ANSWERS

Section A

1. $n_{CaH_2} = \dfrac{100}{42} = 2.38$

$$n_{H_2} = 2 \times n_{CaJ_2} = 2 \times 2.38$$
$$n_{H_2} = 4.76$$
$$\text{mass of } H_2 \text{ produced} = 4.76 \times 2$$
$$= 9.52 \text{ g}$$

2. $n_{CO_2} = \dfrac{10^{+3}}{44} = 22.7$

$$n_{LiOH} = 2_{nCo_2} = 2 \times 22.7$$
$$= 45.4$$
$$\text{mass of LiOH} = 45.4 \times 24 = 1089.6\text{g}$$
$$= 1.0896 \text{ kg}$$

3. $2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$
   H_2S is the limitting reactant at the end of the reaction

$$V_{H_2S} = 0$$
$$V_{O_2} \text{ left} = 10 - \left(\frac{3}{2} \times 4\text{L}\right)$$
$$= 10 - 6 = 4 \text{ L}$$
$$V_{H_2O} = 4\text{L}$$
$$V_{SO_2} = 4\text{L}$$

   Total volume of the mixture at the end of the reaction = 12 L

4. $n_{Fe_2O_3} = \dfrac{700 \times 10^3}{160} = 4375$

$$n_{Coke} = 5833.3$$

   Coke is the limiting reactant

$$n\text{Fe Produced} = \frac{4}{3} \times 5833.3$$
$$\text{mass of Fe produced} = \frac{4}{3} \times 5833.3 \times 56$$
$$= 435555 \text{ kg}$$
$$\approx 436 \text{ tonnes}$$

5. $n_{Al} = \frac{100}{27} = 3.70$

$$n_{Cr_2O_3} = \frac{400}{152} = 2.63$$

Al is the limiting reactant

n_{Cr} obtained = 3.70

mass of Cr obtained = 370 × 52 = 192.4 g

$$\% \text{ yield} = \frac{180}{192.4} \times 100 = 93.55\%$$

6. (a) $n_{H_2O_2} = 2 \times n_{N_2H_4}$

$= 2 \times 0.477$

$= 0.954$

(b) $n_{HNO_3} = n_{H_2O_2} = 0.199$

(c) $n_{H_2O_2} = \frac{49.6 \times 10^{-3}}{34} = 1.46 \times 10^{-3}$

$n_{H_2O} = 4 \times n_{H_2O_2} = 4 \times 1.46 \times 10^{-3}$

$= 5.84 \times 10^{-3}$

mass of H_2O produced = $5.84 \times 10^{-3} \times 18 = 0.105$ g

7. $n_{Li} = \frac{48}{7} = 6.857$

$$n_{N_2} = \frac{1.0 \times 10^{24}}{6.02 \times 10^{23}} = 1.66$$

(a) Li is the limiting reactant

∴ no. of moles of lithium nitride formed

$= \frac{1}{3} \times n_{Li}$

$= \frac{1}{3} \times 6.857 = 2.286$

mass of Li_3N formed = 2.286 × 35

= 79.998

≈ 80g

(b) n_{N_2} left in excess = 0.517

mass of N_2 left = 0.517 × 28

= 14.476 g

8. (a) $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

$$\text{mass of ZnS in ore} = \frac{79.5}{100} \times 445$$
$$= 353.775 \text{ g}$$

$$\text{no. of moles of ZnS} = \frac{353.775}{97} = 3.647$$

$$n_{O_2} \text{ required} = 1.5 \times 3.647$$
$$= 5.47 \text{ mol}$$

$$\text{mass of } O_2 \text{ required} = 5.47 \times 32 = 175.04 \text{ g}$$

(b) $n_{SO_2} = n_{ZnS} = 3.647$

1 mol of SO_2 at STP = 22400 mL

$\therefore$ 3.647 mol of SO_2 at STP occupied

$$= 22400 \times 3.647$$
$$= 81693 \text{ mL}$$

9. 1 L solution contains = 1.08 mol KCl

$$1 \text{ L} = 1000 \text{ cm}^3 = \frac{\text{mass of solution}}{\text{density of solution}}$$

$$\text{mass of solution} = 1000 \times 1.138$$
$$= 1138 \text{ g}$$

$$\text{mass of KCl} = 1.08 \times 74.5 = 80.46 \text{ g}$$

$$\text{percent by mass of KCl} = \frac{80.46}{1138} \times 100$$
$$= 7.07 \%$$

10. Number of moles of 6.00 M H_2SO_4

$$= 6 \times 0.125$$
$$= 0.75$$

Number of moles of 3.00 M H_2SO_4

$$= 3 \times 0.225$$
$$= 0.675$$

Total no. of moles = 0.675 + 0.75

$$= 1.425$$

$$\text{Molarity of the resultant solution} = \frac{1.425}{0.350}$$

$$= 4.07 \text{ M}$$

11. $n_{Ba(OH)_2} = 2.58 \times 10^{-3} \times 41 \times 10^{-3}$

$$= 1.0578 \times 10^{-4}$$

$$n_{HNO_3} = 2 \times n_{Ba(OH)_2}$$

$$= 2 \times 1.0578 \times 10^{-4}$$

$$= 2.1156 \times 10^{-4}$$

$$\text{Volume of } HNO_3 = 36 \times 10^{-3} \text{ L}$$

$$\text{Molarity of } HNO_3 = \frac{2.1156 \times 10^{-4}}{36 \times 10^{-3}}$$

$$= 5.87 \times 10^{-3} \text{ M}$$

12. Milimoles of H_2SO_4 = 12.1 and moles of

$$H_2SO_4 = 12.1 \times 10^{-3}$$

$$\text{mass of NaOH} = x \text{ g}$$

$$\text{mass of KOH} = (1.15 - x)\text{g}$$

$$\underset{\frac{x}{56}\text{mol}}{2KOH} + \underset{\frac{x}{112}\text{mol}}{H_2SO_4} \rightarrow K_2SO_4 + 2H_2O$$

$$\underset{\left(\frac{1.15-x}{40}\right)\text{mol}}{2NaOH} + \underset{\left(\frac{1.15-x}{80}\right)\text{mol}}{H_2SO_4} \rightarrow Na_2SO_4 + 2H_2O$$

Number of moles of H_2SO_4 are

$$\frac{x}{112} + \left(\frac{1.15 - x}{80}\right) = 12.1 \times 10^{-3}$$

$$80\,x + 122.8 - 112x = 108.416$$

$$32\,x = 14.384$$

$$x = 0.4495 \text{ g}$$

$$\text{Mass of KOH} = 0.4495 \text{ g}$$

$$\text{Mass of NaOH} = 0.7005 \text{ g}$$

$$\text{Percentage of KOH} = \frac{0.4495}{1.15} \times 100$$

$$= 39.09\%$$

$$\text{Percentage of NaOH} = \frac{0.7005}{1.15} \times 100$$

$$= 60.9\%$$

13. Mass of alloy = 15.0 g

$$\text{Mass of Cu} = \frac{90}{100} \times 15 = 13.5\text{g}$$

$$\text{Mass of Zn} = \frac{10}{100} \times 15 = 1.5\text{g}$$

$$\text{Number of moles of Cu} = \frac{13.5}{63.5} = 0.213$$

$$\text{Number of moles of Zn} = \frac{1.5}{6.5} = 0.023$$

$$\underset{\substack{0.213\\ \text{mol}}}{\text{Cu}} + \underset{\substack{4\times 0.213\\ =0.852\,\text{mol}}}{4\text{HNO}_3} \rightarrow \text{Cu(NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$$

$$\underset{\substack{0.023\\ \text{mol}}}{4\,\text{Zn}} + \underset{0.0515\ \text{mol}}{10\text{HNO}_3} \rightarrow 4\text{Zn(NO}_3)_2 + \text{NH}_4\text{NO}_3 + 3\text{H}_2\text{O}$$

Total mol of HNO_3 = 0.852 + 0.0575

= 0.9095

$$\text{Volume of HNO}_3 = \frac{0.9095}{3} = 0.3032\text{L}$$

= 303.2 mL

$$\text{no. of moles of NO}_2 = \frac{1}{2} \times n_{\text{HNO}_3} \text{ from Cu reaction}$$

$$= \frac{1}{2} \times 0.852 = 0.426$$

Volume of NO_2 gas produced at 298 K and 1 atm is
0.426 × 24.5 = 10.437 L

14. $\text{Mg} + \frac{1}{2}\text{O}_2 \rightarrow \text{MgO}$ ...(1)

As magnesium is burnt in limited supply of oxygen. Oxygen is the limiting reactant. Some Mg is left unreacted.

$$n_{\text{mg}} = \frac{3.20}{24} = 0.133$$

Out of 0.133 mol Mg, suppose x mol of Mg left unreacted which reacted with H_2SO_4

$\text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2$ ...(b)

$$\text{Molarity of H}_2\text{SO}_4 = \frac{10\,x\text{d}}{\text{MW}} = \frac{10 \times 35 \times 1.28}{98}$$

$$\text{and moles of H}_2\text{SO}_4 = \left(\frac{10 \times 35 \times 1.28}{98}\right) \times 0.1$$

= 0.457

no. of moles of H_2 evolved = $\frac{PV}{RT}$

$$= \frac{740 \times 2.105}{760 \times 0.0821 \times 300} = 0.0833$$

$\therefore$ no. of moles of H_2SO_4 used = 0.0833

no. of moles of H_2SO_4 left unused

= 0.457 – 0.0833

= 0.3737

Molarity of the final H_2SO_4 = $\frac{0.3737}{0.1} = 3.737$

(a) The % by mass of final H_2SO_4

$$= \frac{M \times 98}{10d}$$

$$= \frac{3.737 \times 98}{10 \times 1.15} = 31.85\%$$

(b) Number of moles of Mg used with H_2SO_4
= 0.0833

Number of moles of Mg used with oxyen to form oxide = 0.133 –0.0833

= 0.0497

Mass of Mg = 0.0497 × 24 = 1.193 g

% of Mg converted to oxide

$$= \frac{1.193}{3.20} \times 100 = 37.3\%$$

(c) Number of moles of O_2

$$= = \frac{1}{2} \times n_{\text{Mg}} = \frac{1}{2} \times 0.0497$$

= 0.02485

and mass of oxygen used = 0.02485 × 32

= 0.795 g

15. 100 g of Haemoglobin contain 2.089 Fe

100 g of Haemoglobin contain $\frac{2.08}{56}$

= 0.0371 mol Fe

$\therefore$ 2.56 g of haemoglobin contain

$$\frac{0.0371}{100} \times 2.56 \, \text{mol Fe}$$

Number of Fe atom present

$$= \frac{0.0371}{100} \times 2.56 \times 6.02 \times 10^{23}$$

$$= 5.72 \times 10^{20}$$

16. Only $NaHCO_3$ liberates CO_2 gas. All group 1 carbonates are stable towards heat except $Li_2\ CO_3$.

$$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + H_2O + CO_2$$

$$n_{NaHCO_3} = 2 \times n_{CO_2} = 2 \times \frac{32.0}{22400}$$

$$n_{NaHCO_3} = 2.857 \times 10^{-3}$$

$$\text{mass of } NaHCO_3 = 2.857 \times 10^{-3} \times 84$$

$$= 0.24 \text{ g}$$

Percentage of $NaHCO_3$ = 24%

Percentage of Na_2CO_3 = 76%

17. $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$

$$mm_{Na_2CO_3} = mm_{H_2SO_4}$$

$$= 0.05 \times 35.8 = 1.79$$

$$n_{Na_2CO_3} = 1.79 \times 10^{-3}$$

$$\text{mass of } n_{A_2CO_3} = 1.79 \times 10^{-3} \times 106$$

$$= 0.18974 \text{ in 25 mL}$$

$\therefore$ in 250 ml solution, the mass of

$$Na_2CO_3 = 1.8974 \text{ g}$$

$\therefore$ Percentage of $Na_2CO_3 = \dfrac{1.8974}{5.125} \times 100$

$$= 37.02\%$$

18. In the presence of phenolphthalein indicator, the following reaction is involved.

$2Na_2CO_3 + H_2SO_4 \rightarrow 2NaHCO_3 + Na_2SO_4$

$$nNa_2CO_3 = 2 \times nH_2SO_4 = 2 \times 0.1 \times 5.0 \times 10^{-3}$$

$$nNa_2CO_3 = 1.0 \times 10^{-3}$$

Mass of $Na_2CO_3 = 1.0 \times 10^{-3} \times 106 = 0.106$g in 20 cm^3

$\therefore$ in 1L (1000 cm^3), the mass of

Na_2CO_3 present is $\dfrac{0.106}{20} \times 1000$

$= 5.3$ g/L

In the presence of methyl orange added, the reaction involved are :

$$\underset{\text{(Produced)}}{2NaHCO_3} + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$$

$$\underset{\text{(original)}}{2NaHCO_3} + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$$

$$n_{NaHCO_3\,(\text{prod.})} + n_{NaHCO_3\,(\text{original})} = 2 \times n_{H_2SO_4}$$

But $n_{NaHCO_3\,(\text{prod.})} = 1.0 \times 10^{-3}$

$\therefore \quad 1.0 \times 10^{-3} + n_{NaHCO_3\,(\text{original})} = 2 \times 0.2 \times 5 \times 10^{-3}$

$$n_{NaHCO_3\,(\text{original})} = 2.0 \times 10^{-3} - 1.0 \times 10^{-3}$$

$$= 1.0 \times 10^{-3}$$

Mass of $NaHCO_3 = 1.0 \times 10^{-3} \times 84 = 0.084$ in 20 cm^3

$\therefore$ mass of $NaHCO_3$ in

$$1L(10^3\ cm^3) = \frac{0.084}{20} \times 10^{-3} = 4.2 g/L$$

19. In the presence of phenolphthalien indicator the following reaction takes place

$$Na_2CO_3 + HCl \rightarrow NaCl + NaHCO_3$$

$$n_{Na_2CO_3} = n_{HCl} = 0.11 \times 15.7 \times 10^{-3}$$

$$n_{Na_2CO_3} = 1.727 \times 10^{-3}$$

$$\text{mass of } Na_2CO_3 = 1.727 \times 10^{-3} \times 106$$

$$= 0.183 \text{ g}$$

In the presence of methyl organe indicator:

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

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

$$2 \times n_{Na_2CO_3} + n_{NaHCO_3} = n_{HCl}$$

$$2 \times 1.727 \times 10^{-3} + n_{NaHCO_3} = 0.11 \times 43.8 \times 10^{-3}$$

$$= 4.818 \times 10^{-3}$$

$\therefore \quad n_{NaHCO_3} = 4.818 \times 10^{-3} - 3.454 \times 10^{-3}$

$$= 1.364 \times 10^{-3}$$

$$\text{mass of } NaHCO_3 = 1.364 \times 10^{-3} \times 84$$

$$= 0.1146 \text{ g}$$

Percentage of Na_2CO_3 in the sample $= \dfrac{0.183}{0.527} \times 100 = 34.72\%$

Percentage of Na_2CO_3 in the sample $= \dfrac{0.1146}{0.527} \times 100 = 21.75\ \%$

20. CO_2 gas is evolved only from $NaHCO_3$

$$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + H_2O + CO_2$$

$$n_{NaHCO_3} = 2 \times n_{CO_2} = 2 \times \frac{122.3}{24500}$$
$$= 0.01$$

mass of $NaHCO_3 = 0.01 \times 84 = 0.84$ g

with complete neutralization of solution against HCl, the following reaction taken place.

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

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

$$2 \times n_{Na_2CO_3} + n_{NaCHO_3} = n_{HCl}$$
$$2 \times n_{Na_2CO_3} + 0.01 = n_{HCl}$$
$$n_{Na_2CO_3} = 0.005$$
$$\text{mass of } Na_2CO_3 = 0.005 \times 106$$
$$= 0.53 \text{ g}$$

$$\text{Percentage of } Na_2CO_3 = \frac{0.84}{2.0} \times 100 = 42.0\%$$

$$\text{Percentage of } Na_2CO_3 = \frac{0.53}{2.0} \times 100 = 26.5\%$$

$$\text{Percentage of } Na_2SO_4 = \frac{0.63}{2.0} \times 100 = 31.5\%$$

21. $NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$ ...(1)

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ ...(b)

$$\underset{\text{(excess or residual)}}{H_2SO_4} + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

Number of moles of residual H_2SO_4

$$= \frac{1}{2} \times n_{NaOH}$$
$$= \frac{1}{2} \times 0.5 \times 63 \times 10^{-3}$$
$$= 0.01575$$

Total number of moles of H_2SO_4

$$= \frac{1}{4} \times 150 \times 10^{-3}$$
$$= 0.0375$$

Number of moles of H_2SO_4 neutralized by NH_3 in reaction (b) is

$$0.0375 - 0.01575$$
$$= 0.02175$$

No. of moles of $NH_3 = 2 \times 0.02175 = 0.0435$

Mass of $NH_3 = 0.0435 \times 17 = 0.7395$ g

Percentage of $NH_3 = \dfrac{0.7395}{2.8} \times 100$

$= 26.4\%$

22. Only $(NH_4)_2SO_4$ liberates NH_3 gas on warming with NaOH

$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O + 2NH_3$ ...(1)

$NH_3 + HCl \rightarrow NH_4Cl$ ...(2)

$\underset{\text{(excess)}}{HCl} + NaOH \rightarrow NaCl + H_2O$

Number of moles of excess HCl = no. of moles of NaOH

$= 0.1 \times 18.43 \times 10^{-3}$

$= 0.001843$

Total number of moles of HCl

$= 0.1 \times 20 \times 10^{-3}$

$= 0.002$

Number of moles of HCl neutralized by NH_3

$= 0.002 - 0.001843$

$= 1.57 \times 10^{-4}$

$n_{(NH_4)_2SO_4} = 2 \times n_{NH_3} = 3.14 \times 10^{-4}$

mass of $(NH_4)_2SO_4 = 3.14 \times 10^{-4} \times 132$

$= 0.0414$

Percentage of $(NH_4)_2SO_4 = \dfrac{0.0414}{0.225} \times 100$

$= 18.42\ \%$