LIQUID SOLUTION

1. When 9.45 g of $ClCH_2COOH$ is added to 500 mL of water, its freezing point drops by 0.5°C. The dissociation constant of $ClCH_2COOH$ is $x \times 10^{-3}$. The value of x is ________. (Rounded off to the nearest integer)

$\left[K_{f(H_2O)} = 1.86\,K\,kg\,mol^{-1}\right]$

2. C_6H_6 freezes at 5.5°C. The temperature at which a solution 10 g of C_4H_{10} in 200 g of C_6H_6 freeze is _______ °C. (The molal freezing point depression constant of C_6H_6 is 5.12°C/m.)

3. 1 molal aqueous solution of an electrolyte A_2B_3 is 60% ionised. The boiling point of the solution at 1 atm is _______ K. (Rounded-off to the nearest integer)

[Given K_b for (H_2O) = 0.52 K kg mol^{-1}]

4. If a compound AB dissociates to the extent of 75% in an aqueous solution, the molality of the solution which shows a 2.5 K rise in the boiling point of the solution is ______ molal. (Rounded-off to the nearest integer)

[K_b = 0.52K kg mol^{-1}]

5. 224 mL of $SO_{2(g)}$ at 298 K and 1 atm is passed through 100 mL of 0.1 M NaOH solution. The non-volatile solute produced is dissolved in 36 g of water. The lowering of vapour pressure of solution (assuming the solution is dilute) $\left(P_{(H_2O)} = 24 \text{ mm of Hg}\right)$ is $x \times 10^{-2}$ mm of Hg, the value of x is ______. (Integer answer)

6. When 12.2 g of benzoic acid is dissolved in 100 g of water, the freezing point of solution was found to be –0.93°C ($K_f(H_2O)$ = 1.86K kg mol^{-1}). The number (n) of benzoic acid molecules associated (assuming 100% association) is ____.

7. AB_2 is 10% dissociated in water to A^{2+} and B^-. The boiling point of a 10.0 molal aqueous solution of AB_2 is _______ °C. (Round off to the Nearest Integer).

[Given : Molal elevation constant of water K_b = 0.5 K kg mol^{-1} boiling point of pure water = 100°C]

8. At 363 K, the vapour pressure of A is 21 kPa and that of B is 18 kPa. One mole of A and 2 moles of B are mixed. Assuming that this solution is ideal, the vapour pressure of the mixture is ________ kPa. (Round of to the Nearest Integer).

9. The oxygen dissolved in water exerts a partial pressure of 20 kPa in the vapour above water. The molar solubility of oxygen in water is _______ $\times 10^{-5}$ mol dm^{-3}.

(Round off to the Nearest Integer).

[Given : Henry's law constant

= $K_H = 8.0 \times 10^4$ kPa for O_2.

Density of water with dissolved oxygen = 1.0 kg dm^{-3}]

10. A 1 molal $K_4Fe(CN)_6$ solution has a degree of dissociation of 0.4. Its boiling point is equal to that of another solution which contains 18.1 weight percent of a non electrolytic solute A. The molar mass of A is_____ u. (Round off to the Nearest Integer).

[Density of water = 1.0 g cm^{-3}]

11. 2 molal solution of a weak acid HA has a freezing point of 3.885°C. The degree of dissociation of this acid is _____ $\times 10^{-3}$. (Round off to the Nearest Integer).

[Given : Molal depression constant of water = 1.85 K kg mol^{-1} Freezing point of pure water = 0°C]

12. A solute a dimerizes in water. The boiling point of a 2 molar solution of A is 100.52°C. The percentage association of A is.____.
(Round off to the Nearest integer)
[Use : K_b for water = 0.52 K kg mol^{-1}
Boiling point of water = 100°C]

13. Which one of the following 0.06 M aqueous solutions has lowest freezing point ?
(1) $Al_2(SO_4)_3$ (2) $C_6H_{12}O_6$
(3) KI (4) K_2SO_4

14. CO_2 gas is bubbled through water during a soft drink manufacturing process at 298 K. If CO_2 exerts a partial pressure of 0.835 bar then x m mol of CO_2 would dissolve in 0.9 L of water. The value of x is _______ .
(Nearest integer)
(Henry's law constant for CO_2 at 298 K is 1.67×10^3 bar)

15. When 3.00 g of a substance 'X' is dissolved in 100 g of CCl_4, it raises the boiling point by 0.60 K. The molar mass of the substance 'X' is ________ g mol^{-1}. (Nearest integer).
[Given K_b for CCl_4 is 5.0 K kg mol^{-1}]

16. 1.46 g of a biopolymer dissolved in a 100 mL water at 300 K exerted an osmotic pressure of 2.42×10^{-3} bar.
The molar mass of the biopolymer is _____ $\times 10^4$ g mol^{-1}.
(Round off to the Nearest Integer)
[Use : R = 0.083 L bar mol^{-1} K^{-1}]

17. When 400 mL of 0.2M H_2SO_4 solution is mixed with 600 mL of 0.1 M NaOH solution, the increase in temperature of the final solution is _____ $\times 10^{-2}$ K. (Round off to the nearest integer).
[Use : $H^+ (aq) + OH^-(aq) \rightarrow H_2O$:
$\Delta_\gamma H = -57.1$ kJ mol^{-1}]
Specific heat of H_2O = 4.18 J K^{-1} g^{-1}
density of H_2O = 1.0 g cm^{-3}
Assume no change in volume of solution on mixing.

18. Of the following four aqueous solutions, total number of those solutions whose freezing point is lower than that of 0.10 M C_2H_5OH is ________ (Integer answer)
(i) 0.10 M $Ba_3(PO_4)_2$
(ii) 0.10 M Na_2SO_4
(iii) 0.10 M KCl
(iv) 0.10 M Li_3PO_4

19. 83 g of ethylene glycol dissolved in 625 g of water. The freezing point of the solution is _______K. (Nearest integer)
[Use : Molal Freezing point depression constant of water = 1.86 K kg mol^{-1}]
Freezing Point of water = 273 K
Atomic masses : C : 12.0 u, O : 16.0 u, H : 1.0 u]

20. 1 kg of 0.75 molal aqueous solution of sucrose can be cooled up to –4°C before freezing. The amount of ice (in g) that will be separated out is _______ . (Nearest integer)
[Given : $K_f(H_2O)$ = 1.86 K kg mol^{-1}]

21. 40 g of glucose (Molar mass = 180) is mixed with 200 mL of water. The freezing point of solution is _____ K. (Nearest integer)
[Given : K_f = 1.86 K kg mol^{-1} ; Density of water = 1.00 g cm^{-3}; Freezing point of water = 273.15 K]

22. Which one of the following 0.10 M aqueous solutions will exhibit the largest freezing point depression ?
(1) hydrazine (2) glucose
(3) glycine (4) $KHSO_4$

23. 1.22 g of an organic acid is separately dissolved in 100 g of benzene (K_b = 2.6 K kg mol^{-1}) and 100 g of acetone (K_b = 1.7 K kg mol^{-1}). The acid is known to dimerize in benzene but remain as a monomer in acetone. The boiling point of the solution in acetone increases by 0.17°C. The increase in boiling point of solution in benzene in °C is $x \times 10^{-2}$. The value of x is _______.(Nearest integer)
[Atomic mass : C = 12.0, H = 1.0, O= 16.0]

SOLUTION

1. Official Ans. by NTA (36)

Sol. $ClCH_2COOH \rightleftharpoons ClCH_2COO^{\ominus} + H^+$

$i = 1 + (2-1)\alpha$

$i = 1 + \alpha$

$\Delta T_f = ik_f m$

$$0.5 = (1+\alpha)(1.86)\left(\frac{\left(\frac{9.45}{94.5}\right)}{\left(\frac{500}{1000}\right)}\right)$$

$$\frac{5}{3.72} = 1+\alpha \quad \Rightarrow \alpha = \frac{1.28}{3.72}$$

$$\alpha = \frac{32}{93}$$

$ClCH_2COOH \rightleftharpoons ClCH_2\,COO^{\ominus} + H^+$

$C-C\alpha \qquad C\alpha \qquad C\alpha$

$$K_a = \frac{(C\alpha)^2}{C-C\alpha} = \frac{C\alpha^2}{1-\alpha} \qquad C = \frac{0.1}{500/1000} = 0.2$$

$$K_a = \frac{0.2(32/93)^2}{(1-32/93)} = \frac{0.2\times(32)^2}{93\times 61}$$

$= 0.036$

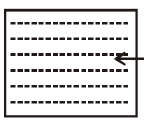
$K_a = 36 \times 10^{-3}$

2. Official Ans. by NTA (1)

Sol. Pure Solvent : $C_6H_6\,(\ell)$

Given : $T_f^{\circ} = 5.5°C$

$K_f = 5.12°C/m$



10g : Solute is non dissociative

200 g C_6H_6

$\because \Delta T_f = k_f \times m$

$$\Rightarrow \left(T_f^0 - T_f^{'}\right) = 5.12 \times \frac{\left(\frac{10}{58}\right)}{\left(\frac{200}{1000}\right)}\frac{\text{mol}}{\text{kg}}$$

$$\Rightarrow 5.5 - T_f^{'} = \frac{5.12\times 5\times 10}{58}$$

$$\Rightarrow \boxed{T_f^{'} = 1.086°C \simeq 1°C}$$

3. Official Ans. by NTA (375)

Sol. $\Delta T_b = iK_b m$

$= (1 + 4\alpha) \times 0.52 \times 1$

$= 3.4 \times 0.52 \times 1 = 1.768$

$T_b = 1.768 + 373.15 = 374.918$ K

$= 375$K

Hence answer is (375)

4. Official Ans. by NTA (3)

Sol. $\alpha = 0.75$, $n = 2$

$i = 1 - \alpha + n\alpha = 1 - 0.75 + 2 \times 0.75 = 1.75$

$\Delta T_b = ik_b m$

or, $2.5 = 1.75 \times 0.52 \times m$

or, $m = \dfrac{2.5}{1.75\times 0.52} = 2.74$

$\therefore$ nearest integer answer will be 3

5. Official Ans. by NTA (24)

Sol.(1) $SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$

$\dfrac{224}{0.0821\times 298}$ 10mmol (L.R.)   5mmol (i = 3)

$= 9.2$ m mol

$P^s = P^0 . X_{solvent}$

$$= 24 \times \frac{2}{(2+15\times 10^{-3})}$$

$= 23.82$

$\Delta P = 0.18$ torr $= 18 \times 10^{-2}$ torr.

Sol.(2) $SO_2 + NaOH \rightarrow NaHSO_3$

9.2	10	–
–	0.8	9.2

$\Delta P = P^0 . X_{solute}$

$$= 24 \times \frac{(1.6+18.4)}{2020}$$

$= 0.2376 = 23.76 \times 10^{-2}$

6. Official Ans by NTA (2)

Sol. $\Delta T_f = i \times k_f \times m$

$$0-(-0.93) = i \times 1.86 \times \frac{12.2}{122 \times 100} \times 1000$$

$$i = \frac{0.93}{1.86} = 0.5$$

$$i = 1 + \left(\frac{1}{n} - 1\right)\alpha \qquad \Rightarrow \frac{1}{2} = 1 + \left(\frac{1}{n} - 1\right) \times 1$$

$n = 2$

7. Official Ans. by NTA (106)

Sol. $AB_2 \rightarrow A^{2+} + 2B^-$

t = 0 a 0 0

t = t $a - a\alpha$ $a\alpha$ $2a\alpha$

$n_T = a - a\alpha + a\alpha + 2a\alpha$

$= a(1 + 2\alpha)$

so $i = 1 + 2\alpha$

Now $\Delta T_b = i \times m \times K_b$

$\Delta T_b = (1 + 2\alpha) \times m \times K_b$

$\alpha = 0.1$ $m = 10$ $K_b = 0.5$

$\Delta T_b = 1.2 \times 10 \times 0.5$

$= 6$

So boiling point = 106

8. Official Ans. by NTA (19)

Sol. Given $P_A^0 = 21 kPa$ $\Rightarrow P_B^0 = 18 kPa$

$\rightarrow$ An Ideal solution is prepared by mixing 1 mol A and 2 mol B.

$\rightarrow X_A = \frac{1}{3}$ and $X_B = \frac{2}{3}$

$\rightarrow$ Acc to Raoult's low

$$P_T = X_A P_A^0 + X_B P_B^0$$

$$\Rightarrow \quad P_T = \left(\frac{1}{3} \times 21\right) + \left(\frac{2}{3} \times 18\right)$$

$$\Rightarrow \quad P_T = 7 + 12 = 19 \text{ KPa}$$

9. Official Ans. by NTA (25)

Official Ans. by ALLEN (1389)

Sol. $P = K_H \cdot x$

$$\text{or, } 20 \times 10^3 = (8 \times 10^4 \times 10^3) \times \frac{n_{O_2}}{n_{O_2} + n_{water}}$$

$$\text{or, } \frac{1}{4000} = \frac{n_{O_2}}{n_{O_2} + n_{water}} = \frac{n_{O_2}}{n_{water}}$$

Means 1 mole water (= 18 gm = 18 ml) dissolves

$\frac{1}{4000}$ moles O_2. Hence, molar solubility

$$= \frac{\left(\frac{1}{4000}\right)}{18} \times 1000 = \frac{1}{72} \text{ mol dm}^{-3}$$

$= 1388.89 \times 10^{-5}$ mol dm^{-3} ≈ 1389 mol dm^{-3}

10. Official Ans. by NTA (85)

Sol. $K_4Fe(CN)_6 \rightleftharpoons 4K^+ + Fe(CN)_6^{4-}$

Initial conc. 1 m 0 0

Final conc. (1 – 0.4)m 4 × 0.4 0.4m

= 0.6 m = 1.6 m

Effective molality = 0.6 + 1.6 + 0.4 = 2.6m

For same boiling point, the molality of another solution should also be 2.6 m.

Now, 18.1 weight percent solution means 18.1 gm solute is present in 100 gm solution and hence, (100 – 18.1 =) 81.9 gm water.

$$\text{Now, } 2.6 = \frac{18.1/M}{81.9/1000}$$

$\therefore$ Molar mass of solute, M = 85

11. Official Ans. by NTA (50)

Sol. $\Delta T_f = (1 + \alpha) K_f.m$

$\alpha = 0.05 = 50 \times 10^{-3}$

12. Official Ans. by NTA (100)

Sol. $\Delta T_b = T_b - T_b^0$

100.52 – 100

= 0.52ºC

$i = \left(1 - \frac{\alpha}{2}\right)$

$\because \Delta T_b = i\,K_b \times m$

$0.52 = \left(1 - \frac{\alpha}{2}\right) \times 0.52 \times 2$

$\alpha = 1$

So, percentage association = 100%.

13. Official Ans. by NTA (1)

Sol. $T_f - T_f' = i\,K_f.m$

For minimum T_f'

'i' should be maximum.

$Al_2(SO_4)_3$	i = 5
$C_6H_{12}O_6$	i = 1
KI	i = 2
K_2SO_4	i = 3

14. Official Ans. by NTA (25)

Sol. From Henry's law

$P_{gas} = K_H.X_{gas}$

$0.835 = 1.67 \times 10^3 \times \dfrac{n(CO_2)}{\dfrac{0.9 \times 1000}{18}}$

$n(CO_2) = 0.025$

Millimoles of $CO_2 = 0.025 \times 1000 = 25$

15. Official Ans. by NTA (250)

Sol. $\Delta T_b = K_b \times$ molality

$0.60 = 5 \times \left(\dfrac{3/M}{100/100}\right)$

M = 250

16. Official Ans. by NTA (15)

Sol. $\pi = CRT$; π = osmotic pressure

C = molarity

T = Temperature of solution

let the molar mass be M gm / mol

2.42×10^{-3} bar

$= \dfrac{\left(\dfrac{1.46g}{M gm/mol}\right)}{0.1\ell} \times \left(\dfrac{0.083\ell - bar}{mol - K}\right) \times (300K)$

$\Rightarrow M = 15.02 \times 10^4$ g/mol

17. Official Ans. by NTA (2)
ALLEN Ans. (82)

Sol. $n_{H^+} = \dfrac{400 \times 0.2}{1000} \times 2 = 0.16$

$n_{OH^-} = \dfrac{600 \times 0.1}{1000} = 0.06$ (L.R)

Now, heat liberated from reaction

= heat gained by solutions

or, $0.06 \times 57.1 \times 10^3$

$= (1000 \times 1.0) \times 4.18 \times \Delta T$

$\therefore \Delta T = 0.8196$ K

$= 81.96 \times 10^{-2}$ K $\approx 82 \times 10^{-2}$ K

18. Official Ans. by NTA (4)

Sol. As 0.1 M C_2H_5OH is non-dissociative and rest all salt given are electrolyte so in each case effective molarity > 0.1 so each will have lower freezing point.

19. Official Ans. by NTA (269)

Sol. $k_f = 1.86$ k. kg/mol

$T_f^o = 273$ k

solvent : H_2O(625 g)

Solute : 83 g $\left(\begin{array}{ll} CH_2 - CH_2 \\ | \quad\quad\ \ | \\ OH \quad\ OH \end{array}\right) \Rightarrow$ Non dissociative solute

$\Rightarrow \Delta T_f = k_f \times m$

$\Rightarrow \left(T_f^o - T_f^1\right) = 1.86 \times \dfrac{83/62}{624/1000}$

$\Rightarrow 273 - T_f^1 = \dfrac{1.86 \times 83 \times 1000}{62 \times 625} = \dfrac{154380}{38750}$

$\Rightarrow 273 - T_f^1 = 4$

$\Rightarrow \boxed{T_f^1 = 259\text{ K}}$

20. Official Ans. by NTA (518)

Sol. Let mass of water initially present = x gm

$\Rightarrow$ Mass of sucrose = (1000 - x) gm

$\Rightarrow$ moles of sucrose = $\left(\dfrac{1000-x}{342}\right)$

$$\Rightarrow 0.75 = \frac{\left(\dfrac{1000-x}{342}\right)}{\left(\dfrac{x}{1000}\right)} \Rightarrow \frac{x}{1000} = \frac{1000-x}{342\times 0.75}$$

$\Rightarrow 256.5\ x = 10^6 - 1000x$

$\Rightarrow x = 795.86$ gm

$\Rightarrow$ moles of sucrose = 0.5969

New mass of H_2O = a kg

$$\Rightarrow\ 4 = \frac{0.5969}{a}\times 1.86 \ \Rightarrow a = 0.2775 \text{ kg}$$

$\Rightarrow$ ice separated = (795.86 – 277.5) = 518.3 gm

21. Official Ans. by NTA (271)

Sol. $$\text{molality} = \frac{\left(\dfrac{40}{180}\right)\text{mol}}{0.2\text{Kg}} = \left(\frac{10}{9}\right)\text{molal}$$

$$\Rightarrow \Delta T_f = T_f - T_f' = 1.86\times\frac{10}{9}$$

$$\Rightarrow T_f' = 273.15 - 1.86\times\frac{10}{9}$$

= 271.08 K

$\simeq$ 271 K (nearest-integer)

22. Official Ans. by NTA (4)

Sol. $\because$ Van't Hoff factor is highest for $KHSO_4$

$\therefore$ colligative property (ΔT_f) will be highest for $KHSO_4$

23. Official Ans. by NTA (13)

Sol. With benzene as solvent

$\Delta T_b = i\ K_b\ m$

$$\Delta T_b = \frac{1}{2}\times 2.6\times\frac{1.22/M_w}{100/1000} \qquad \ldots(1)$$

With Acetone as solvent

$\Delta T_b = i\ K_b\ m$

$$0.17 = 1\times 1.7\times\frac{1.22/M_w}{100/1000} \qquad \ldots(2)$$

(1) / (2)

$$\frac{\Delta T_b}{0.17} = \frac{\dfrac{1}{2}\times 2.6 + \dfrac{1.22/M_w}{100/1000}}{1\times 1.7\times\dfrac{1.22/M_w}{100/1000}}$$

$$\Delta T_b = \frac{0.26}{2}$$

$\Delta T_b = 13\times 10^{-2}$

$\Rightarrow x = 13$