

Class 12 Chemistry
NCERT Solutions for Chapter 2 – Solutions
Intext Questions

2.1. Calculate the mass percentage of benzene (C₆H₆) and carbon tetrachloride (CCl₄) if 22 g of benzene is dissolved in 122 g of carbon tetrachloride.

Ans: Mass of solution = Mass of C₆H₆ + Mass of CCl₄
= 22 g + 122 g = 144 g
Mass % of benzene = $\frac{22}{144} \times 100 = 15.28\%$
Mass % of CCl₄ = $\frac{122}{144} \times 100 = 84.72\%$

2.2. Calculate the mole fraction of benzene in solution containing 30% by mass in carbon tetrachloride.

Ans: 30% by mass of C₆H₆ in CCl₄ => 30 g C₆H₆ in 100 g solution

∴ no. of moles of C₆H₆, ($n_{C_6H_6}$) = $\frac{30}{78} = 0.385$

(molar mass of C₆H₆ = 78g)

no. of moles of

$$CCl_4 (n_{CCl_4}) = \frac{70}{154} = 0.455$$

$$\begin{aligned} x_{C_6H_6} &= \frac{n_{C_6H_6}}{n_{C_6H_6} + n_{CCl_4}} \\ &= \frac{0.385}{0.385 + 0.455} = \frac{0.385}{0.84} = 0.458 \\ x_{CCl_4} &= 1 - 0.458 = 0.542 \end{aligned}$$

2.3. Calculate the molarity of each of the following solutions

(a) 30 g of Co(NO₃)₂·6H₂O in 4.3 L of solution

(b) 30 mL of 0.5 M H₂SO₄ diluted to 500 mL.

Ans:

$$(a) \quad \text{Molarity of solution} = \frac{\text{Mass of solute} / \text{Molar mass of solute}}{\text{Volume of solution in litres}}$$

Mass of solute, $\text{Co}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O} = 30 \text{ g}$.
Molar mass of solute, $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} = 59 + 2 \times 14 + 6 \times 16 + 6 \times 18 = 291 \text{ g mol}^{-1}$.
Volume of solution = 4.3 L

$$\text{Molarity (M)} = \frac{(30\text{g}) / (291\text{g mol}^{-1})}{(4.3\text{L})} = 0.024 \text{ mol L}^{-1} = \mathbf{0.024 \text{ M}}$$

(b) Volume of undiluted H_2SO_4 solution (V_1) = 30 mL
Molarity of undiluted H_2SO_4 solution (M_1) = 0.5 M
Volume of diluted H_2SO_4 solution (V_2) = 500 mL

Molarity of diluted H_2SO_4 (M_2) can be calculated as :

$$M_1 V_1 = M_2 V_2$$

or
$$M_2 = \frac{M_1 V_1}{V_2} = \frac{(30\text{mL}) \times (0.5\text{M})}{(500\text{mL})} = \mathbf{0.03 \text{ M}}$$

2.4. Calculate the mass of urea (NH_2CONH_2) required in making 2.5 kg of 0.25 molal aqueous solution.

Ans: 0.25 Molal aqueous solution to urea means that moles of urea = 0.25 mole

$$\text{mass of solvent } (\text{NH}_2\text{CONH}_2) = 60 \text{ g mol}^{-1}$$

$$\therefore 0.25 \text{ mole of urea} = 0.25 \times 60 = 15\text{g}$$

$$\text{Mass of solution} = 1000 + 15 = 1015\text{g} = 1.015 \text{ kg}$$

1.015 kg of urea solution contains 15g of urea

$$\therefore 2.5 \text{ kg of solution contains urea} = 15 / 1.015 \times 2.5 = 37 \text{ g}$$

2.5. Calculate

(a) molality

(b) molarity and

(c) mole fraction of KI if the density of 20% (mass/mass) aqueous KI solution is 1.202 g mL^{-1} .

Ans:

Step I. Calculation of molality of solution

Weight of KI in 100 g of the solution = 20 g

Weight of water in the solution = $100 - 20 = 80 \text{ g} = 0.08 \text{ kg}$

Molar mass of KI = $39 + 127 = 166 \text{ g mol}^{-1}$.

$$\begin{aligned} \text{Molality of solution } (m) &= \frac{\text{No of gram moles of KI}}{\text{Mass of water in kg}} = \frac{(20\text{g}) / (166\text{g mol}^{-1})}{(0.08\text{kg})} \\ &= 1.506 \text{ mol kg}^{-1} = \mathbf{1.506 \text{ m.}} \end{aligned}$$

Step II. Calculation of molarity of solution

Weight of solution = 100 g ; Density of solution = 1.202 g mL⁻¹.

$$\text{Volume of solution} = \frac{\text{Weight of solution}}{\text{Density}} = \frac{(100 \text{ g})}{(1.202 \text{ g mL}^{-1})} = 83.19 \text{ mL}$$

$$\begin{aligned} \text{Molarity of solution (M)} &= \frac{\text{No. of gram moles of KI}}{\text{Volume of solution in litres}} = \frac{(20 \text{ g}) / (166 \text{ g mol}^{-1})}{(0.083 \text{ L})} \\ &= 1.45 \text{ mol L}^{-1} = \mathbf{1.45 \text{ M}} \end{aligned}$$

Step III. Calculation of mole fraction of KI

$$n_{\text{KI}} = \frac{\text{Mass of KI}}{\text{Molar mass of KI}} = \frac{(20 \text{ g})}{(166 \text{ g mol}^{-1})} = 0.12 \text{ mol}$$

$$n_{\text{H}_2\text{O}} = \frac{\text{Mass of water}}{\text{Molar mass of water}} = \frac{(80 \text{ g})}{(18 \text{ g mol}^{-1})} = 4.44 \text{ mol.}$$

$$x_{\text{KI}} = \frac{n_{\text{KI}}}{n_{\text{KI}} + n_{\text{H}_2\text{O}}} = \frac{(0.12 \text{ mol})}{(0.12 + 4.44) \text{ mol}} = \frac{0.12}{4.56} = \mathbf{0.0263.}$$

2.6. H₂S, a toxic gas with rotten egg like smell, is used for the qualitative analysis. If the solubility of H₂S in water at STP is 0.195 m, calculate Henry's law constant.

Ans: Solubility of H₂S gas = 0.195 m

= 0.195 mole in 1 kg of solvent

1 kg of solvent = 1000g

$$= \frac{1000}{18} = 55.55 \text{ moles}$$

$$\therefore x_{\text{H}_2\text{S}} = \frac{0.195}{0.195 + 55.55}$$

$$= \frac{0.195}{55.745} = 0.0035$$

- Pressure at STP = 0.987 bar

Applying Henry's law,

$$P_{\text{H}_2\text{S}} = K_{\text{H}} \times x_{\text{H}_2\text{S}}$$

$$\Rightarrow K_{\text{H}} = \frac{P_{\text{H}_2\text{S}}}{x_{\text{H}_2\text{S}}} = \frac{0.987}{0.0035} = 282 \text{ bar}$$

2.7. Henry's law constant for CO₂ in water is 1.67 x 10⁸ Pa at 298 K. Calculate the quantity of CO₂ in 500 mL of soda water when packed under 2.5 atm CO₂ pressure at 298 K.

Ans.:

$$K_H = 1.67 \times 10^8 \text{ Pa}$$

$$P_{\text{CO}_2} = 2.5 \text{ atm} = 2.5 \times 101325 \text{ Pa}$$

$$\therefore x_{\text{CO}_2} = \frac{P_{\text{CO}_2}}{K_H} = \frac{2.5 \times 101325}{1.67 \times 10^8} = 1.517 \times 10^{-3}$$

For 500 mL of soda water, water present \approx 500 mL

$$= 500 \text{ g} = \frac{500}{18} = 27.78 \text{ moles}$$

$$\therefore n_{\text{H}_2\text{O}} = 27.78 \text{ moles}$$

$$\therefore \frac{n_{\text{CO}_2}}{27.78} = 1.517 \times 10^{-3}$$

$$\begin{aligned} n_{\text{CO}_2} &= 42.14 \times 10^{-3} \text{ mole} \\ &= 42.14 \text{ mmol} \\ &= 42.14 \times 10^{-3} \times 44 \text{ g} \\ &= 1.854 \text{ g} \end{aligned}$$

2.8 The vapour pressures of pure liquids A and B are 450 mm and 700 mm of Hg respectively at 350 K. Calculate the composition of the liquid mixture if total vapour pressure is 600 mm of Hg. Also find the composition in the vapour phase.

Ans:

Vapour pressure of pure liquid A (P°_A) = 450 mm

Vapour pressure of pure liquid B (P°_B) = 700 mm

Total vapour pressure of the solution (P) = 600 mm

$$\begin{aligned} \text{According to Raoult's Law, } P &= P^\circ_A x_A + P^\circ_B x_B = P^\circ_A x_A + P^\circ_B (1 - x_A) \\ (600 \text{ mm}) &= 450 \text{ mm} \times x_A + 700 \text{ mm} (1 - x_A) \\ &= 700 \text{ mm} + x_A (450 - 700) \text{ mm} \\ &= 700 - x_A (250 \text{ mm}) \end{aligned}$$

$$\text{or } x_A = \frac{(600 - 700) \text{ mm}}{-(250 \text{ mm})} = 0.40$$

$$\text{Mole fraction of A } (x_A) = 0.40$$

$$\text{Mole fraction of B } (x_B) = 1 - 0.40 = 0.60$$

$$P_A = P^\circ_A x_A = (450 \text{ mm}) \times 0.40 = 180 \text{ mm}$$

$$P_B = P^\circ_B x_B = (700 \text{ mm}) \times 0.60 = 420 \text{ mm}$$

$$\text{Mole fraction of A in the vapour phase} = \frac{P_A}{P_A + P_B} = \frac{(180 \text{ mm})}{(180 + 420) \text{ mm}} = 0.30$$

$$\text{Mole fraction of B in the vapour phase} = \frac{P_B}{P_A + P_B} = \frac{(420 \text{ mm})}{(180 + 420) \text{ mm}} = 0.70$$

2.9. Vapour pressure of pure water at 298 K is 23.8 mm Hg. 50 g of urea (NH_2CONH_2) is dissolved in 850 g of water. Calculate the vapour pressure of water for this solution and its relative lowering.

Ans:

$$P^\circ = 23.8 \text{ mm}$$

$$w_2 = 50 \text{ g}, M_2 (\text{urea}) = 60 \text{ g mol}^{-1}$$

$$w_1 = 850 \text{ g}, M_1 (\text{water}) = 18 \text{ g mol}^{-1}$$

To find: P_s and $(P^\circ - P_s)/P^\circ$

Solution: Applying Raoult's law,

$$\frac{P^\circ - P_s}{P^\circ} = \frac{n_2}{n_1 + n_2} = \frac{w_2 / M_2}{w_1 / M_1 + w_2 / M_2}$$

$$\therefore \frac{P^\circ - P_s}{P^\circ} = \frac{50 / 60}{850 / 18 + 50 / 60}$$

$$= \frac{0.83}{47.22 + 0.83} = 0.017$$

Putting $P^\circ = 23.8 \text{ mm}$, we have

$$\frac{23.8 - P_s}{P_s} = 0.017$$

$$\Rightarrow 23.8 - P_s = 0.017 P_s$$

$$\text{or, } 1.017 P_s = 23.8$$

$$\text{or, } P_s = 23.4 \text{ mm}$$

2.10. Boiling point of water at 750 mm Hg is 99.63°C . How much sucrose is to be added to 500 g of water such that it boils at 100°C .

Ans:

$$\text{Given } \Delta T_b = 100 - 99.63 = 0.37^\circ$$

$$\text{Mass of water, } w_1 = 500 \text{ g}$$

$$\text{Molar mass of water, } M_1 = 18 \text{ g mol}^{-1}$$

$$\text{Molar mass of sucrose, } M_2 = 342 \text{ g mol}^{-1}$$

To find: Mass of sucrose, $w_2 = ?$

Solution: We know, $\Delta T_b = K_b \times m$

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

$$\Rightarrow w_2 = \frac{M_2 \times w_1 \times \Delta T_b}{1000 \times K_b} = \frac{342 \times 500 \times 0.37}{1000 \times 0.52}$$

$$w_2 = 1108.2 \text{ g}$$

$$\therefore \text{Mass of solute, } w_2 = 1.11 \text{ kg}$$

2.11 Calculate the mass of ascorbic acid (vitamin C, $\text{C}_6\text{H}_8\text{O}_6$) to be dissolved in 75 g of acetic acid to lower its melting point by 1.5°C . (K_f for CH_3COOH) = 3.9 K

kg mol⁻¹)

Ans:

$$W_B = \frac{M_B \times \Delta T_f \times W_A}{K_f}$$

Mass of acetic acid (W_A) = 75 g = 0.075 kg.

Depression in freezing point (ΔT_f) = 1.5°C = 1.5 K

Molar mass of ascorbic acid (M_B) = 6 × 12 + 8 × 1 + 6 × 16 = 176 g mol⁻¹

Molal depression constant (K_f) = 3.9 K kg mol⁻¹

$$W_B = \frac{(176 \text{ g mol}^{-1}) \times (1.5 \text{ K}) \times (0.075 \text{ kg})}{(3.9 \text{ K kg mol}^{-1})} = 5.08 \text{ g}$$

2.12. Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0 g of polymer of molar mass 185,000 in 450 mL of water at 37°C.

Ans:

Given: $V = 450 \text{ mL} = 0.45 \text{ L}$
 $T = 37^\circ\text{C} = 310 \text{ K}$
 $R = 8.314 \text{ kPa L K}^{-1} \text{ mol}^{-1}$

To find: $\pi = ?$

Solution: Applying the formula,

$$\pi = CRT = \frac{n}{V} RT$$

$$n = \frac{1.0 \text{ g}}{185,000 \text{ g mol}^{-1}}$$

$$\therefore P = \frac{1}{185,000} \times \frac{1}{0.45} \times 8.314$$

$$\begin{aligned} & \times 10^3 \text{ Pa L K}^{-1} \text{ mol}^{-1} \times 310 \text{ K} \\ & = 30.96 \text{ Pa} \end{aligned}$$