Stoichiometry with Solutions

1. What volume of 0.5 M H_3PO_4 is required to fully react with 250 g of Na_2CO_3 ? What amount of water is produced by this reaction?

$$\underset{\substack{\text{? L}\\ \text{0.5 M}}}{2\,H_3PO_4(aq)} + \underset{\text{250 g}}{3\,Na_2CO_3} \longrightarrow 2\,Na_3PO_4(aq) + \underset{\text{? mol}}{3\,H_2O(l)} + 3\,CO_2(g)$$

$$250\text{ g } Na_2CO_3 \times \frac{1\text{ mol } Na_2CO_3}{105.99\text{ g } Na_2CO_3} \times \frac{2\text{ mol } H_3PO_4}{3\text{ mol } Na_2CO_3} = 1.57\text{ mol } H_3PO_4$$

$$\begin{aligned} n &= 1.57\text{ mol} \\ C &= 0.5\text{ mol/L} \\ V &= ?\text{ L} \end{aligned}$$

$$\begin{aligned} V &= \frac{n}{C} \\ V &= \frac{1.57\text{ mol}}{0.5\text{ mol/L}} \\ V &= 3.14\text{ L} \end{aligned}$$

$$250\text{ g } Na_2CO_3 \times \frac{1\text{ mol } Na_2CO_3}{105.99\text{ g } Na_2CO_3} \times \frac{3\text{ mol } H_2O}{3\text{ mol } Na_2CO_3} = 2.36\text{ mol } H_2O$$

2. What volume of 0.25 M lead(II) nitrate is required to consume 500 g of pure silver? What mass of lead metal will form?

$$\underset{\substack{\text{? L}\\ \text{0.25 M}}}{Pb(NO_3)_2(aq)} + \underset{\text{500 g}}{2\,Ag(s)} \longrightarrow \underset{\text{? g}}{Pb(s)} + 2\,AgNO_3(aq)$$

$$500\text{ g Ag} \times \frac{1\text{ mol Ag}}{107.87\text{ g Ag}} \times \frac{1\text{ mol } Pb(NO_3)_2}{2\text{ mol Ag}} = 2.32\text{ mol } Pb(NO_3)_2$$

$$\begin{aligned} n &= 2.32\text{ mol} \\ C &= 0.25\text{ mol/L} \\ V &= ?\text{ L} \end{aligned}$$

$$\begin{aligned} V &= \frac{n}{C} \\ V &= \frac{2.32\text{ mol}}{0.25\text{ mol/L}} \\ V &= 9.27\text{ L} \end{aligned}$$

$$500\text{ g Ag} \times \frac{1\text{ mol Ag}}{107.87\text{ g Ag}} \times \frac{1\text{ mol Pb}}{2\text{ mol Ag}} \times \frac{207.2\text{ g Pb}}{1\text{ mol Pb}} = 480\text{ g Pb}$$

3. 115 g of aluminum sulphate is formed through a reaction between 2250 ml of aluminum nitrate solution and sufficient ammonium sulphate solution. What is the concentration of the aluminum nitrate solution?

$$3\,(NH_4)_2SO_4(aq) \;+\; \underset{\substack{?\ M\\ 2250\ mL}}{2\,Al(NO_3)_3(aq)} \longrightarrow \underset{115\ g}{Al_2(SO_4)_3(s)} \;+\; 6\,NH_4NO_3$$

$$115\ g\ Al_2(SO_4)_3 \times \frac{1\ mol\ Al_2(SO_4)_3}{342.17\ g\ Al_2(SO_4)_3} \times \frac{2\ mol\ Al(NO_3)_3}{1\ mol\ Al_2(SO_4)_3} = 0.672\ mol\ Al(NO_3)_3$$

$$\begin{aligned} n &= 0.672\ mol \\ C &= ?\ mol/L \\ V &= 2250\ mL \rightarrow 2.25\ L \end{aligned}$$

$$\begin{aligned} C &= \frac{n}{V} \\ C &= \frac{0.672\ mol}{2.25\ L} \\ C &= 0.299\ M \end{aligned}$$

4. If 5.00 g of $KHSO_3$ is fully reacted by 208 ml of calcium hydroxide solution, what is the concentration of the calcium hydroxide solution? If only 100 mL of the calcium hydroxide solution was used, what mass of $KHSO_3$ would be consummed?

$$\underset{\substack{?\ M\\ 208\ mL\\ \hline \text{answer for M}\\ 100\ mL}}{Ca(OH)_2(aq)} \;+\; \underset{\substack{5.00\ g\\ \hline ?\ g}}{2\,KHSO_3(s)} \longrightarrow Ca(HSO_3)_2(aq) \;+\; 2\,KOH(aq)$$

$$5.00\ g\ KHSO_3 \times \frac{1\ mol\ KHSO_3}{120.18\ g\ KHSO_3} \times \frac{1\ mol\ Ca(OH)_2}{2\ mol\ KHSO_3} = 0.0208\ mol\ Ca(OH)_2$$

$$\begin{aligned} n &= 0.0208\ mol \\ C &= ?\ mol/L \\ V &= 208\ mL \rightarrow 0.208\ L \end{aligned}$$

$$\begin{aligned} C &= \frac{n}{V} \\ C &= \frac{0.0208\ mol}{0.208\ L} \\ C &= 0.100\ M \end{aligned}$$

$$\begin{aligned} n &= ? \\ C &= 0.100\ mol/L \\ V &= 100\ mL \rightarrow 0.100\ L \end{aligned}$$

$$\begin{aligned} n &= CV \\ n &= 0.100\ mol/L \text{ x } 0.100\ L \\ n &= 0.0100\ mol\ Ca(OH)_2 \end{aligned}$$

$$0.0100\ mol\ Ca(OH)_2 \times \frac{2\ mol\ KHSO_3}{1\ mol\ Ca(OH)_2} \times \frac{120.18\ g\ KHSO_3}{1\ mol\ KHSO_3} = 2.40\ g\ KHSO_3$$

5. In one method of gold purification, potassium gold(III) cyanide is reacted with pure magnesium metal. If 56 000 L of $K_3Au(CN)_6$ solution (yes that is a very large volume) can be fully extracted by 25.2 g of magnesium, what is the concentration of the solution? What mass of pure gold would form?

$$\underset{\substack{?\text{ M}\\56\,000\text{ L}}}{2\,K_3Au(CN)_6(aq)} + \underset{25.2\text{ g}}{3\,Mg(s)} \longrightarrow \underset{?\text{ g}}{2\,Au(s)} + 3\,Mg(CN)_2(aq) + 3\,KCN(aq)$$

$$25.2\text{ g Mg} \times \frac{1\text{ mol Mg}}{24.31\text{ g Mg}} \times \frac{2\text{ mol } K_3Au(CN)_6}{3\text{ mol Mg}} = 0.691\text{ mol } K_3Au(CN)_6$$

$$\begin{aligned} n &= 0.691\text{ mol} \\ C &= ?\text{ mol/L} \\ V &= 56\,000\text{ L} \end{aligned}$$

$$\begin{aligned} C &= \frac{n}{V} \\ C &= \frac{0.691\text{ mol}}{56\,000\text{ L}} \\ C &= 1.23 \text{ x } 10^{-5}\text{ M} \end{aligned}$$

$$25.2\text{ g Mg} \times \frac{1\text{ mol Mg}}{24.31\text{ g Mg}} \times \frac{2\text{ mol Au}}{3\text{ mol Mg}} \times \frac{196.97\text{ g Au}}{1\text{ mol Au}} = 136\text{ g Au}$$