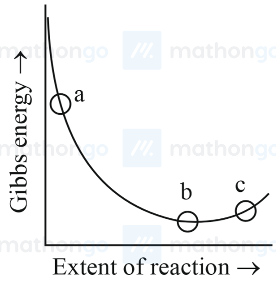
1. The value of $\log K$ for the reaction $A \rightleftharpoons B$ at 298 K is _______. (Nearest integer)
Given: $\Delta H^\circ = -54.07 \text{ kJ mol}^{-1}$
$\Delta S^\circ = 10 \text{ JK}^{-1} \text{ mol}^{-1}$
(Taken $2.303 \times 8.314 \times 298 = 5705$)
[2023 (06 Apr Shift 1)]

2. Consider the graph of Gibbs free energy G vs extent of reaction. The number of statement/s from the following which are true with respect to points (a), (b) and (c) is ______



A. Reaction is spontaneous at (a) and (b)
B. Reaction is at equilibrium at point (b) and non-spontaneous at point (c)
C. Reaction is spontaneous at (a) and non-spontaneous at (c)
D. Reaction is non-spontaneous at (a) and (b)
[2023 (06 Apr Shift 1)]

3. Consider the following data
Heat of combustion of $H_2(g) = -241.8 \text{ kJ mol}^{-1}$
Heat of combustion of $C(s) = -393.5 \text{ kJ mol}^{-1}$
Heat of combustion of $C_2H_5OH(l) = -1234.7 \text{ kJ mol}^{-1}$
The heat of formation of $C_2H_5OH(l)$ is (−) _____ kJ mol^{-1} (Nearest integer).
[2023 (06 Apr Shift 2)]

4. When a 60 W electric heater is immersed in a gas for 100 s in a constant volume container with adiabatic walls, the temperature of the gas rises by $5^\circ C$. The heat capacity of the given gas is JK^{-1} (Nearest integer)
[2023 (08 Apr Shift 1)]

5. For complete combustion of ethene,
$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$
the amount of heat produced as measured in bomb calorimeter is 1406 kJ mol^{-1} at 300 K. The minimum value of $T\Delta S$ needed to reach equilibrium is (−) kJ. (Nearest integer)
Given: $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$
[2023 (08 Apr Shift 2)]

6. The incorrect statements from the following is:
A. The electrical work that a reaction can perform at constant pressure and temperature is equal to the reaction Gibbs energy.
B. E°_{cell} is dependent on the pressure.
C. $\frac{dE^\circ_{cell}}{dT} = \frac{\Delta_r S^\circ}{nF}$
D. A cell is operating reversibly if the cell potential is exactly balanced by an opposing source of potential difference.
[2023 (08 Apr Shift 2)]

7. The enthalpy change for the adsorption process and micelle formation respectively are
[2023 (10 Apr Shift 1)]
(1) $\Delta H_{ads} > 0$ and $\Delta H_{mic} < 0$
(2) $\Delta H_{ads} > 0$ and $\Delta H_{mic} > 0$
(3) $\Delta H_{ads} < 0$ and $\Delta H_{mic} > 0$
(4) $\Delta H_{ads} < 0$ and $\Delta H_{mic} < 0$

8. Given

(A) $2\,\mathrm{CO(g)} + \mathrm{O_2(g)} \rightarrow 2\,\mathrm{CO_2(g)}\ \Delta H_1^{\circ} = -x\ \mathrm{kJ\ mol^{-1}}$

(B) $\mathrm{C(graphite)} + \mathrm{O_2(g)} \rightarrow \mathrm{CO_2(g)}\ \Delta H_2^{\circ} = -y\ \mathrm{kJ\ mol^{-1}}$

The ΔH° for the reaction $\mathrm{C(graphite)} + \frac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{CO(g)}$ is

[2023 (10 Apr Shift 1)]

(1) $\frac{2x-y}{2}$
(2) $\frac{x+2y}{2}$
(3) $\frac{x-2y}{2}$
(4) $2y - x$

9. $\mathrm{FeO_4^{2-}} \xrightarrow{+2.2\,\mathrm{V}} \mathrm{Fe^{3+}} \xrightarrow{+0.70\,\mathrm{V}} \mathrm{Fe^{2+}} \xrightarrow{-0.45\,\mathrm{V}} \mathrm{Fe^{0}}$

$E^{\theta}_{\mathrm{FeO_4^{2-}/Fe^{2+}}}$ is $x \times 10^{-3}$ V. The value of x is _______

[2023 (10 Apr Shift 1)]

10. The number of incorrect statement/s about the black body from the following is______

(A) Emit or absorb energy in the form of electromagnetic radiation.

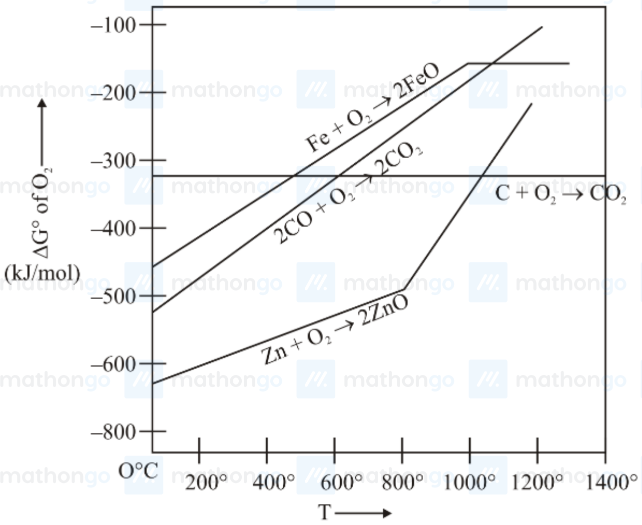
(B) Frequency distribution of the emitted radiation depends on temperature.

(C) At a given temperature, intensity vs frequency curve passes through a maximum value.

(D) The maximum of the intensity vs frequency curve is at a higher frequency at higher temperature compared to that at lower temperature.

[2023 (10 Apr Shift 1)]

11. Gibbs energy vs T plot for the formation of oxides is given below.



For the given diagram, the correct statement is-

[2023 (10 Apr Shift 2)]

(1) At 600°C, CO cannot reduce FeO
(2) At 600°C, CO can reduce ZnO
(3) At 600°C, C can reduce ZnO
(4) At 600°C, C can reduce FeO

12. $\mathrm{A(g)} \rightleftharpoons 2\,\mathrm{B(g)} + \mathrm{C(g)}$

For the given reaction, if the initial pressure is 450 mmHg and the pressure at time t is720 mmHg at a constant temperatureT and constant volume V. The fraction of A(g) decomposed under these conditions is $x \times 10^{-1}$. The value of x is (nearest integer)

[2023 (10 Apr Shift 2)]

13. The number of endothermic process/es from the following is _______.

A. $\mathrm{I_2(g)} \rightarrow 2\mathrm{I(g)}$
B. $\mathrm{HCl(g)} \rightarrow \mathrm{H(g)} + \mathrm{Cl(g)}$
C. $\mathrm{H_2O(l)} \rightarrow \mathrm{H_2O(g)}$
D. $\mathrm{C(s)} + \mathrm{O_2(g)} \rightarrow \mathrm{CO_2(g)}$
E. Dissolution of ammonium chloride in water

[2023 (10 Apr Shift 2)]

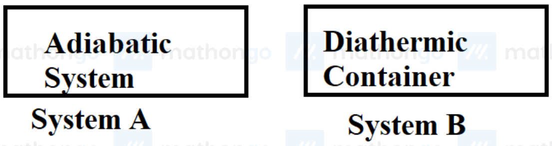
14. Solid fuel used in rocket is a mixture of Fe_2O_3 and Al (in ratio $1 : 2$). The heat evolved (kJ) per gram of the mixture is _____ (Nearest integer)
Given $\Delta H_f^0(Al_2O_3) = -1700\ \text{kJ mol}^{-1}$
$\Delta H_f^0(Fe_2O_3) = -840\ \text{kJ mol}^{-1}$
Molar mass of Fe, Al and O are 56, 27 and 16 g mol^{-1} respectively
[2023 (11 Apr Shift 1)]

15. The total number of intensive properties from the following is..........
Volume, Molar heat capacity, molarity, E^o_{cell}, Gibbs free energy change, Molar mass, Mole
[2023 (11 Apr Shift 2)]

16. One mole of an ideal gas at 350 K is in a 2.0 L vessel of thermally conducting walls, which are in contact with the surroundings. It undergoes isothermal reversible expansion from 2.0 L to 3.0 L against a constant pressure of 4 atm. The change in entropy of the surroundings (ΔS) is _____ J K^{-1} (Nearest integer)
Given: $R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$.
[2023 (12 Apr Shift 1)]

17. $A_2 + B_2 \rightarrow 2\,AB.\ \Delta H_f = -200\ \text{kJ mol}^{-1}$
AB, A_2 and B_2 are diatomic molecules. If the bond enthalpies of A_2, B_2 and AB are in the ratio $1 : 0.5 : 1$, then the bond enthalpy of A_2 is_________kJ mol^{-1} (Nearest integer)
[2023 (13 Apr Shift 1)]

18. What happens when methane undergoes combustion in systems A and B respectively?



[2023 (13 Apr Shift 2)]

(1)

System A	System B
Temperature rises	Temperature remains same

(2)

System A	System B
Temperature remains same	Temperature rises

(3)

System A	System B
Temperature falls	Temperature remains same

(4)

System A	System B
Temperature falls	Temperature rises

19. 30.4 kJ of heat is required to melt one mole of sodium chloride and the entropy change at the melting point is $28.4\ \text{J K}^{-1}\ \text{mol}^{-1}$ at 1 atm. The melting point of sodium chloride is _______ K (Nearest Integer)
[2023 (15 Apr Shift 1)]

ANSWER KEYS

1. (10) **2.** (2) **3.** (278) **4.** (1200) **5.** (1411) **6.** (1) **7.** (3) **8.** (3)
9. (1825) **10.** (0) **11.** (4) **12.** (3) **13.** (4) **14.** (4) **15.** (4) **16.** (3)
17. (800) **18.** (1) **19.** (1070)

1. (10)

We can use the relationship between the equilibrium constant (K) and the standard Gibbs free energy change (ΔG°) to calculate the value of $\log\ K$ at 298 K

Given,

$\Delta H^o\ =\ -\ 54.07\ \text{kJ}\ \ \text{mol}^{-1}$

$\Delta\ S^o\ =\ 10\ \text{JK}^{-1}\ \ \text{mol}^{-1}$

We know,

$\Delta G^\circ = \Delta H^\circ - T\,\Delta\,S^\circ$

$= -54.07 - \frac{298(10)}{1000}$

$= -57.05\ \text{kJ}\,/\,\text{mole}$

$\Delta G^\circ = -2.303\,\text{RT}\ \ \log K_{eq}$

$-57.05 \times 1000 = -2.303 \times 8.314 \times 298\ \log K_{eq}$

$-57.05 \times 1000 = -5705\ \log_{eq}$

$10 = \log K_{eq}$

2. (2)

For spontaneous process, $\Delta G = -$ ve, at equilibrium $\Delta G = 0$ and for non-spontaneous process $\Delta G = +$ ve.

The relation between the change in Gibbs reaction energy and Gibbs energy can be defined as the slope of the Gibbs energy plotted against the extent of reaction at constant pressure and temperature.

At point a: Slope$= -$ ve

$\Delta G = -$ ve

Hence, reaction is spontaneous at point a.

At point b: Slope$= 0$

$\Delta G = 0$

Hence. it is the equilibrium condition.

At point c: Slope$= +$ ve

$\Delta G = +$ ve

Hence, reaction is non-spontaneous at point c.

3. (278)

$C_2H_5\,OH(l) \rightarrow 2\,CO_2(g) + 3H_2O(l) + +\ 3O_2(g)$

Heat of combustion = Heat of formation of products - Heat of formation of reactants

Heat of combustion of hydrogen is equal to heat formation of water, and heat of combustion of carbon is equal to heat of formation of carbon dioxide.

$\Delta H_C = [2\,\Delta\,H_f{}^o(CO_2) + 3\,\Delta\,H_f{}^o(H_2O)] - [\Delta H_f{}^o(C_2H_5\,OH(l))]$

$-1234.7 = [2 \times (-393.5) + 3 \times (-241.8)] - [\Delta H_f{}^o(C_2H_5\,OH(l))]$

$\Delta H_f{}^o C_2H_5OH = -277.7\ \text{kJ}\,/\,\text{mol}$

$\simeq -278\ \text{kJ}\,/\,\text{mol}$

4. (1200)

$\text{Heat capacity}\ = \frac{\text{Heat absorbed}}{\text{change in temperature}}$

1 Watt = 1 Joule per second

Hence, heat absorbed $= 60 \times 100\text{J}$

Change in temperature $= 5^\circ\text{C}$

Heat capacity$= \frac{60 \times 100\ \text{J}}{5}$

$= 1200\,\text{JK}^{-1}$

5. (1411)

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$
$\Delta U = -1406\ kJ\ mol^{-1}$
$T = 300K$
$\Delta H = \Delta U + \Delta n_g RT$
ΔU is the change in the internal energy of the system, which is the sum of the kinetic and potential energies of all the molecules in the system. R is the gas constant ($8.314\ J/(mol\ K)$ and T is the temperature in Kelvin.
$\Delta H = -1406 + \left(-2\right) \times 8.3 \times 300 = -1406 - 4.98$
$= -1410.98\ KJ\ mol-1 \approx -1411$
The minimum value of $T \Delta S$ at equilibrium ΔH
$\Delta H = T \Delta S = -1411\ KJ\ mol^{-1}$

6. (1)

E°_{cell} is dependent on the equilibrium constant, K, which is not dependent on the pressure of any gas involved in the cell. Relation between Electrochemical Cell Potential and Gibbs free Energy change is given by; $\Delta G = -nFE$ where Delta G is Gibbs Free energy change , n is the number of electrons involved in the reaction and F is Faraday and E is the Cell potential.
We know that,
$dG = VdP - SdT$
At constant pressure $dP = 0$
$\Rightarrow dG = -SdT$
$S = -\frac{dG}{dT}$
$\Delta S = -\left(\frac{\Delta(dG)}{dT}\right)_P$
$\Rightarrow \frac{dE^{\circ}_{cell}}{dT} = \frac{\Delta S}{nF}$
A cell is operating reversibly if the cell potential is exactly balanced by an opposing source of potential difference.

7. (3)

Adsorption is exothermic process due to decrease in surface energy. Micelle formation is endothermic, it is due to For any spontaneous process entropy should always increase, hence, $\Delta S > 0$ for micelle formation and micelle formation decreases the stability of the colloidal solution so, energy of the mixture should increase which means $\Delta H > 0$.
The adsorption process $\Delta H = -$ve. For micelle formation ΔH is $+$ve and ΔS is $+$ve.

8. (3)

(A) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)\ \Delta H^o_1 = -x\ kJ\ mol^{-1}$
(B) $C_{graphite} + O_2(g) \rightarrow CO_2(g)\ \Delta H^o_2 = -y\ kJ\ mol^{-1}$
If the equation is multiplied the value n, then the enthalpy change value also multiplied by factor n. If the enthalpy is positive in one direction, it is negative in other direction.
Multiply equation B by 2 and subtract equation (A) from it
$2C_{graphite} + O_2(g) \rightarrow 2CO(g)\ \Delta H^{\circ} = x - 2y$
$C_{graphite} + \frac{1}{2}O_2 \rightarrow CO;\ \ \Delta H^{\circ} = \frac{x-2y}{2}$

9. (1825)

The relation between ΔG^o and E^o_{cell} is
$\Delta G^o = -nFE^o_{cell}$
$FeO_4^{2-} \xrightarrow{+2.2\ V} Fe^{3+}\ \ \Delta G^o_1 = -6.6\ F$(3 electrons are involved)
$Fe^{3+} \xrightarrow{+0.70\ V} Fe^{2+}\ \Delta G^o_2 = -0.7\ F$(one electron is involved)
Hence, for
$FeO_4^{2-} \longrightarrow Fe^{2+}\ \Delta G^o_3 = -7.3\ F$
$= -nFE^o_{cell}$(Four electrons are involved)
$E^0_{FeO_4^{2-}/Fe^{+2}} = \frac{-7.3\ F}{-4\ F} = 1.825,\ n = 4$
$= 1825 \times 10^{-3}\ V$
n = Electron exchange of that half cell reaction.

10. (0)

A black body is an idealised object that absorbs all the radiation that falls on it and emits radiation over a broad range of frequencies.

Black bodies emit and absorb energy in the form of electromagnetic radiation.

The frequency distribution of the emitted radiation from a black body depends on its temperature and is given by Planck's law.

At a given temperature, the intensity vs frequency curve for a black body radiation passes through a maximum value. This frequency is known as the peak frequency or the frequency of maximum emission.

At higher temperatures, the peak frequency of the black body radiation shifts towards higher frequencies (shorter wavelengths). This means that the maximum of the intensity vs frequency curve is at a higher frequency at higher temperature compared to that at lower temperature.

11. (4)

Ellingham diagrams are a particular graphical form of the principle that the thermodynamic feasibility of a reaction depends on the sign of ΔG, the Gibbs free energy change, which is equal to $\Delta H - T\Delta S$, where ΔH is the enthalpy change and ΔS is the entropy change. Hence, element below in Ellingham diagram can reduce oxide of element above it.

C can reduce FeO at 600 ºC.

12. (3)

	$A(g) \rightleftharpoons$	$2B(g)$	$+C(g)$
intial	450	0	0
at time $= t$	$450 - p$	$2p$	p

$(450 - p) + (2p) + (p) = 720$

$450 + 2p = 720$

$2p = 270$

$p = 135$

Fraction of $A(g)$ decomposed$= \frac{\text{Amount of A decomposed}}{\text{Initial amount}} = \frac{135}{450} = 0.3$

The fraction $A(g)$ decomposed $= 3 \times 10^{-1}$

$\Rightarrow x = 3$

13. (4)

The decomposition reactions are endothermic reactions. The reactions $I_2(g) \rightarrow 2I(g)$ and $HCl(g) \rightarrow H(g) + Cl(g)$ are decomposition reactions. The heat vaporisation is an endothermic reaction. Hence, the conversion of $H_2O(l) \rightarrow H_2O(g)$ is endothermic process. The heat of combustion is an exothermic process. The heat involved in $C(s) + O_2(g) \longrightarrow CO_2(g)$ is heat of combustion. The dissolution of ammonium chloride in water is an endothermic process.

$NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq);\ \Delta H = +15.1\ kJ/mol.$

14. (4)

Molten iron can be prepared by alumino thermite process as shown below.

$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$

The iron oxide and aluminium metal ratio is 1 : 2 in the above reaction.

Now, the Enthalpy of the reaction is equal to the difference of enthalpy of formation of products to the enthalpy of formation of reactants.

$\Delta H^0_{reaction} = -1700 + \left(840\right)$

Ratio of Fe_2O_3 and Al

$= 160 : 54$

$= 2.96 \text{ in } 214 \text{ gm mixture}$

$\therefore \frac{\Delta H^\circ}{1 \text{ gm mixture}} = \frac{-860}{214} = -4 \text{ kJ/gram}$

15. (4)

An intensive property is a physical quantity whose value does not depend on the amount of substance which was measured.

Molar heat capacity, molarity, E^o_{cell} and molar mass are intensive properties.

An extensive property of a system depends on the system size or the amount of matter in the system.

Volume, Gibbs free energy change, Mole are extensive properties.

16. (3)

The first law of thermodynamics for isothermal process $Q = -W$

The W for isothermal reversible process is

$W = -nRT \ln \frac{V_2}{V_1}$

$\Delta \mathrm{S} = \frac{\mathrm{Q}}{\mathrm{T}}$

$\Delta S_{\text{surrounding}} = -nR \ln \frac{V_2}{V_1}$

$= -1 \times 8.314 \times 2.303 \times \log \frac{3}{2}$

$= -3.37 \ \mathrm{JK}^{-1}$

$\simeq -3 \ \mathrm{JK}^{-1}$

The given process is mentioned as isothermal reversible process hence the $\Delta S_{\text{surrounding}}$ is calculated.

17. (800)

First write balanced reaction for the formation of one mole of AB with the help of diatomic molecule:

$\frac{1}{2}\mathrm{A}_2 + \frac{1}{2}\mathrm{B}_2 \rightarrow \mathrm{AB} \quad \Delta \mathrm{H}_{\mathrm{f}} = -200 \ \mathrm{kJ} / \mathrm{mol}$

Now,

$\Delta \mathrm{H}_{\text{reaction}} = \frac{1}{2} \Delta \mathrm{H}_{\mathrm{A-A}} + \frac{1}{2} \Delta \mathrm{H}_{\mathrm{B-B}} - \Delta \mathrm{H}_{\mathrm{AB}} \quad (\text{let}, \ \Delta \mathrm{H}_{\mathrm{AB}} = \mathrm{x})$

$\frac{1}{2}\mathrm{x} + \frac{1}{2}\left(0.5\mathrm{x}\right) - \mathrm{x} = -200 \ \Rightarrow \ \frac{\mathrm{x}}{2} + 0.25\mathrm{x} - \mathrm{x} = -200$

$\Rightarrow \ -0.25\mathrm{x} = -200 \ \Rightarrow \ \mathrm{x} = 800 \ \mathrm{kJ} / \mathrm{mol}$

Bond enthalpy $= 800 \ \mathrm{kJ} / \mathrm{mol}$.

18. (1)

For an adiabatic free expansion of an ideal gas, the gas is kept in an insulated container and then permitted to enlarge in a vacuum. Since there is no external pressure for the gas to enlarge against, the work done by or on the system is zero. Since this process does not involve any exchange of heat transfer or work, heat will not escape and temperature of system will rise.

For diathermic container, heat will escape the container and hence temperature of container will remain same.

19. (1070)

The equilibrium process can be written as follows,

$\mathrm{NaCl(s)} \rightleftharpoons \mathrm{NaCl(l)}$

$\Delta \mathrm{S} = \frac{\Delta \mathrm{H}}{\mathrm{Temp}}$

$\mathrm{T} = \frac{\Delta \mathrm{H}}{\Delta \mathrm{S}}$

$= \frac{30.4 \times 10^3}{28.4}$

$= 1070.4 \ \mathrm{K}$