1. Mass of Urea (NH_2CONH_2) required to be dissolved in 1000 g of water in order to reduce the vapour pressure of water by 25% is _______ g. (Nearest integer)

Given : Molar mass of N, C, O and H are 14, 12, 16 and 1 g mol^{-1} respectively.

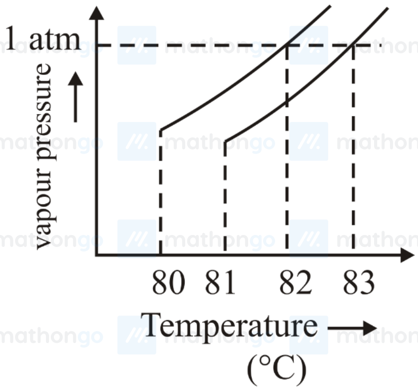
[2023 (06 Apr Shift 1)]

2. Consider the following pairs of solution which will be isotonic at the same temperature. The number of pairs of solutions is/ are _____

A. 1 M aq. NaCl and 2 M aq. urea
B. 1 M aq. $CaCl_2$ and 1.5 M aq. KCl
C. 1.5 M aq. $AlCl_3$ and 2 M aq. Na_2SO_4
D. 2.5 M aq. KCl and 1 M aq. $Al_2(SO_4)_3$

[2023 (06 Apr Shift 2)]

3. The vapour pressure vs. temperature curve for a solution solvent system is shown below.



The boiling point of the solvent is _____°C.

[2023 (08 Apr Shift 1)]

4. If the boiling points of two solvents X and Y (having same molecular weights) are in the ratio 2: 1 and their enthalpy of vaporizations are in the ratio 1 : 2, then the boiling point elevation constant of X is m times the boiling point elevation constant of Y. The value of m is (nearest integer).

[2023 (08 Apr Shift 2)]

5. If the degree of dissociation of aqueous solution of weak monobasic acid is determined to be 0.3, then the observed freezing point will be _____ % higher than the expected/theoretical freezing point. (Nearest integer).

[2023 (10 Apr Shift 1)]

6. An aqueous solution of volume 300 cm^3 contains 0.63 g of protein. The osmotic pressure of the solution at 300 K is 1.29 mbar. The molar mass of the protein is $gmol^{-1}$.

Given : $R = 0.083\ L_{bar}K^{-1}\ mol^{-1}$

[2023 (10 Apr Shift 2)]

7. 0.004 M K_2SO_4 solution is isotonic with 0.01 M glucose solution. Percentage dissociation of K_2SO_4 is _____ (Nearest integer)

[2023 (11 Apr Shift 1)]

8. What weight of glucose must be dissolved in 100 g of water to lower the vapour pressure by 0.20 mm Hg?

(Assume dilute solution is being formed)

Given: Vapour pressure of pure water is 54.2 mm Hg at room temperature.Molar mass of glucose is 180 g mol^{-1}

[2023 (11 Apr Shift 2)]

(1) 3.59 g
(2) 3.69 g
(3) 4.69 g
(4) 2.59 g

9. 80 mole percent of $MgCl_2$ is dissociated in aqueous solution. The vapour pressure of 1.0 molal aqueous solution of $MgCl_2$ at 38°C is _____ mm Hg. (Nearest integer)

Given: Vapour pressure of water at 38°C is 50 mm Hg

[2023 (12 Apr Shift 1)]

10. Solution of 12 g of non-electrolyte (A) prepared by dissolving it in 1000 mL of water exerts the same osmotic pressure as that of 0.05 M glucose solution at the same temperature. The empirical formula of A is CH_2O. The molecular mass of A is ________g. (Nearest integer)

[2023 (13 Apr Shift 1)]

11. Sea water contains 29.25% NaCl and 19% $MgCl_2$ by weight of solution. The normal boiling point of the sea water is °C (Nearest integer) Assume 100% ionization for both NaCl and $MgCl_2$ Given: $K_b\left(H_2O = 0.52\ K\ \ kg\ \ mol^{-1}\right)$ Molar mass of NaCl and $MgCl_2$ is 58.5 and $95\ g\ mol^{-1}$ respectively.

[2023 (13 Apr Shift 2)]

12. The vapour pressure of 30% (w/v), aqueous solution of glucose is ________ mm Hg at 25°C.

[Given: The density of 30% (w/v), aqueous solution of glucose is $1.2\ g\ cm^{-3}$ and vapour pressure of pure water is $24\ mm\ Hg$.]

(Molar mass of glucose is $180\ g\ mol^{-1}$)

[2023 (15 Apr Shift 1)]

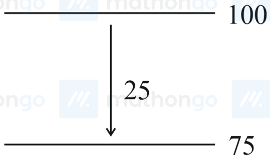
ANSWER KEYS

1. (1111) **2.** (4) **3.** (82) **4.** (8) **5.** (30) **6.** (40535) **7.** (75) **8.** (2)
9. (48) **10.** (240) **11.** (116) **12.** (23)

1. (1111)

Relative lowering of vapour pressure=Mole fraction of solute

$\frac{\text{Lowering of vapour pressure}}{\text{Vapoure pressure of solution}} = \frac{\text{moles of solute}}{\text{moles of solvent}}$



$\frac{25}{75} = \frac{\text{moles of urea}}{\left(\frac{1000}{18}\right)}$

$\frac{1}{3} \times \frac{1000}{18}$ =moles of urea

Mass of urea$= \frac{1}{3} \times \frac{1000}{18} \times 60$

$= 1111.11 \text{ gm}$

2. (4)

A solution having the same solute and solvent concentration as a cell across the semipermeable membrane is referred to as isotonic solution.

The effective concentration of each solution can be calculated as follows,

$\text{Effective concentration} = \text{i}\left(\text{Von' t Hoff factor}\right) \times \text{C}$

1M NaCl has effective concentration $= 2 \times 1 = 2\text{M}$ and hence it is isotonic with two molar urea solution.

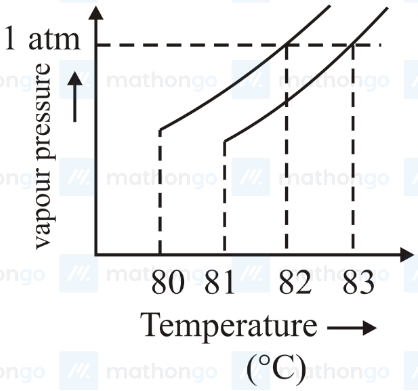
1M CaCl_2 has effective concentration $=$ 3M and 1.5M KCl has also 3M, hence, both are isotonic.

$1.5\text{M AlCl}_3 \cong 6\text{M}$ and $2\text{M Na}_2\text{SO}_4 \cong 6\text{M}$, Hence both are isotonic.

$2.5\text{M KCl} \cong 5\text{M}$ and $1\text{M Al}_2(\text{SO}_4)_3 \cong 5\text{M}$, Hence both are isotonic.

3. (82)

We know that the temperature at which vapour pressure of a liquid becomes 1 atm. is called the boiling point of the liquid.



From the figure, we can clearly see that Graph I is for pure solvent whereas graph II is for solution. Hence the boiling point of solvent and solution are 82°C and 83°C respectively.

4. **(8)**

The boiling point elevation constant (K_b) of a volatile liquid is given by the following expression

$K_b = \frac{RT_b^2 M}{\Delta H_v}$

Where T_b =boiling point of the liquid
M =molar mass of the liquid
ΔH_v = Enthalpy of vaporisation

The boiling points of the two solvents are in the ratio 2 : 1, which means that the boiling point elevation constants are also in the ratio 2 : 1. Let's call the boiling point elevation constant of solvent X as $(T_b)_x$, and the boiling point elevation constant of solvent Y as $(T_b)_y$.

Given: $M_x = M_y$

$(T_b)_x = 2(T_b)_y$

$2(\Delta H_v)x = (\Delta H_v)_y$

$\therefore \frac{(K_b)_x}{(K_b)_y} = \left(\frac{2}{1}\right)^2 \times \frac{2}{1} = \frac{8}{1} = m$

$\therefore m = 8$

Therefore, the value of m is 8(nearest integer).

5. **(30)**

$\underset{1-\alpha}{HA} \leftrightharpoons \underset{\alpha}{H^+} + \underset{\alpha}{A^-}$

Van't Hoff factor, $i = 1 + \alpha(n-1)$
$= 1 + 0.3(2-1)$
$= 1 + 0.3$
$= 1.3$

ΔT_f without considering dissociation $= k_f \times$ molality

ΔT_f without considering dissociation $= ik_f \times$ molality

$= \Delta T_f'$

$\Delta T_f' - \Delta T_f = 0.3\ (k_f \times \text{molality})$

$\frac{\Delta T_f^1 - \Delta T_f}{\Delta T_f} = \frac{0.3\,(k_f \times \text{molality})}{k_f \times \text{molality}} = 0.3$

% value = 30

6. **(40535)**

The osmotic pressure of a non-electrolytic solution can be calculated as follows,

$\pi = CRT$

π = osmotic pressure

C = molarity= $\frac{\text{Number of moles}}{\text{Volume of solution in L}}$

$(1.29 \times 10^{-3}) = \frac{0.63}{(MW)(0.3)} \times (0.083) \times 300$

$MW = \frac{0.63 \times 0.083 \times 300}{(0.3) \times (1.29 \times 10^{-3})}$

$= 40534.88$

≈ 40535 (Nearest integer)

7. **(75)**

Osmotic pressure $\pi = iCRT$

i =Van't Hoff Factor

C =Molarity

R =Same gas constant

T =Temperature

For isotonic solutions, osmotic pressure are equal, Hence, we have

$(0.004) \times i = 0.01$

$\Rightarrow i = \frac{0.01}{0.004}$

$= \frac{10}{4} = \frac{5}{2} = 1 + 2\alpha$

$2\alpha = 1.5$

$\alpha = 0.75$

$\% \alpha = 75$

8. **(2)**

Sol. Using the formula

$\frac{P^{o}-P_{s}}{P^{o}}=\frac{\text{Moles of solute}}{\text{Moles of solvent}}$(for dilute solution)

P^{o} =Vapour pressure of pure water

P_{s} =Vapour pressure of solution

$\frac{54.2-54}{54.2}=\frac{w/180}{\frac{100}{18}}$

$w=\frac{0.2\times1000}{54.2}$

$=\frac{200}{54.2}=3.69$

9. **(48)**

One molal solution means one of solute present in one kg of solvent.

$MgCl_{2}\rightleftharpoons Mg^{2+}+2\,Cl^{-}$

$1 \qquad 0 \qquad 0$

$1-0.8 \qquad 0.8 \qquad 1.6$

Hence, overall moles after dissociation $=2.6$

The relative lowering of vapour pressure

$\frac{p^{o}-p_{s}}{p^{o}}=\frac{\text{moles of solute}}{\text{moles of solute}+\text{moles of solvent}}$

$\frac{p^{\circ}-p_{s}}{p^{\circ}}=\frac{2.6}{\frac{1000}{18}+2.6}$

For dilute solution

$\frac{p^{\circ}-p_{s}}{p^{\circ}}=\frac{2.6}{\frac{1000}{18}}$

$p=47.66\simeq48\ \text{mm Hg}$

10. **(240)**

The pressure which applied externally in the solution side to prevent the osmosis process is known as osmotic pressure. It can be denoted by π.

Since, $(\pi_{1})_{\text{non electrolyte}}=(\pi_{2})_{\text{glucose}}$

$C_{1}RT=C_{2}RT$

$\frac{W_{1}}{M_{1}}=\frac{W_{2}}{M_{2}}$

Empirical mass of

$\frac{12}{M_{1}}=0.05$

$M_{1}=\frac{12}{0.05}=240$

11. **(116)**

Molality of solution$=\frac{\text{moles of solute}}{\text{mass of solvent}}\times1000$

Number of moles NaCl $=\frac{29.25}{58.5}=0.5$

Number of moles of $MgCl_{2}=\frac{19}{95}=0.2$

$NaCl=\frac{0.5}{51.75}\times1000$

$MgCl_{2}=\frac{0.2}{51.75}\times1000$

$(\Delta T_{b})=\{(i_{1}\,m_{1})+(i_{2}\,m_{2})\}k_{b}$

ΔT_{b}= Elevation in boiling point

i =Van't Hoff factor

m = molality

k_{b} = molal elevation constant

$\Delta T_{b=}\left(\frac{2\times0.5\times1000}{51.75}\times\frac{3\times0.2\times1000}{51.75}\right)\times0.52$

$=16.077$

Boiling point of sea water

$=116.077^{\circ}C$

$\approx116^{\circ}C$ (Nearest integer)

12. **(23)**

To calculate the vapour pressure of the 30% (w/v) aqueous solution of glucose, we can use Raoult's law, which states that the vapour pressure of a component in an ideal solution is directly proportional to its mole fraction in the solution.

Weight of solution $= 100 \times 1.2 = 120 \text{ gm}$

Weight of water $= 120 - 30 = 90 \text{ gm}$

Now using formula

$\frac{\mathrm{P_0 - P}}{\mathrm{P}} = \frac{\text{moles of glucose}}{\text{moles of water}}$

$\frac{24 - \mathrm{P}}{\mathrm{P}} = \frac{\frac{30}{180}}{\frac{90}{18}} = \frac{3}{90}$

$24 \times 90 - \mathrm{P} \times 90 = 3\,\mathrm{P}$

$\Rightarrow \mathrm{P} = 23.22$