Solution

SOLUTIONS AND COLLIGATIVE PROPERTIES

Class 12 - Chemistry

1. $\pi_1 = \pi_2$
   $\frac{w_{\text{urea}}}{M_{\text{urea}}} = \frac{w_A}{M_A}$
   $\frac{4}{60} = \frac{5\cdot2}{M_A}$
   $M_A = 5.2 \times 15 = 78.0$ g mol^{-1}
2. Moles of NaOH = $\frac{5\text{g}}{40\text{gmol}^{-1}}$ = 0.125 mol
   Volume of the solution in litres = $\frac{450\ mL}{1000\ mL\ L^{-1}}$
   Using equation of the molarity
   Molarity = $\frac{0.125\text{mol}\times1000\text{mLL}^{-1}}{450\text{mL}}$ = m
   = 0.278 mol L^{-1}
   = 0.278 mol dm^{-3}
3. $\frac{P_A^0 - P_A}{P_A^0} = \frac{W_B \times M_A}{W_A \times M_B}$
   W_B = mass of urea = 10g
   M_A = molar mass of water = 18g
   W_A = mass of water = 90g
   M_B = molar mass of urea = 60g/mol
   P_A^0 = vapour pressure of water = 55.3mmHg
   P_A = vapour pressure of solution = ?
   $55.3 - P_A = \frac{10\times18\times55.3}{90\times60}$
   P_A = 53.46mm Hg
4. $\pi_{\text{Glucose}} = \pi_{\text{Unknown}}$
   $C_G = C_U$
   $\frac{W_G}{M_G} = \frac{W_U}{M_U}$
   $\frac{6}{180} = \frac{2\cdot5}{M_U}$
   $M_U = \frac{2.5\times180}{6}$ g mol^{-1}
   = 75 g mol^{-1}
5. The elevation (ΔT_b) in the boiling point = 354.11 K - 353.23 K = 0.88 K
   Substituting these values in the following equation we get
   $M_2 = \frac{2.53\text{Kkgmol}^{-1}\times1.8\text{g}\times1000\text{gkg}^{-1}}{0.88\text{K}\times90\text{g}}$ = 58 g mol^{-1}
   Therefore, the molar mass of the solute, M_2 = 58 g mol^{-1}.
6. T = 37^0C = 310 k
   $\pi = CRT = \frac{n}{v}RT$
   $= 0.25 \times 0.083 \times 310$
   = 6.43 bar.
7. 50 mL of NaOH solution contains = 2g of NaOH
   $\therefore$ 1000 mL of NaOH solution will contain $= \frac{2}{50} \times 1000$
   = 40 g of NaOH
   Molecular mass of NaOH = 23 + 16 + 1 = 40
   Number of moles of NaOH $= \frac{\text{Mass}}{\text{molecular mass}}$
   $\therefore$ Molarity of the solution = 1 M

8. $\pi_1 = \pi_2$

$\frac{W_1}{M_1} = \frac{W_2}{M_2}$

$\frac{3}{180} = \frac{2\cdot 5}{M_2}$

$M_2 = \frac{2\cdot 5 \times 180}{3} = 150\ g\ mol^{-1}$

9. $p_{Total} = p_X^\circ \chi_X + p_Y^\circ \chi_B$

$\chi_X = \chi_B = 0.5$

P_{Total} = (120 $\times$ 0.5) + (160 $\times$ 0.5)

= 140 mm Hg

10. $\Delta T_f = K_f m$

$= K_f \times \frac{w_2 \times 1000}{M_2 \times w_1}$

$= \frac{1.86 \times 60 \times 1000}{180 \times 250}$

= 2.48 K

$\Delta T_f = T_f^o - T_f$

2.48 = 273.15 - T_f

T_f = 273.15 - 2.48 = 270.67 K

11. Number of moles of A dissolved $= \frac{20}{140}$ = 0.143

Number of moles of $B = \frac{80}{18} = 4.44$

Mole fraction of A $(\chi_A) = \frac{0.143}{0.143+4.44} = 0.031$

Mole fraction of B $(\chi_B) = \frac{4.44}{0.143+4.44} = 0.969$

Total pressure = 160 mm

$= p_A \times \chi_A + p_B \times \chi_B$

160 = $p_A \times 0.031 + 150 \times 0.969$

$\therefore p_A$ = 472.58 mm

12. Given, mass of ethanoic acid = 2.5g

Molar mass of $C_2H_4O_2$: 12 $\times$ 2+1 $\times$ 4+16 $\times$ 2 = 60 g mol^{-1}

Moles of $C_2H_4O_2$ = $\frac{2.5g}{60 g mol^{-1}}$ = 0.0417 mol

Mass of benzene in kg = 75 g / 1000 g kg^{-1} = 75 $\times$ 10^{-3} kg

Molality of $C_2H_4O_2$ = $\frac{\text{Moles of } C_2H_4O_2}{\text{kg of benzene}} = \frac{0.0417 mol \times 1000 g kg^{-1}}{75 g}$

= 0.556 mol kg^{-1}

13. Mass of Glauber's salt = 8.0575 $\times$ 10^{-2} kg

= 8.0575 $\times$ 10^{-2} $\times$ 10^3 g

= 80.575 g

Molecular mass of Glauber's salt ($Na_2SO_4 \cdot 10H_2O$)

= 322

Number of moles of Glauber's salt

$= \frac{80.575}{322} = 0.25$

Mass of solution per dm^3 = 1077.2 kg m^{-3}

= 1077.2 $\times$ 10^3 gm^{-3}

= 1077.2 $\times$ 10^3 $\times$ 10^{-3} g dm^{-3}

= 1077.2 g

Mass of water = 1077.2 - 80.575 = 996.625 g

Molarity $= \frac{0.25}{1 dm^3} = 0.25$

Mole fraction $= \frac{\text{Molarity}}{\text{Molarity} + \frac{\text{mass of water}}{\text{molecular mass of water}}}$

$= \frac{0.25}{0.25 + \frac{996.625}{18}} = 4.49 \times 10^{-3}$

14. The various quantities known to us are as follows osmotic pressure of solution $\Pi = 2.57 \times 10^{-3}$ bar.

$V = 200\ cm^3 = 0.200$ litre

T = 300 K

$R = 0.083\ L\ bar\ mol^{-1}\ K^{-1}$

Substituting these values in equation (2.42) we get

$M_2 = \frac{1.26 g \times 0.083 L bar K^{-1} mol^{-1} \times 300 K}{2.57 \times 10^{-3} bar \times 0.200 L} = 61.022\ g\ mol^{-1}$

15. i. Molarity (M) $\times$ Molecular mass of solute

= Normality (N) $\times$ Equivalent mass of solute

ii. Solubility of gas (C_1) = 0.08 g /litre

$P_1 = 760$ mm

$P_2 = 1520$ mm

Solubility of gas (C_2) at pressure P_2 = ?

By Henry's law,

$\frac{C_1}{C_2} = \frac{P_1}{P_2}$

$C_2 = \frac{C_1 \times P_2}{P_1} = \frac{0.08 \times 1520}{760} = 0.16$ g/ litre

$\therefore$ Solubility of nitrogen in 4 litres of water

= 0.16 $\times$ 4 = 0.64 g

16. $\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$

$\frac{(32 - 31 \cdot 84)}{32} = \frac{5\ g}{M_2} \times \frac{18}{200\ g}$

M_2 = 90 g/ mol

(Deduct half mark for no or incorrect unit)

17. a. 0.5 (in case of dimer)

b. $M = \frac{wRT}{\Pi V}$

$= \frac{3.5 \times 0.0821 \times 310}{0.035 \times 0.05}$

$= 50902\ g\ mol^{-1}$

18. The various quantities known to us are as follows:

$p_1^0 = 0.850$ bar; p = 0.845 bar; $M_1 = 78 g\ mol^{-1}$; $w_2 = 0.5$ g; $w_1 = 39$ g

Substituting these values in equation of relative lowering of vapour pressure, we get

$\frac{0.850\ bar - 0.845\ bar}{0.850\ bar} = \frac{0.5 g \times 78 g mol^{-1}}{M_2 \times 39 g}$

Therefore, $M_2 = 170\ g\ mol^{-1}$

19. $\pi = i \frac{n_B}{V} RT$

$6.5 = i \times \frac{W_B}{M_B} \times \frac{1000}{V} \times 0.0821$

$6.5 = i \times \frac{6 \cdot 1}{122} \times \frac{1000}{100 L} \times 0.0821 \times 300$ K

$i = \frac{6 \cdot 5 \times 122}{6 \cdot 1 \times 0 \cdot 0821 \times 300 \times 10} = 0.528$

$\alpha = \frac{1 - i}{1 - \frac{1}{n}} = \frac{1 - 0.528}{1 - \frac{1}{2}} =$ percentage association= 0.944 or 94.4%

20. π = CRT

4.98 = (30/180/1) $\times$ RT

4.98= 0.166 RT …(i)

1.52 = CRT …(ii)

Divide eq. (ii) by (i)

0.305 = C/0.166

$C = 0.0506\ mol\ l^{-1}$

Hence, its concentration would be $0.0506\ mol\ l^{-1}$

21. The given quantities are: w_2 = 2g; (Molar depression constant of benzene) $K_f = 4.9\ K\ kg\ mol^{-1}$; w_1 = 25 g

Depression in freezing point equal to

ΔT_f = 1.62 K

Substituting these values in equation (2.36) we get:

$M_1 = \frac{4.9 \mathrm{K kg mol^{-1}} \times 2\mathrm{g} \times 1000 \mathrm{g kg^{-1}}}{25\mathrm{g} \times 1.62\mathrm{K}}$ = 241.98 g mol^{-1}

Thus, the experimental molar mass of benzoic acid in benzene is

= 241.98 g mol^{-1}

Now consider the following equilibrium for the acid:

$2C_6H_5COOH\} \rightleftharpoons (C_6H_5\{COOH)_2$

If x represents the degree of association of the solute then we would have (1 - x) mol of benzoic acid left in unassociated form and correspondingly $\frac{x}{2}$ as associated moles of benzoic acid at equilibrium. Therefore, the total number of moles of particles at equilibrium is:

1 - x + $\frac{x}{2} = 1 - \frac{x}{2}$

Thus, the total number of moles of particles at equilibrium equals van't Hoff factor i.

But i = $\frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$

= $\frac{122 \mathrm{g mol^{-1}}}{241.98 \mathrm{g mol^{-1}}}$

or $\frac{x}{2} = 1 - \frac{122}{241.98}$ = 1 - 0.504 = 0.496

or x = 2 $\times$ 0.496 = 0.992

Therefore, degree of association of benzoic acid in benzene is 99.2 %

22. a. Given,

w_B $(glucose)$ = 0.520 g

w_A (H_2O) = 80.2 g

K_f $(H_2O) = 1.86 Km^{-1}$

$M_2(glucose) = 180\ g\ mol^{-1}$

$\Delta T_f = \frac{K_f \times w_B \times 1000}{M_B \times w_A}$

$\Delta T_f = \frac{1.86 Km^{-1} \times 0.520 g \times 1000}{180 g\ mol^{-1} \times 80.2 g}$

$\Delta T_f = 0.0669\ K\ or\ 0.0669^0 C$

$T_f^0 - T_f = 0.0669^0 C$

$0 - T_f = 0.0669^0 C$

$T_f = 0.0669^0 C$

b. Given, w_A = 500 g

Boiling point of solution (T_b)= 100.42^0C

$K_b(H_2O) = 0.512\ K\ kg\ mol^{-1} M_2(C_3H_8O_3)$

$= (3 \times 2) + (8 \times 1) + (3 \times 16)$

$= 92\ g\ mol^{-1}$

$\Delta T_b = T_b - T_b^0$

$= 373.42 - 373\ K\ = 0.420\ K$

As we know

$\Delta T_b = \frac{k_b \times w_B \times 1000}{M_B \times\ w_A}$

$\Rightarrow\ w_B = \frac{\Delta T_b \times M_B \times w_A}{K_b \times 1000}$

$w_B = \frac{0.42\ K\ \times 92\ g\ mol^{-1} \times 500 g}{0.512\ K\ kg\ mol^{-} \times 100 kg^{-1}} = 377.3 g$

23. i. 6.5 g of $C_9H_8O_4$ is dissolved in 450 g of CH_3CN

Then, total mass of the solution = (6.5 + 450) g

= 456.5 g

Therefore, mass percentage of $C_9H_8O_4$

$= \frac{6.5}{456.5} \times 100\%$

= 1.424 %

ii. Density of HCI = 1.19 g cm^{-3}

Mass of 1000 cm^3 of commercial HCl

= 1000 $\times$ 1.19 = 1190 g

Mass of HCI in 1190 g (1000 cm^2) of the solution

$= \frac{1190\times38}{100} = 452.2$ g

Molar mass of HCI = 1 + 35.5 = 36.5 g

452.2 g of HCl $= \frac{452.2}{36.5}$ moles of HCl

= 12.4 moles of HCI

$\therefore$ 1.0 L of the commercial HCI solution contains 12. 4 moles of HCl.

Molarity of the commercial HCI solution

= 12.4 M