CHAPTER 2

Solutions

TRY YOURSELF ANSWERS

1. Mixture, milk may appear to be a homogeneous mixture to the unaided eye, but the tiny oil and protein droplets in the system make milk appear as white. Actually, milk is a colloidal solution.

2. CO_2 gas dissolved in water to form soda water.

3. Mass of $H_2SO_4 = 75$ g

Mass of solution = 100 g

Molecular mass of $H_2SO_4 = 98$

$d = 1.8\text{g mL}^{-1}$

Volume of solution $= \frac{m}{d} = \frac{100}{1.8}$

$$\text{Molarity} = \frac{\frac{75}{98}}{\frac{100}{1.8}} \times 1000 = 13.77 \text{ M}$$

$M_1V_1 = M_2V_2$

$13.77 \times V_1 = 0.2 \times 1$

$V_1 = 0.0145\text{L} = 14.5 \text{ mL}$

4. Density of water = 1g mL^{-1}

Mass of 1000 mL of water $= V \times d$

$= 1000 \text{ mL} \times 1 \text{ g mL}^{-1}$

$= 1000$ g

$$\text{Moles of water} = \frac{1000}{18} = 55.55 \text{ mol}$$

Hence, 55.55 moles of H_2O is present in 1000 mL or 1 L of water.

So, molarity = 55.55 M

5. Moles of calcium = 10/40 = 0.25

$$\text{Concentration } (C) = \frac{n}{V_L} = \frac{0.25}{1} = 0.25 \text{ M} \quad \text{or} \quad 0.25 \text{ mol/L}$$

6. Given $n_B = 5.2, n_A = \frac{1000}{18}$

$\therefore$ $n_B \Rightarrow$ Moles of CH_3OH

n_A = Moles of H_2O

$$\therefore \text{Mole fraction} = \frac{5.2}{5.2 + \frac{1000}{18}}$$

$$= \frac{5.2 \times 18}{93.6 + 1000} = \frac{93.6}{1093.6} = 0.0855 \approx 0.086$$

7. Three ways to increase the solubility of a solid substance are increasing the temperature, increasing the amount of solvent, and using a solvent with similar polarity as the solute.

8. The pH of an aqueous solution can affect the solubility of the solute. If the pH of the solution is such that a particular molecule carries no net electric charge, the solute often has minimal solubility and precipitates out of the solution.

9. Gases are more soluble in cold liquid as the escaping tendency of gaseous molecule decreases at lower temperature.

In warm liquid, particles of solid gain kinetic energy and shows random motion and gets to more easily dissolve.

10. (i) The solubility of a gas in liquid decreases with increasing temperature. With increase in temperature thermal energy of gaseous molecules increases which overcome the force of attraction between gaseous molecules and solvent molecules.

(ii) On increasing pressure, the solubility of a gas in liquid increases. The effect of change of pressure on the solubility of gases is given by Henry's law according to which solubility $\propto$ pressure.

11. Both laws state that the partial pressure of the volatile component is directly proportional to its mole fraction in solution.

12. Vapour pressure is the pressure caused by the evaporation of liquids. Three common factors that influence vapour pressure are surface area, intermolecular forces and temperature. The vapour pressure of a molecule differs at different temperatures.

13. Water does not have higher vapour pressure than ethanol due to extensive hydrogen bonding which provides stronger intermolecular attractions, hence fewer molecules escaping the liquid, and a lower vapour pressure is observed than ethanol.

14. At room temperature, the substance with the lowest boiling point will have the highest vapour pressure (easiest to get into the gases phase). The substance with the highest boiling point will have the lowest vapour pressure. Vapour pressure is a liquid property related to evaporation.

15. Solutions with strong intermolecular forces produce a lower rate of evaporation and a lower vapour pressure. Solution with weak intermolecular forces produce a higher rate of evaporation and a higher vapour pressure. As the temperature increases, the vapour pressure increases.

16. If moles of benzene = moles of toluene,

Then, mole fraction of benzene = mole fraction of toluene = 0 .5

$$V_{p\text{ Solution}} = V_{p\text{ benzene}} \times X_{\text{benzene}} + V_{p\text{ toluene}} \times X_{\text{toluene}}$$

$V_{p\ \text{Benzene}} = 0.5(183) = 91.5$ torr
$V_{p\ \text{Toluene}} = 0.5(59.2) = 29.6$ torr
$V_{p\ \text{Solution}} = 91.5 + 29.6 = 121.1$ torr

17. $p_T = p_X^\circ x_X + p_Y^\circ x_Y$

where, p_T = Total pressure

p_X° = Vapour pressure of X in pure state

p_Y° = Vapour pressure of Y in pure state

x_X = Mole fraction of X = 1/4

x_Y = Mole fraction of Y = 3/4.

(i) When $T = 300$ K, $p_T = 550$ mm Hg

$\therefore\ 550 = p_X^\circ\left(\frac{1}{4}\right) + p_Y^\circ\left(\frac{3}{4}\right)$

$\Rightarrow\ p_X^\circ + 3p_Y^\circ = 2200$ ...(i)

(ii) When at $T = 300$ K, 1 mole of Y is added,

$p_T = (550 + 10)$ mm Hg

$\therefore\ x_X = 1/5$ and $x_y = 4/5$

$\Rightarrow\ 560 = p_X^\circ\left(\frac{1}{5}\right) + p_y^\circ\left(\frac{4}{5}\right)$

or $p_X^\circ + 4p_y^\circ = 2800$ ...(ii)

On solving equation (i) and (ii), we get $p_y^\circ = 600$ mm Hg and $p_X^\circ = 400$ mm Hg.

18. Van't Hoff factor is the ratio of total number of particles undergoes association or dissociation to the total number of particles present.

(a) $\alpha = \frac{i-1}{n-1}$

(b) $\alpha = \frac{i-1}{\frac{1}{n}-1}$

19. $m = \frac{\text{Weight of solute / molecular mass of solute}}{\text{Mass of solvent (g)}} \times 1000$

$m = \frac{w/62}{1000} \times 1000 = \frac{w}{62}$

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

$2.8 = 1.86 \times \frac{w}{62} \Rightarrow w = \frac{62 \times 2.8}{1.86} = 93.3$ g

20. For association,

w = weight of solute; m = molecular mass of solute

W = weight of solvent

$\Delta T = \frac{1000 \times K_f \times w}{m \times W} \times \left(1 - \alpha + \frac{\alpha}{n}\right)$

$w = 20 \times 10^{-3}$ kg, $W = 1$ kg

$K_f = 5.12$, $\Delta T = 0.69$

$0.69 = \frac{1000 \times 5.12 \times 20 \times 10^{-3}}{94 \times 1} \times \left(1 - \alpha + \frac{\alpha}{2}\right)$ $(\because n = 2)$

$1 - \frac{\alpha}{2} = 0.633$

$\alpha = 0.734$ or 73.4%