) Planck (*d*) Hahn and strassman.

161. The ultimate product of radioactive disintegration of uranium is
(*a*) thorium (*b*) polonium
(*c*) lead (*d*) radium.

ANSWERS

1. (*c*)	2. (*b*)	3. (*d*)	4. (*c*)	5. (*c*)
6. (*a*)	7. (*c*)	8. (*b*)	9. (*a*)	10. (*c*)
11. (*b*)	12. (*b*)	13. (*c*)	14. (*c*)	15. (*b*)
16. (*a*)	17. (*a*)	18. (*c*)	19. (*b*)	20. (*b*)
21. (*b*)	22. (*a*)	23. (*c*)	24. (*d*)	25. (*a*)
26. (*b*)	27. (*b*)	28. (*c*)	29. (*b*)	30. (*b*)
31. (*d*)	32. (*a*)	33. (*b*)	34. (*c*)	35. (*a*)
36. (*b*)	37. (*b*)	38. (*a*)	39. (*c*)	40. (*c*)
41. (*d*)	42. (*c*)	43. (*b*)	44. (*a*)	45. (*b*)
46. (*b*)	47. (*c*)	48. (*d*)	49. (*b*)	50. (*a*)
51. (*c*)	52. (*b*)	53. (*a*)	54. (*b*)	55. (*c*)
56. (*b*)	57. (*a*)	58. (*d*)	59. (*d*)	60. (*b*)
61. (*b*)	62. (*d*)	63. (*c*)	64. (*d*)	65. (*b*)
66. (*c*)	67. (*a*)	68. (*c*)	69. (*b*)	70. (*c*)
71. (*a*)	72. (*a*)	73. (*a*)	74. (*a*)	75. (*c*)
76. (*b*)	77. (*c*)	78. (*d*)	79. (*b*)	80. (*c*)
81. (*c*)	82. (*b*)	83. (*d*)	84. (*c*)	85. (*c*)
86. (*c*)	87. (*c*)	88. (*a*)	89. (*d*)	90. (*a*)
91. (*d*)	92. (*b*)	93. (*b*)	94. (*a*)	95. (*a*)
96. (*c*)	97. (*b*)	98. (*a*)	99. (*d*)	100. (*b*)
101. (*a*)	102. (*a*)	103. (*b*)	104. (*b*)	105. (*a*)
106. (*c*)	107. (*c*)	108. (*d*)	109. (*c*)	110. (*d*)
111. (*b*)	112. (*d*)	113. (*b*)	114. (*d*)	115. (*b*)
116. (*c*)	117. (*b*)	118. (*d*)	119. (*b*)	120. (*c*)
121. (*b*)	122. (*c*)	123. (*b*)	124. (*c*)	125. (*b*)
126. (*b*)	127. (*d*)	128. (*a*)	129. (*d*)	130. (*d*)
131. (*b*)	132. (*c*)	133. (*d*)	134. (*d*)	135. (*d*)
136. (*a*)	137. (*c*)	138. (*d*)	139. (*c*)	140. (*d*)
141. (*a*)	142. (*a*)	143. (*c*)	144. (*c*)	145. (*d*)
146. (*b*)	147. (*a*)	148. (*c*)	149. (*b*)	150. (*a*)
151. (*b*)	152. (*b*)	153. (*a*)	154. (*c*)	155. (*c*)
156. (*b*)	157. (*b*)	158. (*b*)	159. (*b*)	160. (*a*)
161. (*c*).				

15

Renewable Sources of Energy

DEFINITIONS

Air mass. Path length of radiation through the earth's atmosphere relative to the vertical path legnth.

Albedo. Synonymous with reflectance; specifically refers to the reflectance of earth and or its atmosphere.

Altitude. Angle between the horizontal plane and the direction of beam.

Angle of incidence. Angle between a ray and the normal to the plane on which it is incident.

Angle of reflection. Angle between the normal to a surface and the direction of reflected radiation.

Angle of refraction. Angle between the normal to a refracting surface and the direction of the refracted ray.

Atmospheric radiation. Radiation from clouds, air molecules, dust, *etc.* due to their temperature.

Beam radiation. Radiation coming directly from the sun without change of direction.

Bolometer. Instrument for measuring irradiance. Its principle is based on the variation of electrical resistance, as a result of temperature change caused by incoming radiation, of one or both of the resistance elements which comprise the instrument.

Chromosphere. The layer of the sun's atmosphere, outside the photosphere.

Cloudiness (cloud cover). Amount of sky covered by cloud, usually expressed by a scale of tenths of sky covered.

Collector. A device for converting solar radiation into thermal

energy; includes compound parabolic, concentrating, evacuated tube, flat-plate, solar pond, etc.

Collector efficiency. The ratio of useful energy gain for a period of time to the solar energy incident on the collector (usually the aperture area, sometimes the gross area). Can be instantaneous, *i.e.* over a period of substantially constant insolation or average for a day, month or year.

Collimator. A device (usually a tube) for producing a beam of parallel radiation by eliminating diffuse radiation.

Czochralski process. A process for growing single crystal materials by drawing a rod from a molten mass.

Day length. Time between sunrise and sunset, usually taken as the interval between times when solar altitude angle increases from zero to the time it decreases to zero.

Declination. Angular position of the sun at solar noon with respect to the plane of the equator, *i.e.* the angular position of the sun north or south of the equator.

Diffuse radiation. (*a*) Solar radiation which is scattered in transmission through the atmosphere (sky radiation);

(*b*) Beam and/or sky radiation reflected by non-specular surfaces.

Extraterrestrial radiation. The solar radiation which would be received on a surface if there were no atmosphere.

Fill factor. The ratio of maximum power output of a photovoltaic cell or array to the product of the open circuit voltage and the short circuit current.

Fuel cell. A device, similar to electric battery, in which fuel is oxidized to produce electricity.

Global radiation. Refers to solar radiation as received on earth; sum of beam and diffuse components.

Heliostat. A device, usually reflecting, for redirecting beam radiation into a fixed direction.

Hour angle. Angular displacement of the sun east or west of the observer's meridian due to rotation of the earth on its axis at 15° per hour.

Langley. A unit for measuring radiant energy per unit area; 1 langley = 41·86 kJm^{-2}.

Latitude. Angle between the equatorial plane and the radius of the earth through the location.

Longitude. Angular distance measured on the earth's equator from a fixed meridian through Greenwhich.

Nocturnal radiation. Atmospheric radiation occurring at night; generally there will be a net flow outwards from the earth.

n-p Junction. Specifically means a thin n-type layer with the bulk of the wafer of p-type.

Ocean thermal system. A heat engine for utilising the temperature difference existing between the surface waters of the oceans and those at a great depth for the production of power.

Organic Rankine cycle engine. A Rankine cycle engine which uses an organic fluid such as dichlorodifluoromethane or toluene or dichlorobenzene; suitable for use at temperature in the range of 100-400°C so they are of interest for small solar thermal systems.

Parabolic focusing collector. A concentrating collector which focuses beam radiation with a parabolic reflector.

Passive solar system. A solar energy system in which energy is transported as heat by virtue of a temperature difference; includes conduction, natural convection and radiation.

Photoelectric conversion. Conversion of radiant energy into electricity by absorption of a photon to release an electron.

Photosphere. Upper layer of the convective zone in the sun from which most of the radiation is emitted.

Photosynthesis. The fixation of carbon in plants by the absorption of radiation; chlorophyll is the active plant material; the carbon comes from atmospheric carbon dioxide while oxygen is released from the process.

Photovoltaic converter. A form of photoelectric converter in which the photo-exited carriers are separated by electric field inherent in the cell structure to produce an electric current in the external circuit.

p-n junction. Boundary between a p-type layer having an excess of "holes" and an n-type layer having an excess of electrons; used in photovoltaic cells; usually implies a thin p-type layer with the bulk of the wafer of n-type.

Pyrgeometer. An instrument for measuring the net atmospheric radiant flux density on a horizontal upward facing black surface at ambient temperature.

Pyrheliometer. A radiometer used to measure the direct or beam solar irradiance incident on a surface normal to the radiation.

Seebeck effect. Voltage gradient produced in a conductor by a heat flow in the absence of electric current ; also applied to open circuit voltage of a thermocouple.

Selective surface. A surface having pronounced differences in reflectance at short and long wavelengths ; selective black surfaces have low reflectance to short wavelengths (solar radiations) and high reflectance to long wavelengths (thermal radiations) ; selective white surfaces have high reflectance to short wavelengths and low reflectance to long wavelengths.

Semiconductor. The class of materials that have values of electrical conductivity between insulators and conductors ; they have high Seebeck effect, negative temperature coefficient to resistance, a capacity to act as a diode, or a resistivity affected by light.

Snell's law. Defines a refractive index, n, by

$$n = \sin i/\sin r$$

where i is angle of incidence and r is angle of refraction.

Solar constant. Irradiance on a plane in space which faces the sun and is at the earth's mean distance from the sun.

Solstice. The time when the sun in its apparent motion in the celestial sphere attains the maximum angular displacement from the equatorial plane. (June 21 is the summer solstice (northern hemisphere) and Decemeber 21 is the winter solstice)(northern hemisphere).

Standard time. The local mean time of some standard meridian which is used in a zone around the meridian ; standard time zones are usually based on meridians separated by 15° or 1 hour and starting from 0°.

Thermopile. The temperature sensor consisting of several thermocouples connected in series to increase the voltage signal per unit temperature change.

Trombe wall. A vertical glass wall facing south (northern hemisphere) with a solid masonry wall for heat storage behind it.

Turbidity. Any condition of the atmosphere which reduces the transmission of radiation, but generally refers to smoke, haze and dust which affect the cloudless section of the sky.

1. Energy may be defined as
(*a*) the capacity to do work
(*b*) the product of mass and acceleration
(*c*) the rate of doing work
(*d*) the product of force and velocity.

2. Sun radiates energy to the earth
(*a*) in the form of electromagnetic radiation
(*b*) at a relatively constant rate of $3{\cdot}83 \times 10^{26}$ W
(*c*) 24 hours per day, 365 day of the year
(*d*) all of the above.

3. Most of the electromagnetic radiation reaching the earth emanates from the
(*a*) corona (*b*) chromosphere
(*c*) photosphere (*d*) sun's interior

4. Compared to the photosphere, the corona region is characterized by
(*a*) low-density gas mixture
(*b*) higher temperature
(*c*) variation in energy and diameter with time
(*d*) all of the above.

5. The angle subtended by a vertical line to the zenith (*i.e.* the point directly overhead) and the line of sight to the sun is called
(*a*) zenith angle (*b*) declination angle
(*c*) hour angle (*d*) latitude angle

6. The solar radiation at sea level corresponds to an air mass value of
(*a*) 0 (*b*) 1
(*c*) 2 (*d*) 3

7. Solar photovoltaic energy sources produce
(*a*) AC electricity (*b*) DC electricity
(*c*) both *a* and *b* (*d*) neither *a* nor *b*

8. The two major constituents of the sun are
(*a*) helium and hydrogen (*b*) oxygen and nitrogen
(*c*) helium and carbon dioxide (*d*) oxygen and hydrogen

9. The two major constituents of the sun are helium and hydrogen. The percentage of the helium by volume in the sun is about
(*a*) 74 (*b*) 25
(*c*) 99 (*d*) 52

10. The sun exists in a state of equilibrium between the force of gravitation and
(*a*) the outward radiation pressure from fusion reactions

(*b*) the outward force due to nuclear fission
(*c*) the centrifugal force due to its rotation
(*d*) none of the above

11. Most of the sun's energy results from

(*a*) thermonuclear reactions (*b*) chemical reactions
(*c*) gravity (*d*) none of the above

12. The wavelength of which of the following is the largest ?

(*a*) Radio waves (*b*) Light waves
(*c*) X-ray waves (*d*) Gamma ray waves

13. When light wave passes from air into glass the ray describing the motion of the wave front changes direction according to Snell's law of refraction and the light ray

(*a*) is bent toward the normal to the glass surface
(*b*) is bent away from the normal to the glass surface
(*c*) does not bend at all
(*d*) completely reflected at the air-glass interface.

14. A pane of glass reflects 5% of the incident light and absorbs 10%. The amount of light transmitted is

(*a*) 95% (*b*) 85%
(*c*) 90% (*d*) 15%

15. As the temperature of a hot, glowing object increases, the wavelength at the maximum of the blackbody radiation curve

(*a*) increases (*b*) decreases
(*c*) remains the same (*d*) increases linearly

16. A blockbody absorbs all of the incident radiation. It also

(*a*) reflects radiation with 100% efficiency
(*b*) transmits radiation with 100% efficiency
(*c*) emits radiation with 100% efficiency
(*d*) emits radiation with 0% efficiency.

17. If λ_1 and λ_2 are the wavelengths at the point of maximun intensity of a blackbody spectrum for a system at a temperature of 3000 K and 6000 K, then

(*a*) $\lambda_1 = 2\lambda_2$ (*b*) $\lambda_2 = 2\lambda_1$
(*c*) $\lambda_1 = \lambda_2$ (*d*) $2727\lambda_1 = 5727\lambda_2$.

18. Which of the following constituents of earth's atmosphere is mainly responsible for absorbing the ultraviolet radiation ?

(*a*) O_2 (*b*) N_2
(*c*) O_3 (*d*) Water vapour

19. When visible light is scattered by air molecules, which wavelengths are scattered the least ?

(*a*) Violet (*b*) Yellow
(*c*) Blue (*d*) Red.

20. Which of the following is scattered the most by air molecules ? Waves with a wavelength of

(*a*) 0·5 micron (*b*) 0·6 micron
(*c*) 0·7 micron (*d*) 0·8 micron

21. A pyrheliometer is an instrument which measures

(*a*) beam radiation (*b*) diffuse radiation
(*c*) global radiation (*d*) duration of bright sunshine.

22. A pyranometer is an instrument which measures

(*a*) beam radiation (*b*) global radiation
(*c*) duration of bright sunshine (*d*) none of the above.

23. The radiation coming from the sun appears to be essentially equivalent to that of coming from a blackbody at a temperature of

(*a*) 10000 K (*b*) 5762 K
(*c*) 600 K (*d*) 1800 K

24. The angle, in minute, subtended by sun on the earth's surface is about

(*a*) 23 (*b*) 32
(*c*) 53 (*d*) 43

25. The solar constant, which is defined as the rate at which energy is received from the sun on a unit area perpendicular to the rays of the sun at the mean distance of the earth from the sun, outside of the atmosphere has a standard value of

(*a*) 5669 W/m^2 (*b*) 1353 W/m^2
(*c*) 1·353 W/m^2 (*d*) none of the above.

26. The maximum value of the extraterrestrial solar radiation occurs at a wavelength of about

(*a*) 0·12 μm (*b*) 4 μm
(*c*) 0·48 μm (*d*) 0·78 μm.

27. Which of the following statements is correct ?

(*a*) Global radiation = beam radiation – diffuse radiation
(*b*) Global radiation = beam radiation + diffuse radiation
(*c*) Global radiation = diffuse radiation – beam radiation
(*d*) Global radiation = (beam radiation + diffuse radiation)/2.

28. If θ is the angle between an incident beam of flux I_{bn} and the normal to a plane surface, then the equivalent flux falling normal to the surface is

(*a*) $I_{bn} \sin \theta$ (*b*) $I_{bn} \cos \theta$
(*c*) $I_{bn} \sec \theta$ (*d*) I_{bn}

29. Solar radiation flux is often reported in langleys per year. The unit langley is equal to
(*a*) 1 cal/cm^2 (*b*) 1 Btu/ft^2
(*c*) 1 J/m^2 (*d*) 1 Btu/in.^{2}.

30. The perihelion occurs on about
(*a*) June 21 (*b*) July 3
(*c*) January 2 (*d*) March 21.

31. The aphelion occurs on about
(*a*) July 3 (*b*) January 2
(*c*) June 21 (*d*) March 21.

32. At equinoxes, the declination angle is
(*a*) 0° (*b*) 90°
(*c*) 45° (*d*) 30°.

33. At equinoxes,
(*a*) the declination angle is zero
(*b*) the time during which the sun is visible is 12 hours
(*c*) the time during which the sun is not visible is 12 hours
(*d*) all of the above.

34. The winter solstice occurs on about
(*a*) November 21 (*b*) January 21
(*c*) December 22 (*d*) December 31.

35. The summer solstice occurs on about
(*a*) June 21 (*b*) April 22
(*c*) May 22 (*d*) July 21.

36. The declination angle has a value of 23·45° on
(*a*) March 21 (*b*) June 21
(*c*) September 22 (*d*) December 21.

37. The declination angle has a value of –23·45° on
(*a*) March 21 (*b*) September 22
(*c*) June 21 (*d*) December 21.

38. The declination angle is zero on the two equinox days of about
(*a*) March 21 and september 22
(*b*) March 21 and June 21
(*c*) March 21 and July 21
(*d*) June 21 and May 21.

39. The hour angle is zero at
(*a*) solar noon (*b*) sunset
(*c*) sun rise (*d*) none of the above.

40. An expression for the hour angle, ω, is
(*a*) $\omega = 15(t_s - 6)$ (*b*) $\omega = 15(t_s + 6)$
(*c*) $\omega = 15(t_s - 12)$ (*d*) $\omega = 15(t_s + 12)$
where t_s is the solar time in hours.

41. The sum of the solar altitude angle and the solar zenith angle is
(*a*) 90° (*b*) 180°
(*c*) 0° (*d*) 360°.

42. Which of the following angles is zero at solar noon ?
(*a*) Solar altitude angle (*b*) Solar zenith angle
(*c*) Hour angle (*d*) Latitude angle.

43. Which of the following angles is zero at sunset ?
(*a*) Latitude angle (*b*) Hour angle
(*c*) Solar zenith angle (*d*) Solar altitude angle.

44. At solar noon on the equinoxes, the solar zenith angle is equal to
(*a*) the latitude angle (*b*) the hour angle
(*c*) the solar altitude angle (*d*) none of the above.

45. The hour angle is an angular measure of time and is equivalent to
(*a*) 5° per hour (*b*) 10° per hour
(*c*) 15° per hour (*d*) 30° per hour

46. The hour angle is
(*a*) measured from noon based on the local apparent time
(*b*) positive in the forenoon
(*c*) negative in the afternoon
(*d*) all of the above.

47. At 1400 *h* (local apparent time), the hour angle is
(*a*) 30° (*b*) –30°
(*c*) 210° (*d*) 0°.

48. At 0900 *h* (local apparent time), the hour angle is
(*a*) 15° (*b*) 45°
(*c*) – 45° (*d*) –15°.

49. Suppose that the transmissivity is zero for a very thick piece of material. If the material is perfectly black
(*a*) $\alpha = 0$ (*b*) $\alpha + \gamma = 0$
(*c*) $\gamma = 1$ (*d*) $\gamma = 0$
where α = absorptivity and γ = reflectivity

50. Suppose that the transmissivity is zero for a very thick piece of material. If the material is perfectly white
(*a*) $\alpha = 0$ (*b*) $\alpha = 1$
(*c*) $\gamma = 0$ (*d*) $\alpha + \gamma = 0$
where α = absorptivity and γ = reflectivity

51. Suppose that we have an ideal piece of glass with $\alpha = 0$. If $\gamma = 0{\cdot}09$,
(*a*) $\tau = 0{\cdot}09$ (*b*) $\tau = 1$
(*c*) $\gamma + \tau = 1$ (*d*) $\gamma + \tau = 0$
where τ = transmissivity, γ = reflectivity and α = absorptivity

52. Which of the following is usually not used as the heat-exchange fluid in a flat-plate solar collector ?
(*a*) Air (*b*) Fuel oil
(*c*) Water (*d*) Ethylene glycol and water

53. What is the serious problem with using a thin plastic sheet as the glazing material in a flat-plate solar collector ?
(*a*) It is structurally too weak
(*b*) It absorbs too much of the incoming radiation
(*c*) Opacity to long-wavelength radiation is reduced
(*d*) It is too expensive for routine use in collectors

54. The percent transmission of incoming solar radiation through the top cover plate of flat-plate collectors is typically
(*a*) 99 (*b*) 85
(*c*) 95 (*d*) 30

55. The absorptivity of the black absorber plate coated with a common flat-black paint is typically
(*a*) 80% (*b*) 94%
(*c*) 99% (*d*) 85%

56. The radiative heat loss between the top cover of flat-plate solar collector at a temperature of T_P (*K*) and ambient air at a temperature of T_a (*K*) is proportional to
(*a*) $T_P^4 + T_a^4$ (*b*) $T_P - T_a$
(*c*) $T_P^4 - T_a^4$ (*d*) $T_P^2 - T_a^2$

57. Compare the heat loss between the absorber plate of flat-plate collector and the cover with that between the cover and the ambient air at steady state.
(*a*) The two heat losses are equal
(*b*) The heat loss between the absorber plate and the cover plate is greater
(*c*) The heat loss between the cover plate and the ambient air is greater
(*d*) Information available is insufficient to decide

58. If the wind is blowing with a 10 kilometer per hour, the dominant heat loss mechanism(s) between the top cover plate of flat-plate solar collector and the ambient air is/are
(*a*) convection (*b*) radiation
(*c*) conduction (*d*) convection and radiation

59. The efficiency of a flat-plate solar collector using water as a heat-exchange fluid is largest at which of the following temperature for the absorber plate ? Assume $T_a = 25°C$.
(*a*) 40°C (*b*) 60°C
(*c*) 80°C (*d*) 100°C

60. When solar radiation strikes the boundary between the air and top of the cover plate, the percent of the incident intensity reflected is
(*a*) 0% (*b*) 4%
(*c*) 8% (*d*) 20%

61. Selective surfaces
(*a*) maximize the absorption of solar energy and emission of radiative loss
(*b*) minimize the absorption of solar energy and emission of radiative loss
(*c*) maximize the absorption of solar energy and minimize emission of radiative loss
(*d*) minimize the absorption of solar energy and maximize emission of radiative loss

62. Which of the following passes through a maximum with increase in the number of covers (glazings) used in a flat-plate solar collector ?
(*a*) Transmissivity-absorptivity product
(*b*) Top loss coefficient
(*c*) Collector efficiency
(*d*) Heat loss from the top cover

63. The directions of the incident and refracted beams of light are related to each other by
(*a*) Bouger's law (*b*) Snell's law
(*c*) Wien's law (*d*) Hottel-Whillier-Bliss equation

64. Which of the following is not combustible ?
(*a*) H_2 (*b*) CO
(*c*) CCl_4 (*d*) CH_4

65. The extinction coefficient for different qualities of glasses varies in the range of
(*a*) 5–25 m^{-1} (*b*) 5–25 cm^{-1}
(*c*) 5–25 mm^{-1} (*d*) 5–25 km^{-1}

67. Which of the following is not a good way to improve the performance of a flat-plate solar collector ?
(*a*) Use of a selective surface
(*b*) Use of an anti-reflective coating
(*c*) Use of three cover plate
(*d*) Use of an evacuated collector

68. The log-mean temperature difference is defined as

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln (\Delta T_1/\Delta T_2)}$$

What is the value of the first derivative of ΔT_{lm} with respect to ΔT_1 in the limit $\Delta T_1 = \Delta T_2$?

(*a*) 0 (*b*) 1
(*c*) 0·5 (*d*) none of the above

69. Select the correct statement for positive values of ΔT_1 and ΔT_2.

(*a*) $\Delta T_{lm} > \Delta T_{am} > \Delta T_{gm} > \Delta T_{hm}$
(*b*) $\Delta T_{hm} > \Delta T_{gm} > \Delta T_{am} > \Delta T_{lm}$
(*c*) $\Delta T_{am} > \Delta T_{lm} > \Delta T_{hm} > \Delta T_{gm}$
(*d*) $\Delta T_{am} > \Delta T_{lm} > \Delta T_{gm} > \Delta T_{hm}$

where subscripts lm, am, gm and hm denote logarithmic mean, arithmetic mean, geometric mean and harmonic mean, respectively.

70. Overall heat transfer coefficient is proportional to the tube side volumetric flow rate raised to the power 0·8. This holds only if the ratio of the tube side film resistance to the total resistance is nearly

(*a*) infinite (*b*) unity
(*c*) zero (*d*) twenty

71. For a fluid flowing in an annulus, the ratio of the equivalent diameter for heat transfer calculation to the equivalent diameter for pressure drop calculation is

(*a*) 1 (*b*) $(D_1 + D_2)/D_1$
(*c*) $D_2/(D_1 + D_2)$ (*d*) $(D_1 + D_2)/D_2$

where D_1 = outer diameter of the inner pipe, D_2 = inner diameter of the outer pipe

72. When water is heated from 0°C to 10°C, the volume of water

(*a*) increases steadily
(*b*) decreases steadily
(*c*) first increases and then decreases
(*d*) first decreases and then increases

73. Which of the following is not a good way to provide freeze protection for a flat-plate collector system ?

(*a*) Use movable insulatioin to cover the collector
(*b*) Drain the collector when it is not operating during periods of low ambient temperatures
(*c*) Circulate an antifreeze solution rather than water
(*d*) Increase the rate of water flow through the collector by a factor of 2, leaving it on at all times

74. A severe disadvantage of using a mixture of ethylene glycol and water as the heat-exchange fluid for a flat-plate collector is that

(*a*) it has an extremely low specific heat
(*b*) too much pumping power is required
(*c*) it is toxic
(*d*) it does not freeze at −1°C

75. Water circulates in a thermosiphon, hot-water heating system by

(*a*) forced circulation using a pump
(*b*) the fact that hot water is less dense than cold water
(*c*) the fact that cold water is less dense than hot water
(*d*) gravity flow from top of the collector to the lower storage tank

76. An advantage of using copper for the absorber plate is that

(*a*) it has a higher thermal conductivity than other metals
(*b*) it weighs less than steel or aluminium
(*c*) it is cheaper than steel or aluminium
(*d*) it will not corrode easily so that water can be used as heat-exchange fluid.

77. Evacuated flat-plate collectors are better than non-evacuated ones at high operating temperatures because

(*a*) convective heat losses from the top cover plate are greatly reduced
(*b*) convective heat losses from the absorber plate are greatly reduced
(*c*) conductive heat losses from the absorber plate are greatly reduced
(*d*) radiative heat losses from the absorber plate are greatly reduced

78. Wind energy, transferred to the large sea surface, is stored in waves as

(*a*) chemical energy (*b*) thermal energy
(*c*) electrical energy (*d*) mechanical energy

79. Air velocity in the pipelines should be limited to about

(*a*) 2·25 m/s (*b*) 10 m/s
(*c*) 25 m/s (*d*) 50 m/s

80. Addition of ethylene glycol into the water causes a depression in

(*a*) freezing point (*b*) pour point
(*c*) boiling point (*d*) none of the above

81. Freezing point and pour point are equal for

(*a*) water (*b*) crude oil
(*c*) aviation turbine fuel (*d*) kerosene

82. A good selective surface utilizes materials that strongly

(*a*) absorb both the far-infrared and visible wavelengths
(*b*) reflect both the far-infrared and visible wavelengths
(*c*) reflect far-infrared radiation and absorb visible light
(*d*) reflect visible light and absorb far-infrared radiation

83. A difference of temperature between the two junctions of a thermocouple will produce

(*a*) a flow of holes
(*b*) a voltage difference between the two junctions
(*c*) melting of wires
(*d*) no measureable effect

84. n-type silicon is formed by adding a minute amounts of elements with

(*a*) three valence electrons (*b*) four valence electrons
(*c*) five valence electrons (*d*) six valence electrons

85. p-type silicon is formed by adding a minute amounts of elements with

(*a*) three valence electrons (*b*) four valence electrons
(*c*) five valence electrons (*d*) six valence electrons

86. At room temperature the theoretical maximum efficiency of a perfect solar cell cannot exceed about

(*a*) 2% (*b*) 45%
(*c*) 99% (*d*) 5%

87. One eV is defined as the energy gained by an electron when it is accelerated by a voltage difference of

(*a*) 1 V (*b*) 1 kV
(*c*) 1 MV (*d*) 1 mV

88. The energy content of a photon corresponding to waves in the blue wavelength region is

(*a*) more than that for waves in red portion of the spectrum
(*b*) less than that for waves in red portion of the spectrum
(*c*) equal to that for waves in red portion of the spectrum
(*d*) none of the above.

89. Suppose that hot water is stored at a temperature that is 25°C higher than room temperature. Water required to store 1 million cal of heat is about

(*a*) 40 litre (*b*) 40 kilolitre
(*c*) 25 litre (*d*) 2500 litre.

90. If the thickness of insulation in the walls and ceiling of a house is doubled, the heat loss is expected to decrease by a factor of

(*a*) None (*b*) 2
(*c*) 4 (*d*) 16

91. For a 25°C rise in temperature, which of the following materials will store the most heat ?

(*a*) A ton of water (*b*) A ton of iron
(*c*) A ton of rocks (*d*) A ton of wood

92. In USA the mixture of 26·5% diphenyl and 73·5% diphenyl oxide is known as

(*a*) Dowtherm G (*b*) Dowtherm J
(*c*) Dowtherm A (*d*) Dowtherm HT

93. Pour point of a fluid

(*a*) relates to a considerable increase of viscosity with decrease in temperature
(*b*) refers to the change of phase from liquid to solid
(*c*) refers to sudden discontinuity in fluid properties
(*d*) none of the above

94. Which of the following is maximum for aniline ?

(*a*) Flash point (*b*) Fire point
(*c*) Ignition point (*d*) Boiling point

95. For optimum storage of heat with rocks, small pebbles should be utilized because

(*a*) this gives a large surface area to mass ratio
(*b*) this gives a small surface area to mass ratio
(*c*) this increases their specific heat
(*d*) the economical cost of the rocks is decreased

96. Which of the following statements about using water as a heat-exchange fluid in flat-plate collectors is not true ?

(*a*) It is convenient to obtain and handle
(*b*) It has a large heat capacity
(*c*) A large amount of electric power is required to run the water pump
(*d*) Freeze protection can be obtained by mixing with ethylene glycol

97. A pure substance at its triple point

(*a*) exists in gas, liquid and solid phases simultaneously
(*b*) changes directly from solid to vapour
(*c*) loses phase distinction between liquid and vapour
(*d*) behaves as an ideal gas

98. When moist air is cooled by sensible heat removal, which of the following is incorrect ?

(*a*) Neither relative humidity nor specific humidity changes
(*b*) Specific humidity changes but not relative humidity
(*c*) Both relative humidity and specific humidity change
(*d*) None of the above

99. Solar pond is a body of saline water in which the salt concentration

(*a*) increases from the top surface to the bottom surface
(*b*) decreases from the top surface to the bottom surface
(*c*) remains the same in the whole pond
(*d*) none of the above

100. Solar pond usually consists of an upper convective layer (UCL), a nonconvective layer (NCL), and a lower convective layer (LCL). The solar energy is stored in

(*a*) UCL (*b*) NCL
(*c*) LCL (*d*) UCL and LCL

101. In solar ponds the upper convective layer

(*a*) has no useful role in energy collection
(*b*) is caused by wind action and heat transfer
(*c*) is considered a homogeneous low salinity layer
(*d*) all of the above

102. In solar ponds, the transfer of heat and salt is convective in the

(*a*) UCL and LCL (*b*) UCL and NCL
(*c*) NCL and LCL (*d*) UCL, NCL, and LCL

where UCL, NCL, and LCL are upper convective layer, nonconvective layer, and lower convective layer, respectively

103. In solar ponds, there is a diffusive transport of heat and salt in the

(*a*) UCL (*b*) NCL
(*c*) LCL (*d*) all of the above

104. The nonconvective layer of solar ponds is an example of

(*a*) single-diffusive system (*b*) double-diffusive system
(*c*) triple-diffusive system (*d*) none of the above

105. In solar ponds operating in a sunny climate, salt (sodium chloride) is transported from nonconvective layer into upper convective layer at a rate of the order of

(*a*) 40 kg m^{-2} $year^{-1}$ (*b*) 40 kg m^{-2} $month^{-1}$
(*c*) 40 kg m^{-2} day^{-1} (*d*) 40 kg m^{-2} $hour^{-1}$

106. For a solar pond with a 1·5 m thick lower convective layer and 1·5 m nonconvective layer the amount of sodium chloride required is about

(*a*) 700 kg m^{-2} (*b*) 7000 kg m^{-2}
(*c*) 70000 kg m^{-2} (*d*) 70 kg m^{-2}

107. Tides are generated primarily by

(*a*) gravitational attraction between the earth and moon
(*b*) interaction of winds with the surface of oceans
(*c*) absorption of solar radiation in the atmosphere
(*d*) rotation of the earth about its axis and its motion around the sun

108. Tides arise

(*a*) once a day (*b*) twice a day
(*c*) thrice a day (*d*) four times a day

109. Wave energy

(*a*) arises because of the interaction of winds with the surface of oceans

(*b*) available varies with the size and frequency of waves
(*c*) of about 10 kW is available for every metre of wave front
(*d*) all of the above

110. Solar cells convert the sunlight into

(*a*) electrical energy (*b*) mechanical energy
(*c*) heat energy (*d*) chemical energy

111. Conversion efficiencies for silicon cells range between

(*a*) 10 and 15% (*b*) 30 and 35%
(*c*) 90 and 95% (*d*) 95 and 99%

112. For silicon, the value of the band gap energy is

(*a*) 0·012 eV (*b*) 0·12 eV
(*c*) 1·2 eV (*d*) 12 eV

113. The fill factor (the ratio of the maximum useful power to the ideal power) for a silicon cell may vary from

(*a*) 0·1 to 0·15 (*b*) 0·2 to 0·3
(*c*) 0·35 to 0·5 (*d*) 0·65 to 0·8

114. Winds are caused

(*a*) because of the absorption of solar radiation on the earth's surface and in the atmosphere
(*b*) because of the rotation of the earth about its axis and its motion around the sun
(*c*) both *a* and *b*
(*d*) neither *a* nor *b*

115. The function of a windmill is to extract energy from the wind and to produce

(*a*) mechanical energy (*b*) thermal energy
(*c*) electrical energy (*d*) chemical energy

116. Which of the following is a vertical axis windmill ?

(*a*) Multiblade type (*b*) Sail type
(*c*) Propeller type (*d*) Savonius type

117. Sail type windmill has

(*a*) two blades (*b*) three blades
(*c*) four blades (*d*) five blades

118. Popeller type windmill runs at speeds of

(*a*) 60 to 80 rpm (*b*) 100 to 120 rpm
(*c*) 180 to 200 rpm (*d*) 300 to 400 rpm

119. Sail type windmill runs at speeds of

(*a*) 300 to 400 rpm (*b*) 60 to 80 rpm
(*c*) 200 to 220 rpm (*d*) 180 to 190 rpm

120. Which of the following windmills runs independently of the direction of the wind ?

(*a*) Darrieus type (*b*) Sail type
(*c*) Propeller type (*d*) Multiblade type

121. Darrieus type windmill

(*a*) requires less surface area as compared to Savonius type windmill
(*b*) has two or three blades shaped like aerofoils
(*c*) runs independently of the direction of the wind
(*d*) all of the above

122. The coefficient of performance (C_P) of a windmill rotor is defined as the ratio of power delivered by the rotor (P) to the maximum power available in the wind and is given by

(*a*) $C_P = 2P/\rho A V_\infty^3$ (*b*) $C_P = 3P/\rho A V_\infty^3$
(*c*) $C_P = 4P/\rho A V_\infty^3$ (*d*) $C_P = 5P/\rho A V_\infty^5$

where ρ = density of air, A = swept area, V_∞ = velocity of the wind

123. The maximum power available in the wind is directly proportional to the velocity of the wind raised to the power

(*a*) 1 (*b*) 2
(*c*) 3 (*d*) 4

124. The performance of a windmill rotor is indicated by plotting the variation of

(*a*) coefficient of performance against tip speed ratio
(*b*) maximum power available in the wind against wind speed
(*c*) power delivered by the rotor against wind speed
(*d*) maximum power available in the wind against speed at the tip of the rotor

125. Which of the following differences between water at the surface and the lower levels of the oceans is utilized in ocean thermal energy conversion (OTEC) systems ?

(*a*) Salinity difference (*b*) Temperature difference
(*c*) Pressure difference (*d*) Density difference

126. The temperature difference between water at the surface and the lower levels of the ocean (over a few hundred metres) is about

(*a*) 40°C (*b*) 60°C
(*c*) 20°C (*d*) 50°C

127. The process of transformation of a substance from solid phase into vapour phase directly without passing through the liquid phase is called

(*a*) melting (*b*) vaporization
(*c*) sublimation (*d*) crystallization

128. Compared to the combined melting-vaporization process, sublimation occurs at

(*a*) higher pressures (*b*) lower pressures
(*c*) same pressure (*d*) none of the above

129. In the ideal Rankine cycle, heat is added at constant

(*a*) temperature (*b*) pressure
(*c*) volume (*d*) entropy

130. In an ideal Stirling cycle, heat is added at constant

(*a*) temperature (*b*) pressure
(*c*) entropy (*d*) volume

131. In ideal Brayton cycle, heat is added at constant

(*a*) pressure (*b*) temperature
(*c*) volume (*d*) entropy

132. For the ideal simple Brayton cycle, increase in pressure ratio across the compressor results in

(*a*) higher cycle efficiency (*b*) lower cycle efficiency
(*c*) same cycle efficiency (*d*) none of the above

133. Compared to air, helium is preferred for solar Brayton cycles because

(*a*) of higher cycle efficiency
(*b*) it has high heat transfer capability
(*c*) it is inert
(*d*) all of the above

134. Which of the following is used as working fluid in solar Rankine cycle ?

(*a*) Steam (*b*) Air
(*c*) Hydrogen (*d*) Helium

135. The ideal Stirling cycle combines

(*a*) two constant pressure processes and two constant volume processes
(*b*) two constant temperature processes and two constant volume proceses
(*c*) two constant pressure processes and two constant temperature processes
(*d*) two constant pressure processes and two constant entropy processes

136. Biot number signifies

(*a*) the ratio of heat conducted to heat convected
(*b*) the ratio of heat convected to heat conducted
(*c*) the ratio of external convective resistance to internal conductive resistance
(*d*) none of the above

137. The diffuse radiation may be assumed to be equivalent to beam radiation coming at an angle of incidence of

(*a*) 30° (*b*) 45°
(*c*) 60° (*d*) 90°

138. In a shell and tube heat exchanger, the baffles are used

(*a*) to provide mixing of the fluid
(*b*) to deflect the flow in a particular direction
(*c*) to reduce the fouling of the tube surface
(*d*) to reduce the pressure drop

139. Glass is the most favoured material for the transparent covers to be used in flat-plate collectors. The usual practice is to have 1 or 2 covers with spacings in the range of

(*a*) 0·2–0·4 cm (*b*) 5–10 cm
(*c*) 1·5–3 cm (*d*) 15–20 cm

140. For zenith angles from 0° to 70° at sea level, air mass, m, is given by

(*a*) $m = \cos \theta_z$ (*b*) $m = 1/\cos \theta_z$
(*c*) $m = \sin \theta_z$ (*d*) $m = 1/\sin \theta_z$

where θ_z is zenith angle

141. For zenith angle of 60° at sea level, air mass is

(*a*) 0 (*b*) 1
(*c*) 2 (*d*) 3

142. Which radiation is not dangerous ?

(*a*) Cosmic radiation (*b*) X-ray radiation
(*c*) Infrared radiation (*d*) Ultraviolet radiation

143. Which of the following statements about light is incorrect ?

(*a*) Light is energy
(*b*) Light cannot travel through vacuum
(*c*) Light travels in waves
(*d*) Velocity of light is greater than the velocity of sound

144. The present theory of how the sun's energy is produced is based on Einstein's discovery of the relationship between

(*a*) energy and gravity (*b*) matter and gravity
(*c*) gravity and light (*d*) energy and matter

145. The Carnot refrigeration cycle

(*a*) transfers energy from a low level of temperature to a high level of temperature
(*b*) requires the addition of external work for its operation
(*c*) performs the reverse effect of the heat engine
(*d*) all of the above

146. For a steady state system

(*a*) the rate of input is zero
(*b*) the rate of the generation is zero
(*c*) the rate of consumption is zero
(*d*) the rate of accumulation is zero

147. Service air systems normally operate at a pressure of

(*a*) 1 bar (*b*) 2 bar
(*c*) 3 bar (*d*) 7 bar

148. Instrument air is supplied to each instrument supply station at 7 bar with air of dew point of

(*a*) 20°C (*b*) 60°C
(*c*) –15°C (*d*) 4°C

149. In any practical refrigeration system, the maintenance of low temperature requires the removal of heat from the product at low temperature and the discharge of this heat at

(*a*) higher temperature (*b*) lower temperature
(*c*) same temperature (*d*) none of the above

150. Dry ice is solid

(*a*) water (*b*) carbon dioxide
(*c*) sodium chloride (*d*) carbon monoxide

151. Dry ice sublimes at

(*a*) –273°C (*b*) 0°C
(*c*) –78°C (*d*) 4°C

152. The adiabatic throttling process

(*a*) is one example of a steady-flow expansion
(*b*) can be performed in a pipe with a restriction
(*c*) of a perfect gas is one of constant enthalpy
(*d*) all of the above

153. The adiabatic throttling process of a perfect gas is one of constant enthalpy in which

(*a*) there is no drop in temperature
(*b*) there is a reduction in temperature
(*c*) there is an increase in temperature
(*d*) none of the above

154. The adiabatic throttling process of a perfect gas is one of constant

(*a*) kinetic energy (*b*) enthalpy
(*c*) potential energy (*d*) pressure

155. The Joule-Thomson coefficient is defined as

(*a*) $(\partial P/\partial T)_H$ (*b*) $(\partial P/\partial \hat{H})_T$
(*c*) $(\partial T/\partial P)_H$ (*d*) $(\partial H/\partial T)_P$

156. Which of the following decreases during adiabatic throttling of a perfect gas ?
(*a*) Temperature (*b*) Enthalpy
(*c*) Entropy (*d*) Pressure

157. At the inversion point, the Joule-Thomson coefficient is
(*a*) zero (*b*) negative
(*c*) positive (*d*) infinite

158. The Carnot heat engine
(*a*) receives energy at a high level of temperature
(*b*) converts a portion of the energy received into
(*c*) discharges portion of the energy received to a heat sink level of temperature
(*d*) all of the above

159. The index of performance of a refrigerating system is called
(*a*) efficiency (*b*) effectiveness
(*c*) coefficient of performance (*d*) drop in temperature

160. The coefficient of performance is defined as
(*a*) the ratio of useful refrigeration to the net work
(*b*) the ratio of net work to the useful refrigeration
(*c*) the drop in temperature achieved
(*d*) the drop in pressure achieved

161. The coefficient of performance has the units of
(*a*) work (*b*) pressure
(*c*) temperature (*d*) none of the above

162. The coefficient of performance of the Carnot cycle
(*a*) is a function of the temperature limits
(*b*) can vary from zero to infinite
(*c*) both *a* and *b*
(*d*) neither *a* nor *b*

163. The rate of cooling, Btu/h, required to freeze 1 ton of water at 0°C into ice at 0°C in a day is
(*a*) 200 (*b*) 12000
(*c*) 3·3 (*d*) 1200

ANSWERS

1. (*a*)	2. (*d*)	3. (*c*)	4. (*d*)	5. (*a*)
6. (*b*)	7. (*b*)	8. (*a*)	9. (*b*)	10. (*a*)

11. (*a*)	12. (*a*)	13. (*a*)	14. (*b*)	15. (*b*)
16. (*c*)	17. (*a*)	18. (*c*)	19. (*d*)	20 (*a*)
21. (*a*)	22. (*b*)	23. (*b*)	24. (*b*)	25. (*b*)
26. (*c*)	27. (*b*)	28. (*b*)	29. (*a*)	30. (*c*)
31. (*a*)	32. (*a*)	33. (*a*)	34. (*c*)	35. (*a*)
36. (*b*)	37. (*d*)	38. (*d*)	39. (*a*)	40. (*c*)
41. (*a*)	42. (*c*)	43. (*d*)	44. (*a*)	45. (*c*)
46. (*d*)	47. (*b*)	48. (*b*)	49. (*d*)	50. (*a*)
51. (*c*)	52. (*b*)	53. (*c*)	54. (*b*)	55. (*b*)
56. (*c*)	57. (*a*)	58. (*a*)	59. (*a*)	60. (*c*)
61. (*c*)	62. (*c*)	63. (*b*)	64. (*c*)	65. (*a*)
	67. (*c*)	68. (*c*)	69. (*d*)	70. (*b*)
	72. (*d*)	73. (*d*)	74. (*c*)	75. (*b*)
	77. (*a*)	78. (*d*)	79. (*b*)	80. (*a*)
81. (*a*)	82. (*c*)	83. (*b*)	84. (*c*)	85. (*a*)
86. (*b*)	87. (*a*)	88. (*a*)	89. (*a*)	90. (*b*)
91. (*a*)	92. (*c*)	93. (*a*)	94. (*a*)	95. (*a*)
96. (*b*)	97. (*a*)	98. (*a*)	99. (*a*)	100. (*c*)
101. (*d*)	102. (*a*)	103. (*b*)	104. (*b*)	105. (*a*)
106. (*a*)	107. (*a*)	108. (*b*)	109. (*d*)	110. (*a*)
111. (*a*)	112. (*c*)	113. (*d*)	114. (*c*)	115. (*a*)
116. (*d*)	117. (*b*)	118. (*d*)	119. (*b*)	120. (*a*)
121. (*d*)	122. (*a*)	123. (*c*)	124. (*a*)	125. (*b*)
126. (*c*)	127. (*c*)	128. (*b*)	129. (*b*)	130. (*a*)
131. (*a*)	132. (*a*)	133. (*d*)	134. (*a*)	135. (*b*)
136. (*b*)	137. (*c*)	138. (*a*)	139. (*c*)	140. (*b*)
141. (*c*)	142. (*c*)	143. (*b*)	144. (*d*)	145. (*d*)
146. (*d*)	147. (*d*)	148. (*c*)	149. (*a*)	150. (*b*)
151. (*c*)	152. (*d*)	153. (*a*)	154. (*b*)	155. (*c*)
156. (*d*)	157. (*a*)	158. (*d*)	159. (*c*)	160. (*a*)
161. (*d*)	162. (*c*)	163. (*b*).		