1. SOLUTION

2.6 How many mL of 0.1 M HCl are required to react completely with 1 g mixture of Na_2C0_3 and $NaHCO_3$ containing equimolar amounts of both?

Sol. Calculation of no. of moles of components in the mixture.

Let x g of Na_2CO_3 is present in the mixture.

$\therefore$ $(1-x)$ g of $NaHCO_3$ is present in the mixture.

Molar mass of Na_2CO_3

$= 2 \times 23 + 12 + 3 \times 16 = 106 \text{ g mol}^{-1}$

and molar mass of $NaHCO_3$

$= 23 \times 1 + 1 + 12 + 3 \times 16 = 84 \text{ g mol}^{-1}$

No. of moles of Na_2CO_3 in x g $= \frac{x}{106}$

No. of moles of $NaHCO_3$ in $(1-x)$ g $= (1-x)/84$

As given that the mixture contains equimolar amounts of Na_2CO_3 and $NaHCO_3$, therefore

$$\frac{x}{106} = \frac{1-x}{84}$$

$106 - 106x = 84x$

$106 = 190x$

$$\therefore \quad x = \frac{106}{190} = 0{\cdot}558\text{g}$$

$\therefore$ No. of moles of Na_2CO_3 present

$$= \frac{0{\cdot}558}{106} = 0{\cdot}00526$$

and no. of moles of $NaHCO_3$ present

$$= \frac{1 - 0{\cdot}558}{84} = 0{\cdot}00526$$

Calculation of no. of moles of HCl required

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

$$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$$

As can be seen, each mole of Na_2CO_3 needs 2 moles of HCl,

$\therefore$ 0·00526 mole of Na_2CO_3 needs

$= 0{\cdot}00526 \times 2 = 0{\cdot}01052$ mole

Each mole of $NaHCO_3$ needs 1 mole of HCl.

$\therefore$ 0·00526 mole of $NaHCO_3$ needs

$= 1 \times 0{\cdot}00526 = 0{\cdot}00526$ mole

Total amount of HCl needed will be

$= 0{\cdot}01052 + 0{\cdot}00526 = 0{\cdot}01578$ mole.

0·1 mole of 0.1 M HCl are present in 1000 mL of HCl

$\therefore$ 0·01578 mole of 0·1 M HCl will be present in

$$= \frac{1000}{0{\cdot}1} \times 0{\cdot}01578 = 157{\cdot}8 \text{ mL.}$$

2.7 A solution is obtained by mixing 300 g of 25% solution and 400 g of 40% solution by mass. Calculate the mass percentage of the resulting solution.
Sol.

300g of 25% solution will contain $= \frac{25 \times 300}{100}$

$= 75$ g of solute.

400g of 40% solution will contain

$= \frac{40 \times 400}{100} = 160$ g of solute.

$\therefore$ Total mass of solute $= 160 + 75 = 235$g

Total mass of solution $= 300 + 400 = 700$g

Now, the percentage of solute in solution

$= \frac{235}{700} \times 100 = 33{\cdot}5\%$

and, the percentage of water in solution

$= 100 - 33{\cdot}5\% = 66{\cdot}5\%$

2.8 An antifreeze solution is prepared from 222.6 g of ethylene glycol, ($C_2H_6O_2$) and200 g of water. Calculate the molality of the solution. If the density of the solution is 1.072 g mL^{-1}, then what shall be the molarity of the solution?
Sol.

Mass of solute $= 222{\cdot}6$g

Molar mass of solute, $C_2H_4(OH)_2$

$= 12 \times 2 + 4 + 2(12 + 1) = 62$ g mol^{-1}

$\therefore$ Moles of solute $= \frac{222{\cdot}6}{62} = 3{\cdot}59$

Mass of solvent $= 200$ g

$\therefore$ Molality$= \frac{3{\cdot}59}{200} \times 1000 = 17{\cdot}95$ mol kg^{-1}

Total mass of solution$= 422{\cdot}6$ g

Volume of solution$= \frac{422{\cdot}6}{1{\cdot}072} = 394{\cdot}21$ mL.

$\therefore$ Molarity$= \frac{3{\cdot}59}{394{\cdot}2} \times 1000 = 9{\cdot}1$ mol L^{-1}

2.9 A sample of drinking water was found to be severely contaminated with chloroform ($CHCl_3$), supposed to be a carcinogen. The level of contamination was 15 ppm (by mass).

(i) express this in percent by mass.
(ii) determine the molality of chloroform in the water sample.
Sol. 15 ppm means 15 parts in million (10^6) by mass in the solution.

$$\therefore \text{ Percentage by mass} = \frac{15}{10^6} \times 100 = 15 \times 10^{-4}\%$$

As only 15g of chloroform is present in 10^6g of the solution, mass of the solvent = 10^6 g

$$\text{Molar mass of } CHCl_3 = 12 + 1 + 3 \times 35{\cdot}5 = 119{\cdot}5 \text{ g mol}^{-1}$$

$$\text{Moles of } CHCl_3 = \frac{15}{119{\cdot}5}$$

$$\therefore \text{ Molality} = \frac{15/119{\cdot}5 \times 1000}{10^6} = 1{\cdot}25 \times 10^{-4} \text{ m}$$

2.10 What role does the molecular interaction play in a solution of alcohol and water?
Sol. Alcohol and water both have strong tendency to form intermolecular hydrogen bonding. On mixing the two, a solution is formed as a result of formation of H-bonds between alcohol and H_2O molecules but these interactions are weaker and less extensive than those in pure H_2O. Thus they show a positive deviation from ideal behaviour. As a result of this, the solution of alcohol and water will have higher vapour pressure and lower boiling point than that of water and alcohol.