# Chemistry 2.1
# Quantitative Analysis

## Chemical Calculation 2

# Stoichiometry

- Stoichiometry is the determination of the numerical ratio of the mole relationships in a chemical reaction.
- Stoichiometry follows the basic principle of “matter cannot be created or destroy”
- Using Stoichiometry, chemist can accurately estimate the amount of reactant required or the amount of product forms.

# Example

- For reaction

$$4\,Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

The stoichiometry (ratio) between

$Al : O_2 = 4 : 3$

$Al : Al_2O_3 = 2 : 1$

$O_2 : Al_2O_3 = 3 : 2$

# Calculation example 1

Calculate the mass of water that will react completely with 4.0 g of pure calcium metal according to the following equation

$$Ca_{(s)} + 2\ H_2O_{(l)} \rightarrow Ca(OH)_{2(s)} + H_{2(g)}$$

Step 1: calculate the mole of Ca

$g \div gmol^{-1} = mol$

$4.0\ g \div 40.0\ gmol^{-1} = 0.1\ mol$

Step 2: determine the ratio between

$Ca : H_2O$

$Ca : H_2O = 1 : 2$

Step 3: determine the mole of $H_2O$ by applying the ratio

$2 \times 0.1\ mol = 0.2\ mol$

Step 4: calculate the mass of $H_2O$

$mol \times gmol^{-1} = g$

$0.2\ mol \times 18.0\ gmol^{-1} = \underline{3.6\ g}$

# Calculation example 2

Calculate the mass of $CO_2$ formed when 10.0 g of ethane is fully combusted

$$C_2H_6 + 3½\ O_2 \rightarrow 2CO_2 + 3H_2O$$

Step 1: calculate the mole of $C_2H_6$

$g \div gmol^{-1} = mol$

$10.0g \div 30.0gmol^{-1} = 0.333mol$

Step 2: determine the ratio between

$C_2H_6 : CO_2$

$C_2H_6 : CO_2 = 1 : 2$

Step 3: determine the mole of $CO_2$ by applying the ratio

$2 \times 0.33\ mol = 0.667\ mol$

Step 4: calculate the mass of $CO_2$

$mol \times gmol^{-1} = g$

$0.667\ mol \times 44\ gmol^{-1} = \underline{29.3\ g}$

# Calculation example 3

Calculate the volume of 0.1 $molL^{-1}$ of HCl is needed to react with 20.0mL of 0.0986 $molL^{-1}$ of NaOH

$$HCl + NaOH \rightarrow NaCl + H_2O$$

Step 1: calculate the mole of NaOH

$molL^{-1} \times L = mol$

$0.0986molL^{-1} \times 0.02L =$

$1.972 \times 10^{-3}$ mol

Step 2: determine the ratio between

HCl : NaOH

HCl : NaOH = 1 : 1

Step 3: determine the mole of HCl by applying the ratio

$1.972 \times 10^{-3}$ mol

Step 4: calculate the volume

$mol \div molL^{-1} = L$

$1.972 \times 10^{-3}$ mol $\div$ $0.1molL^{-1}$

= <u>0.01972 L = 19.7 mL (3s.f.)</u>

# Calculation example 4

Calculate the concentration of HCl when 20.7mL of 0.103 $molL^{-1}$ of NaOH is needed to react with 20.0 mL of HCl.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

Step 1: calculate the mole of NaOH

$molL^{-1} \times L = mol$

$0.103molL^{-1} \times 0.0207L = 2.1321 \times 10^{-3}$ mol

Step 2: determine the ratio between

HCl : NaOH

HCl : NaOH = 1 : 1

$2.1321 \times 10^{-3}$ mol

Step 3: determine the mole of HCl by applying the ratio

Step 4: calculate the volume

$mol \div L = molL^{-1}$

$2.1321 \times 10^{-3}$ mol $\div$ 0.02 L = <u>0.107 $molL^{-1}$(3s.f.)</u>