Calculating and comparing solution concentrations

Learning objectives

1. Recall how to convert between volumes in cm^3 and dm^3.
2. Define the word 'concentration' from a given numerical value.
3. Calculate the concentration of a solution in both g dm^{-3} and mol dm^{-3}.
4. Convert the concentration of a solution from g dm^{-3} to mol dm^{-3} and vice versa.

Introduction

In chemistry, concentration describes how much of a substance (the solute) is present in a given volume of solution. Concentration is most commonly expressed in two ways: grams per cubic decimetre (g dm^{-3}) and moles per cubic decimetre (mol dm^{-3}).

Both units relate the amount of solute to the volume of solution. Being confident in using them is essential for quantitative chemistry, including titrations and stoichiometric calculations.

In this lesson, you will recap key information including converting between units, calculating concentration in both g dm^{-3} and mol dm^{-3}, as well as converting between them.

You will use the following equations throughout this worksheet:

$$\text{concentration (g dm}^{-3}) = \frac{\text{mass (g)}}{\text{volume (dm}^3)}$$

$$\text{concentration (mol dm}^{-3}) = \frac{\text{moles (mol)}}{\text{volume (dm}^3)}$$

$$\text{moles (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1})}$$

The molar mass of the solute is used to convert between mol dm^{-3} and g dm^{-3}:

- to convert from mol dm^{-3} to g dm^{-3}, multiply by the molar mass
- to convert from g dm^{-3} to mol dm^{-3}, divide by the molar mass

Explaining concentrations

Complete the explanation boxes below to show how you would attempt a particular problem. Once completed tick one of the **can do/can't do/not sure** boxes.

Once you have completed this independently, pair up with another learner and turn your 'can't do' or 'not sure' boxes into 'can do' boxes. Use a different coloured pen so you can see how you have improved your knowledge.

Explanation	Can do	Can't do	Not sure
Convert 20 cm^3 into dm^3			
Convert 1.5 dm^3 into cm^3			
Describe what a solution having a concentration of 0.5 mol dm^{-3} means.			
Explain how to convert 4 g of sodium hydroxide into moles.			
Calculate the concentration in g dm^{-3} of a sodium chloride solution when 4 g of sodium chloride is dissolved in 50 cm^3 of water.			

Card matching

Task 1

Your teacher will provide you with a series of concentration cards (reproduced below). Work in pairs to match each concentration with the correct mass and volume. Use the equations at the top of the page to support you.

2 g NaOH	4 g NaOH
10 g NaOH	40 g NaOH
100 cm^3 water	0.5 dm^3 water
250 cm^3 water	2 dm^3 water
4 g dm^{-3} NaOH	0.4 mol dm^{-3} NaOH
0.5 mol dm^{-3} NaOH	2.5 mol dm^{-3} Na^+ ions

Write your answers in the table below.

Concentration	Mass of NaOH	Volume of water
4 g dm^{-3} NaOH		
0.4 mol dm^{-3} NaOH		
0.5 mol dm^{-3} NaOH		
2.5 mol dm^{-3} Na^+ ions		

Task 2

Your teacher will provide you with a set of blank concentration cards. You must pick one solute from the list below and create a series of calculations based on this.

- sodium carbonate
- sulfuric acid
- potassium hydroxide
- calcium bromide
- copper(II) sulfate

As above, you need to have four different concentrations (a mixture of g dm^{-3} and mol dm^{-3}) with the corresponding mass and volume. Record these in the table below so that your classmates can assess their answers.

Concentration	Mass of …	Volume of water

Task 3

Swap your concentration cards with another group. Determine the mass and volume needed to make solutions of a certain concentration.

Write your answers in the table below.

Concentration	Mass of …	Volume of water

Extension activity

Calculate the final concentrations in mol dm^{-3} of H^+, Na^+, Cl^- and SO_4^{2-}, when the following three solutions are mixed to give a total volume of 2 dm^3:

- 1000 cm^3 of 0.1 mol dm^{-3} HCl
- 500 cm^3 of 0.2 mol dm^{-3} $NaCl$
- 500 cm^3 of 0.2 mol dm^{-3} Na_2SO_4

Blank cards for task 2

concentration (g dm-3)	concentration (g dm-3)	concentration (mol dm-3)
concentration (mol dm-3)	mass	mass
mass	mass	volume
volume	volume	volume