Tutorial 1 – The Mole Concept and Stoichiometry (Suggested Answers)

Answers

1 **(a)** Mass of F^- in 1000 cm^3 of fluorinated reservoir water = $10 \times 0.16 = 1.6$ mg

Optional working:
Mass of F^- in 100 cm^3 of diluted solution = $0.1 \times 0.16 = 0.016$ mg
Mass of F^- in 10.0 cm^3 of fluorinated reservoir water = 0.016 mg
Mass of F^- in 1000 cm^3 of fluorinated reservoir water = $100 \times 0.016 = 1.60$ mg

(b) Amount of F^- in fluorinated reservoir water = $\frac{1.6\times10^{-3}}{19.0}$ = 8.421×10^{-5} mol

Amount of H_2SiF_6 required = $\frac{1}{6} \times 8.421 \times 10^{-5} = 1.404 \times 10^{-5}$ mol

Mass of H_2SiF_6 required = $(1.404 \times 10^{-5})(144.1) = 2.02 \times 10^{-3}$ g = 2.02 mg

(Note: answer can be given in grams or milligrams, since the question did not specify.)

2

Concentration of $\mathbf{M}_2CO_3 = \dfrac{5.30}{500\times10^{-3}} = \underline{10.6 \text{ g dm}^{-3}}$

$$\mathbf{M}_2CO_3 + 2HCl \rightarrow 2\mathbf{M}Cl + H_2O + CO_2$$

Amount of $HCl = \dfrac{26.0}{1000}\times0.192 = 4.992\times10^{-3}$ mol

Amount of $\mathbf{M}_2CO_3 = \dfrac{1}{2}\times4.992\times10^{-3} = 2.496\times10^{-3}$ mol

Concentration of $\mathbf{M}_2CO_3 = \dfrac{2.496\times10^{-3}}{25.0\times10^{-3}} = 0.09984$ mol dm^{-3}

Let the relative atomic mass of **M** be x.

$$0.09984(2x+12.0+3\times16.0)=10.6$$
$$x = \underline{23.1}$$

3 **(a)** $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$
$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$

(b) Applying Avogadro's law, V is proportional to n,

Volume of CO_2 formed = 10 × 3
= 30 cm^3

(c) Amount of NaOH present initially $= \dfrac{50}{1000}\times0.50 = 0.025$ mol

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

Amount of H_2SO_4 used $= \dfrac{24.40}{1000}\times0.35 = 8.54\times10^{-3}$ mol

Amount of NaOH reacted with $H_2SO_4 = 2\times8.54\times10^{-3} = 0.01708$ mol

Amount of NaOH reacted with gaseous products $= 0.025 - 0.01708 = \underline{7.92\times10^{-3} \text{ mol}}$

(d) $CO_2(g) + 2NaOH(aq) \rightarrow Na_2CO_3(aq) + H_2O(l)$

At room temperature and pressure,

$$\text{Amount of NaOH reacted with } CO_2 = 2 \times \frac{30 \times 10^{-3}}{24} = 2.50 \times 10^{-3} \text{ mol}$$

$$\text{Amount of NaOH reacted with } NO_2 = 7.92 \times 10^{-3} - 2.50 \times 10^{-3} = 5.42 \times 10^{-3} \text{ mol}$$

Since mole ratio of NO_2 to NaOH is 1:1 (as given in the equation),

$$\text{Amount of } NO_2 = 5.42 \times 10^{-3} \text{ mol}$$

$$\frac{2z \times 10^{-3}}{24} = 5.42 \times 10^{-3}$$

$$z = \underline{65.0}$$

4 **(a)** $(NH_4)_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2NH_3(g) + 2H_2O(l)$

$HCl(aq) + NH_3(g) \rightarrow NH_4Cl(aq)$

Or

$NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$

$H^+(aq) + NH_3(g) \rightarrow NH_4^+(aq)$

(b) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

$$\text{Amount of unreacted HC}l \text{ (step III)} = \text{Amount of NaOH used}$$

$$= \frac{20.0}{1000} \times 0.100 = 2.00 \times 10^{-3} \text{ mol}$$

$$\text{Amount of HC}l \text{ (step II)} = \frac{50.0}{1000} \times 0.100 = 5.00 \times 10^{-3} \text{ mol}$$

$$\text{Amount of } NH_3 = \text{Amount of HC}l \text{ reacted with liberated } NH_3$$

$$= 5.00 \times 10^{-3} - 2.00 \times 10^{-3}$$

$$= 3.00 \times 10^{-3} \text{ mol} = \text{Amount of N present in 1.00 g of a foodstuff}$$

$$\text{Mass of N} = 3.00 \times 10^{-3} \times 14.0 = 0.0420 \text{ g}$$

$$\text{\% by mass of N in the foodstuff} = \frac{0.0420}{1.00} \times 100\% = \underline{4.20\%}$$