

Section A

$$1. n_{\text{CaH}_2} = \frac{100}{42} = 2.38$$

$$n_{\text{H}_2} = 2 \times n_{\text{CaH}_2} = 2 \times 2.38$$

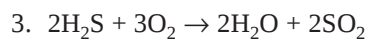
$$n_{\text{H}_2} = 4.76$$

$$\begin{aligned} \text{mass of H}_2 \text{ produced} &= 4.76 \times 2 \\ &= 9.52 \text{ g} \end{aligned}$$

$$2. n_{\text{CO}_2} = \frac{10^{+3}}{44} = 22.7$$

$$\begin{aligned} n_{\text{LiOH}} &= 2 n_{\text{CO}_2} = 2 \times 22.7 \\ &= 45.4 \end{aligned}$$

$$\begin{aligned} \text{mass of LiOH} &= 45.4 \times 24 = 1089.6 \text{ g} \\ &= 1.0896 \text{ kg} \end{aligned}$$



H₂S is the limiting reactant at the end of the reaction

$$V_{\text{H}_2\text{S}} = 0$$

$$\begin{aligned} V_{\text{O}_2 \text{ left}} &= 10 - \left(\frac{3}{2} \times 4\text{L} \right) \\ &= 10 - 6 = 4 \text{ L} \end{aligned}$$

$$V_{\text{H}_2\text{O}} = 4\text{L}$$

$$V_{\text{SO}_2} = 4\text{L}$$

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

$$4. n_{\text{Fe}_2\text{O}_3} = \frac{700 \times 10^3}{160} = 4375$$

$$n_{\text{Coke}} = 5833.3$$

Coke is the limiting reactant

$$n_{\text{Fe Produced}} = \frac{4}{3} \times 5833.3$$

$$\begin{aligned} \text{mass of Fe produced} &= \frac{4}{3} \times 5833.3 \times 56 \\ &= 435555 \text{ kg} \\ &\approx 436 \text{ tonnes} \end{aligned}$$

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

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

Al is the limiting reactant

$$n_{Cr} \text{ obtained} = 3.70$$

$$\text{mass of Cr obtained} = 3.70 \times 52 = 192.4 \text{ g}$$

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

$$6. \quad (a) \quad n_{H_2O_2} = 2 \times n_{N_2H_4} \\ = 2 \times 0.477 \\ = 0.954$$

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

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

$$n_{H_2O} = 4 \times n_{H_2O_2} = 4 \times 1.46 \times 10^{-3} \\ = 5.84 \times 10^{-3}$$

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

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

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

(a) Li is the limiting reactant

$\therefore$ no. of moles of lithium nitride formed

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

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

$$\text{mass of } Li_3N \text{ formed} = 2.286 \times 35$$

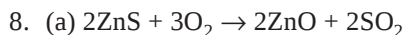
$$= 79.998$$

$$\approx 80 \text{ g}$$

$$(b) \quad n_{N_2} \text{ left in excess} = 0.517$$

$$\text{mass of } N_2 \text{ left} = 0.517 \times 28$$

$$= 14.476 \text{ g}$$



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

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

$$\begin{aligned}\text{n}_{\text{O}_2} \text{ required} &= 1.5 \times 3.647 \\ &= 5.47 \text{ mol}\end{aligned}$$

$$\text{mass of O}_2 \text{ required} = 5.47 \times 32 = 175.04 \text{ g}$$

(b) $n_{\text{SO}_2} = n_{\text{ZnS}} = 3.647$

$$1 \text{ mol of SO}_2 \text{ at STP} = 22400 \text{ mL}$$

$$\begin{aligned}\therefore 3.647 \text{ mol of SO}_2 \text{ at STP occupied} \\ &= 22400 \times 3.647 \\ &= 81693 \text{ mL}\end{aligned}$$

9. 1 L solution contains = 1.08 mol KCl

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

$$\begin{aligned}\text{mass of solution} &= 1000 \times 1.138 \\ &= 1138 \text{ g}\end{aligned}$$

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

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

$$\begin{aligned}10. \text{ Number of moles of } 6.00 \text{ M H}_2\text{SO}_4 \\ &= 6 \times 0.125 \\ &= 0.75\end{aligned}$$

$$\begin{aligned}\text{Number of moles of } 3.00 \text{ M H}_2\text{SO}_4 \\ &= 3 \times 0.225 \\ &= 0.675\end{aligned}$$

$$\begin{aligned}\text{Total no. of moles} &= 0.675 + 0.75 \\ &= 1.425\end{aligned}$$

$$\begin{aligned}\text{Molarity of the resultant solution} &= \frac{1.425}{0.350} \\ &= 4.07 \text{ M}\end{aligned}$$

$$\begin{aligned}
 11. \quad n_{\text{Ba(OH)}_2} &= 2.58 \times 10^{-3} \times 41 \times 10^{-3} \\
 &= 1.0578 \times 10^{-4} \\
 n_{\text{HNO}_3} &= 2 \times n_{\text{Ba(OH)}_2} \\
 &= 2 \times 1.0578 \times 10^{-4} \\
 &= 2.1156 \times 10^{-4}
 \end{aligned}$$

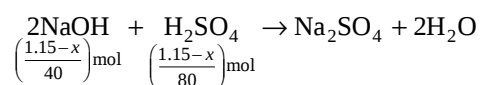
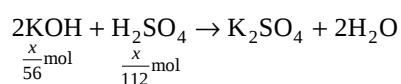
$$\text{Volume of HNO}_3 = 36 \times 10^{-3} \text{ L}$$

$$\begin{aligned}
 \text{Molarity of HNO}_3 &= \frac{2.1156 \times 10^{-4}}{36 \times 10^{-3}} \\
 &= 5.87 \times 10^{-3} \text{ M}
 \end{aligned}$$

$$\begin{aligned}
 12. \quad \text{Milimoles of H}_2\text{SO}_4 &= 12.1 \text{ and moles of} \\
 \text{H}_2\text{SO}_4 &= 12.1 \times 10^{-3}
 \end{aligned}$$

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

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



Number of moles of H₂SO₄ are

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

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

$$32x = 14.384$$

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

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

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

$$\begin{aligned}
 \text{Percentage of KOH} &= \frac{0.4495}{1.15} \times 100 \\
 &= 39.09\%
 \end{aligned}$$

$$\begin{aligned}
 \text{Percentage of NaOH} &= \frac{0.7005}{1.15} \times 100 \\
 &= 60.9\%
 \end{aligned}$$

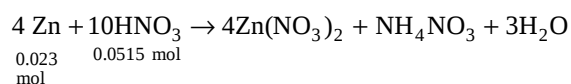
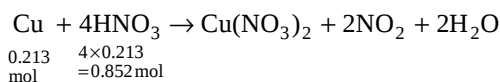
$$13. \quad \text{Mass of alloy} = 15.0 \text{ g}$$

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

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

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

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



$$\begin{aligned} \text{Total mol of HNO}_3 &= 0.852 + 0.0575 \\ &= 0.9095 \end{aligned}$$

$$\begin{aligned} \text{Volume of HNO}_3 &= \frac{0.9095}{3} = 0.3032\text{L} \\ &= 303.2 \text{ mL} \end{aligned}$$

$$\begin{aligned} \text{no. of moles of NO}_2 &= \frac{1}{2} \times n_{\text{HNO}_3} \text{ from Cu reaction} \\ &= \frac{1}{2} \times 0.852 = 0.426 \end{aligned}$$

Volume of NO₂ gas produced at 298 K and 1 atm is
 $0.426 \times 24.5 = 10.437 \text{ L}$



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 H₂SO₄



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

$$\begin{aligned} \text{and moles of H}_2\text{SO}_4 &= \left(\frac{10 \times 35 \times 1.28}{98} \right) \times 0.1 \\ &= 0.457 \end{aligned}$$

$$\begin{aligned}\text{no. of moles of H}_2 \text{ evolved} &= \frac{PV}{RT} \\ &= \frac{740 \times 2.105}{760 \times 0.0821 \times 300} = 0.0833\end{aligned}$$

$$\therefore \text{ no. of moles of H}_2\text{SO}_4 \text{ used} = 0.0833$$

$$\begin{aligned}\text{no. of moles of H}_2\text{SO}_4 \text{ left unused} \\ &= 0.457 - 0.0833 \\ &= 0.3737\end{aligned}$$

$$\text{Molarity of the final H}_2\text{SO}_4 = \frac{0.3737}{0.1} = 3.737$$

(a) The % by mass of final H₂SO₄

$$\begin{aligned}&= \frac{M \times 98}{10d} \\ &= \frac{3.737 \times 98}{10 \times 1.15} = 31.85\%\end{aligned}$$

(b) Number of moles of Mg used with H₂SO₄
= 0.0833

$$\begin{aligned}\text{Number of moles of Mg used with oxygen to form oxide} &= 0.133 - 0.0833 \\ &= 0.0497\end{aligned}$$

$$\text{Mass of Mg} = 0.0497 \times 24 = 1.193 \text{ g}$$

% of Mg converted to oxide

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

(c) Number of moles of O₂

$$\begin{aligned}&= \frac{1}{2} \times n_{\text{Mg}} = \frac{1}{2} \times 0.0497 \\ &= 0.02485\end{aligned}$$

$$\begin{aligned}\text{and mass of oxygen used} &= 0.02485 \times 32 \\ &= 0.795 \text{ g}\end{aligned}$$

15. 100 g of Haemoglobin contain 2.089 Fe

$$\begin{aligned}100 \text{ g of Haemoglobin contain } &\frac{2.08}{56} \\ &= 0.0371 \text{ mol Fe}\end{aligned}$$

$$\therefore 2.56 \text{ g of haemoglobin contain}$$

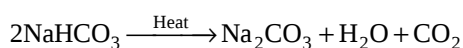
$$\frac{0.0371}{100} \times 2.56 \text{ mol Fe}$$

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_2CO_3 .



$$n_{\text{NaHCO}_3} = 2 \times n_{\text{CO}_2} = 2 \times \frac{32.0}{22400}$$

$$n_{\text{NaHCO}_3} = 2.857 \times 10^{-3}$$

$$\text{mass of NaHCO}_3 = 2.857 \times 10^{-3} \times 84$$

$$= 0.24 \text{ g}$$

Percentage of $\text{NaHCO}_3 = 24\%$

Percentage of $\text{Na}_2\text{CO}_3 = 76\%$

17. $\text{Na}_2\text{CO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O} + \text{CO}_2$

$$mm_{\text{Na}_2\text{CO}_3} = mm_{\text{H}_2\text{SO}_4}$$

$$= 0.05 \times 35.8 = 1.79$$

$$n_{\text{Na}_2\text{CO}_3} = 1.79 \times 10^{-3}$$

$$\text{mass of } n_{\text{Na}_2\text{CO}_3} = 1.79 \times 10^{-3} \times 106$$

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

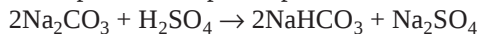
$\therefore$ in 250 ml solution, the mass of

$$\text{Na}_2\text{CO}_3 = 1.8974 \text{ g}$$

$$\therefore \text{Percentage of Na}_2\text{CO}_3 = \frac{1.8974}{5.125} \times 100$$

$$= 37.02\%$$

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



$$n_{\text{Na}_2\text{CO}_3} = 2 \times n_{\text{H}_2\text{SO}_4} = 2 \times 0.1 \times 5.0 \times 10^{-3}$$

$$n_{\text{Na}_2\text{CO}_3} = 1.0 \times 10^{-3}$$

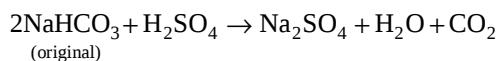
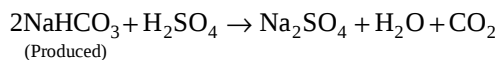
$$\text{Mass of Na}_2\text{CO}_3 = 1.0 \times 10^{-3} \times 106 = 0.106 \text{ g in } 20 \text{ cm}^3$$

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

$$\text{Na}_2\text{CO}_3 \text{ present is } \frac{0.106}{20} \times 1000$$

$$= 5.3 \text{ g/L}$$

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



$$n_{\text{NaHCO}_3(\text{prod.})} + n_{\text{NaHCO}_3(\text{original})} = 2 \times n_{\text{H}_2\text{SO}_4}$$

$$\text{But } n_{\text{NaHCO}_3(\text{prod.})} = 1.0 \times 10^{-3}$$

$$\therefore 1.0 \times 10^{-3} + n_{\text{NaHCO}_3(\text{original})} = 2 \times 0.2 \times 5 \times 10^{-3}$$

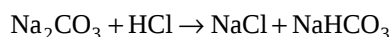
$$\begin{aligned} n_{\text{NaHCO}_3(\text{original})} &= 2.0 \times 10^{-3} - 1.0 \times 10^{-3} \\ &= 1.0 \times 10^{-3} \end{aligned}$$

$$\text{Mass of NaHCO}_3 = 1.0 \times 10^{-3} \times 84 = 0.084 \text{ in } 20 \text{ cm}^3$$

$\therefore$ mass of NaHCO_3 in

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

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

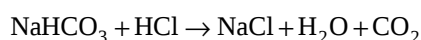
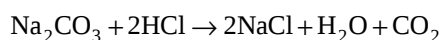


$$n_{\text{Na}_2\text{CO}_3} = n_{\text{HCl}} = 0.11 \times 15.7 \times 10^{-3}$$

$$n_{\text{Na}_2\text{CO}_3} = 1.727 \times 10^{-3}$$

$$\begin{aligned} \text{mass of Na}_2\text{CO}_3 &= 1.727 \times 10^{-3} \times 106 \\ &= 0.183 \text{ g} \end{aligned}$$

In the presence of methyl orange indicator:



$$2 \times n_{\text{Na}_2\text{CO}_3} + n_{\text{NaHCO}_3} = n_{\text{HCl}}$$

$$\begin{aligned} 2 \times 1.727 \times 10^{-3} + n_{\text{NaHCO}_3} &= 0.11 \times 43.8 \times 10^{-3} \\ &= 4.818 \times 10^{-3} \end{aligned}$$

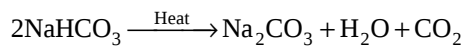
$$\begin{aligned} \therefore n_{\text{NaHCO}_3} &= 4.818 \times 10^{-3} - 3.454 \times 10^{-3} \\ &= 1.364 \times 10^{-3} \end{aligned}$$

$$\begin{aligned} \text{mass of NaHCO}_3 &= 1.364 \times 10^{-3} \times 84 \\ &= 0.1146 \text{ g} \end{aligned}$$

$$\text{Percentage of Na}_2\text{CO}_3 \text{ in the sample} = \frac{0.183}{0.527} \times 100 = 34.72\%$$

$$\text{Percentage of NaHCO}_3 \text{ in the sample} = \frac{0.1146}{0.527} \times 100 = 21.75 \%$$

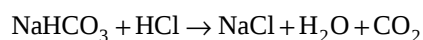
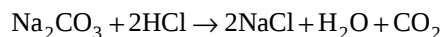
20. CO₂ gas is evolved only from NaHCO₃



$$n_{\text{NaHCO}_3} = 2 \times n_{\text{CO}_2} = 2 \times \frac{122.3}{24500} \\ = 0.01$$

$$\text{mass of NaHCO}_3 = 0.01 \times 84 = 0.84 \text{ g}$$

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



$$2 \times n_{\text{Na}_2\text{CO}_3} + n_{\text{NaHCO}_3} = n_{\text{HCl}}$$

$$2 \times n_{\text{Na}_2\text{CO}_3} + 0.01 = n_{\text{HCl}}$$

$$n_{\text{Na}_2\text{CO}_3} = 0.005$$

$$\text{mass of Na}_2\text{CO}_3 = 0.005 \times 106$$

$$= 0.53 \text{ g}$$

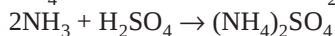
$$\text{Percentage of Na}_2\text{CO}_3 = \frac{0.84}{2.0} \times 100 = 42.0\%$$

$$\text{Percentage of Na}_2\text{CO}_3 = \frac{0.53}{2.0} \times 100 = 26.5\%$$

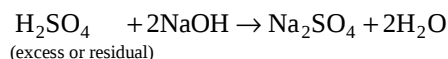
$$\text{Percentage of Na}_2\text{SO}_4 = \frac{0.63}{2.0} \times 100 = 31.5\%$$

21. NH₄Cl + NaOH → NaCl + H₂O + NH₃

...(1)



...(b)



(excess or residual)

Number of moles of residual H₂SO₄

$$= \frac{1}{2} \times n_{\text{NaOH}}$$

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

$$= 0.01575$$

Total number of moles of H₂SO₄

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

$$= 0.0375$$

Number of moles of H₂SO₄ neutralized by NH₃ in reaction (b) is

$$0.0375 - 0.01575$$

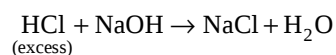
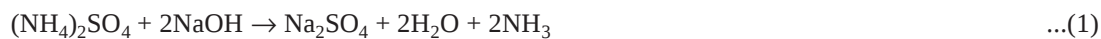
$$= 0.02175$$

$$\text{No. of moles of NH}_3 = 2 \times 0.02175 = 0.0435$$

$$\text{Mass of NH}_3 = 0.0435 \times 17 = 0.7395 \text{ g}$$

$$\begin{aligned} \text{Percentage of NH}_3 &= \frac{0.7395}{2.8} \times 100 \\ &= 26.4\% \end{aligned}$$

22. Only $(\text{NH}_4)_2\text{SO}_4$ liberates NH_3 gas on warming with NaOH



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

$$\begin{aligned} &= 0.1 \times 18.43 \times 10^{-3} \\ &= 0.001843 \end{aligned}$$

Total number of moles of HCl

$$\begin{aligned} &= 0.1 \times 20 \times 10^{-3} \\ &= 0.002 \end{aligned}$$

Number of moles of HCl neutralized by NH_3

$$\begin{aligned} &= 0.002 - 0.001843 \\ &= 1.57 \times 10^{-4} \end{aligned}$$

$$n_{(\text{NH}_4)_2\text{SO}_4} = 2 \times n_{\text{NH}_3} = 3.14 \times 10^{-4}$$

$$\begin{aligned} \text{mass of } (\text{NH}_4)_2\text{SO}_4 &= 3.14 \times 10^{-4} \times 132 \\ &= 0.0414 \end{aligned}$$

$$\begin{aligned} \text{Percentage of } (\text{NH}_4)_2\text{SO}_4 &= \frac{0.0414}{0.225} \times 100 \\ &= 18.42\% \end{aligned}$$