# Acid – Base Stoichiometry

1. The concentration of hydrochloric acid in the human stomach is approximately 0.10 mol $dm^{-3}$. Excess of this acid causes discomfort referred to as 'heartburn' or 'acid indigestion'. Remedies designed to neutralize some of this excess acid often contain compounds such as magnesium hydroxide, $Mg(OH)_2$, and sodium hydrogencarbonate, $NaHCO_3$.

a. Write a balanced chemical equation for the reaction of $Mg(OH)_2$ with hydrochloric acid.

b. Calculate the number of moles of hydrochloric acid which can be neutralized by 1.00 g of magnesium hydroxide.

c. Calculate the volume of 0.100 mol $dm^{-3}$ HCl which can be neutralized by 1.00 g of magnesium hydroxide, giving your answer to 3 significant figures.

2. A household cleaner contains aqueous ammonia, $NaOH_{(aq)}$. A 2.447 g sample of the cleaner is diluted with water to 20.00 $cm^3$ . This solution requires 28.51 $cm^3$ of 0.4040 mol $dm^{-3}$ sulphuric acid, $H_2SO_{4\ (aq)}$ .

a. Write a balanced equation for the neutralisation of sodium hydroxide solution with sulphuric acid to form sodium sulphate.

b. Calculate the number of moles of sulphuric acid used in the neutralisation.

c. Calculate the number of moles of sodium hydroxide neutralised by the sulphuric acid.

d. Calculate the mass of sodium hydroxide neutralised by the sulphuric acid.

e. Calculate the percentage by mass of sodium hydroxide present in the household cleaner.

3. If 5.25 g of barium hydroxide is to be neutralized with phosphoric acid, 0.200 mol $L^{-1}$ according to the equation:

$$Ba(OH)_{2\ (aq)} + H_3PO_{4\ (aq)} \longrightarrow Ba_3(PO_4)_{2\ (aq)} + H_2O_{(l)}$$

a. Balance the above equation.
b. What volume of acid would be required for complete reaction?

4. How many grams of $Ca(NO_3)_2$ can be prepared by reacting 125 mL of 5.00 M $HNO_3$ with 5.55 g of $Ca(OH)_2$ ?

$$HNO_{3\ (aq)} + Ca(OH)_{2\ (s)} \longrightarrow Ca(NO_3)_{2\ (aq)} + H_2O_{(l)}$$

**(Balance ???, think Limiting reactant???)**

5. Zinc metal reacts with $HCl_{(aq)}$, according to the following equation:

$$Zn_{(s)} + HCl_{(aq)} \longrightarrow H_{2\,(g)} + ZnCl_{2\,(aq)}$$

Determine the mass of zinc that is required to completely react with 75.0 mL of 3.0 M HCl.

6. Calculate the volume of 1.50 M HCl that is required for 5.40 g of Al to react completely.

$$Al_{(s)} + HCl_{(aq)} \longrightarrow AlCl_{3\,(aq)} + H_{2\,(g)}$$

7. An Alka-Seltzer tablet contains hydrogen carbonate, citric acid, and an analgesic (painkiller). When water is added, the hydrogen ions from the citric acid react with the hydrogen carbonate ion as follows:

$$H^{+1}_{(aq)} + NaHCO_{3(aq)} \longrightarrow Na^{+1}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

If an Alka–Seltzer tablet contains 1.65 g of sodium hydrogen carbonate, $NaHCO_{3(s)}$, and is reacted with 2.00 mol $L^{-1}$ hydrochloric acid, $HCl_{(aq)}$, according to the above equation,

a. What volume of hydrochloric acid is required for complete reaction?

b. Suggest why citric acid is used rather than any other acid.

8. Tums, essentially calcium carbonate, $CaCO_3$, on the market are sold as an antacid. A tablet of Tums was crushed and reacted with hydrochloric acid, $HCl_{(aq)}$. 28.50 mL of 0.200 mol $L^{-1}$ hydrochloric acid was required to completely neutralize one of the Tums tablet.

a. Write a balanced equation for the reaction of the Tums tablet, ($CaCO_{3\,(s)}$) with hydrochloric acid, $HCl_{(aq)}$.

b. Determine the mols of hydrochloric acid consumed.

c. Determine the mols of Tums consumed.

d. Determine the mass of the $CaCO_{3(s)}$ in each of the Tums tablet.

9. Copper (II) nitrate, $Cu(NO_3)_2$, can be prepared by reacting nitric acid, $HNO_{3(aq)}$, with copper metal.

a. Write a balanced chemical equation.

A student carries out this reaction by adding 0.0345 mol of copper(II) oxide to 36.0 $cm^3$ of 1.15 mol $L^{-1}$ nitric acid solution.

b. Calculate the amount (in mol) of nitric acid.

c. Identify the limiting reactant.

d. Determine the number of mols of copper (II) nitrate that is formed in this reaction.

e. Determine the mass of copper (II) nitrate that is formed in this reaction.