Mass concentration ($g.L^{-1}$)

The mass concentration (ρ) of a solution is a measure of the mass (m) of solute (in grams) per unit volume (V) of solution (in litres).

$$\rho = \frac{m}{V} \qquad \text{SI unit} = \frac{g}{L} = g.L^{-1}$$

ρ	=	Mass concentration	(grams per litre)
m	=	Mass of solute	(grams)
V	=	Volume of solution	(litres)

Example 1

An iodine solution used as a disinfectant is prepared by dissolving 0.050 g of iodine (I_2) in 20 mL of distilled water.

Determine the mass concentration of the iodine solution.

$$\rho = \frac{m}{V}$$

$$\rho = \frac{0.050}{0.020}$$

$$\rho = 2.5\ g.L^{-1}$$

Example 2

A popular brand of drain cleaner contains sodium hydroxide in a concentration of 50 $g.L^{-1}$.

Determine the mass of sodium hydroxide in a 600 mL volume of drain cleaner.

$$m = \rho V$$

$$m = 50 \times 0.600$$

$$m = 30\ g$$

Percentage weight per volume (%w/v)

The mass concentration of a solution in percentage weight per volume is equivalent to the mass of solute (in grams) in a 100 mL volume (V) of solution.

$$\%w/v = \frac{m\ (g)}{V\ (mL)} \times 100$$

%w/v	=	Percent weight per volume	
m	=	Mass of solute	(grams)
V	=	Volume of solution	(millilitres)

Example 1

A 75 mL tube of whitening toothpaste contains sodium fluoride 0.017 g of sodium fluoride (NaF).

Determine the %w/v of sodium fluoride in the tube of toothpaste.

$$\%w/v = \frac{m}{V} \times 100$$

$$\%w/v = \frac{0.017}{75} \times 100$$

$$\%w/v = 0.023$$

Example 2

A bottle of white wine contains ethanol in a concentration of 11%w/v.

Determine the mass of ethanol in a 750 mL bottle of white wine.

$$\%w/v = \frac{m}{V} \times 100$$

$$m = \frac{\%w/v \times V}{100}$$

$$m = \frac{11 \times 750}{100}$$

$$m = 83\ g$$

Knowledge of the mole ratios of reactants can be used in quantitative calculations.

- Perform stoichiometric calculations when given the reaction equation and the necessary data.

Stoichiometry describes the quantitative relationships between reactants and products in a chemical reaction. Stoichiometry uses the reacting mole ratio (stoichiometric ratio/ratio of coefficients) from a balanced chemical equation to determine the quantity (mass, number of moles, volume or concentration) of a material that is reacted or produced in a chemical reaction.

Example

Hydrochloric acid solution (0.50 mol.L^{-1}, 50 mL) is poured onto a sample of calcium carbonate ($CaCO_3$).

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

Determine the maximum mass of carbon dioxide (CO_2) that can be produced in the reaction.

1. The first step in solving the problem is to determine the number of moles of hydrochloric acid that reacted with calcium carbonate in the reaction.

$$n_{HCl} = cV$$
$$n_{HCl} = 0.50 \times 0.050$$
$$n_{HCl} = 0.025 \text{ mol}$$

2. The maximum number of moles (n) of carbon dioxide that can be produced in the reaction is predicted from the stoichiometric ratio of hydrochloric acid to carbon dioxide.

$$\text{ratio} = 2n_{HCl} : 1n_{CO_2}$$
$$n_{CO_2} = \frac{n_{HCl}}{2}$$
$$n_{CO_2} = \frac{0.025}{2}$$
$$n_{CO_2} = 0.013 \text{ mol } (0.0125)$$

3. The maximum mass (m) of carbon dioxide that can be produced in the reaction is determined from the number of moles (n) and molar mass (M) of carbon dioxide (44.01 g.mol^{-1}).

$$m_{CO_2} = n_{CO_2} M_{CO_2}$$
$$m_{CO_2} = 0.0125 \times 44.01$$
$$m_{CO_2} = 0.55 \text{ g}$$