Concentrations in mol/dm³

4.3.4 · Quantitative chemistry · revision notes

Concentration can also be measured in moles per dm^3 (mol/dm^3). You use it to find the amount or mass of solute in a solution and, from titration results, the concentration of an unknown solution. This subtopic is in GCSE Chemistry only (not Combined Science) and is Higher tier only.

Key facts

- concentration (mol/dm^3) = moles ÷ volume (dm^3)
- volume (dm^3) = moles ÷ concentration
- g/dm^3 = mol/dm^3 × M_r
- Concordant titres: within 0.10 cm^3 of each other
- moles = concentration × volume (dm^3)
- cm^3 ÷ 1000 = dm^3
- Titration: moles known → ratio → moles unknown → ÷ volume

Notes

Concentration in mol/dm³

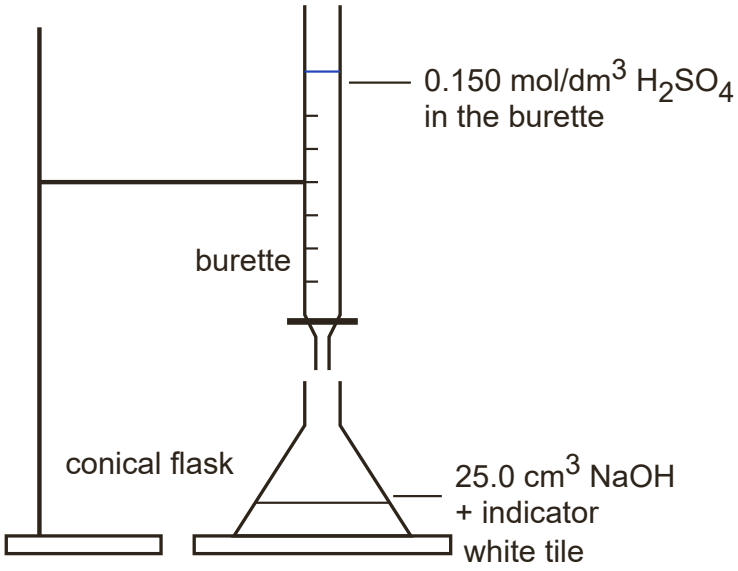
- concentration (mol/dm^3) = amount of solute (mol) ÷ volume of solution (dm^3)
- Rearranged: moles = concentration × volume (dm^3). Always convert cm^3 to dm^3 first (÷ 1000).
- Mass of solute = moles × M_r, so concentration in g/dm^3 = concentration in mol/dm^3 × M_r.
- Example: 25.0 cm^3 of 0.200 mol/dm^3 NaOH contains 0.200 × 0.0250 = 0.00500 mol, which is 0.00500 × 40 = 0.200 g.
- The concentration is higher if there is more solute (more moles or more grams) in the same volume, or the same amount of solute in a smaller volume.

Titration calculations

- A **titration** finds the volumes of two solutions that react completely. If you know the concentration of one, you can calculate the concentration of the other.
- Step 1: moles of the solution you know = concentration × volume (dm^3).
- Step 2: use the balanced equation to find the moles of the other substance.
- Step 3: concentration of the unknown = moles ÷ its volume (dm^3).
- Use the mean of **concordant** titres (results within 0.10 cm^3 of each other).

Worked example

- 25.0 cm^3 of sodium hydroxide solution is neutralised by 20.0 cm^3 of 0.150 mol/dm^3 sulfuric acid. H_2SO_4 + $2NaOH \rightarrow Na_2SO_4 + 2H_2O$



The worked example on the bench: 20.0 cm^3 of the acid (known concentration) neutralises the 25.0 cm^3 of alkali.

- Moles of H_2SO_4 = 0.150 × 0.0200 = 0.00300 mol.
- The ratio is 1 : 2, so moles of NaOH = 0.00600 mol.
- Concentration of NaOH = 0.00600 ÷ 0.0250 = 0.240 mol/dm^3. In g/dm^3: 0.240 × 40 = 9.60 g/dm^3.

How to answer each type of question

Calculate the moles or mass of solute in a solution 2 to 3 marks **Grade 6**

1. Convert the volume to dm^3.
2. Moles = concentration × volume.
3. If a mass is asked for, multiply by the M_r.

Example. Calculate the mass of potassium hydroxide, KOH, in 50.0 cm^3 of a 0.400 mol/dm^3 solution. A_r: H = 1; O = 16; K = 39 [3 marks]

Model answer.

moles = 0.400 × (50.0 ÷ 1000) = 0.0200 mol (1)

M_r of KOH = 56 (1)

mass = 0.0200 × 56 = 1.12 g (1)

Compare the concentrations of two solutions

2 marks | Grade 7

1. Convert both to the same unit (usually mol/dm^3).
2. Compare the numbers and state which is more concentrated.

Example. Solution A contains 4.0 g of sodium hydroxide in 500 cm^3. Solution B contains 0.10 mol of sodium hydroxide in 250 cm^3.
Which solution is more concentrated? Show your working.
M_r: NaOH = 40 [2 marks]

Model answer.

A: 4.0 ÷ 40 = 0.10 mol, and 0.10 ÷ 0.500 = 0.20 mol/dm^3 (1)

B: 0.10 ÷ 0.250 = 0.40 mol/dm^3, so B is more concentrated (1)

Calculate a concentration from titration results

4 marks | Grade 8

1. Moles of the known solution = concentration × volume (dm^3).
2. Use the equation to find the moles of the unknown.
3. Divide by the volume of the unknown in dm^3.
4. Give the unit, mol/dm^3.

Example. A student titrated 25.0 cm^3 of hydrochloric acid with 0.100 mol/dm^3 sodium hydroxide solution. The mean titre was 27.5 cm^3.
$NaOH + HCl \rightarrow NaCl + H_2O$

Calculate the concentration of the hydrochloric acid in mol/dm^3. [4 marks]

Model answer.

moles of NaOH = 0.100 × 0.0275 = 0.00275 mol (1)

ratio 1 : 1, so moles of HCl = 0.00275 mol (1)

concentration = 0.00275 ÷ 0.0250 (1)

= 0.110 mol/dm^3 (1)

Titration with a 1 : 2 ratio, answer in g/dm^3

5 marks | Grade 9

1. Find the moles of the solution you know.
2. Apply the mole ratio carefully (halve or double).
3. Find the concentration in mol/dm^3.
4. Multiply by the M_r to get g/dm^3.

Example. 20.0 cm^3 of calcium hydroxide solution was neutralised by 16.0 cm^3 of 0.0500 mol/dm^3 hydrochloric acid.

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

Calculate the concentration of the calcium hydroxide solution in g/dm^3.

M_r: $Ca(OH)_2$ = 74 [5 marks]

Model answer.

moles of HCl = 0.0500 × 0.0160 = 8.00 × 10^{-4} mol	(1)
moles of $Ca(OH)_2$ = 8.00 × 10^{-4} ÷ 2 = 4.00 × 10^{-4} mol	(1)
concentration = 4.00 × 10^{-4} ÷ 0.0200 = 0.0200 mol/dm^3	(1)
0.0200 × 74	(1)
= 1.48 g/dm^3	(1)

Don’t lose marks

- Using cm^3 in the equation without dividing by 1000.
- Ignoring the mole ratio when it is not 1 : 1 (e.g. with H_2SO_4 or $Ca(OH)_2$).
- Dividing by the wrong volume at the end: use the volume of the solution whose concentration you want.
- Including the rough titre, or a titre that is not concordant, in the mean.
- Mixing up mol/dm^3 and g/dm^3, or giving the wrong unit.

More tips

Memory tricks

- Triangle: moles on top, concentration × volume (dm^3) underneath.
- Titration chain: known concentration × volume → moles → ratio → moles → ÷ volume → unknown concentration.
- Sense check: in a 1 : 1 titration, the solution that needed the smaller volume is the more concentrated one.
- mol/dm^3 to g/dm^3: multiply by M_r. g/dm^3 to mol/dm^3: divide by M_r.

Exam technique

- Set out titration calculations line by line with labels; each line is usually worth a mark.
- Keep full calculator values between steps and round at the end, usually to 3 significant figures.
- Check the unit asked for: some questions want mol/dm^3 and others want g/dm^3.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 6 — **Calculate concentration in mol/dm^3**

Concentration = moles of solute ÷ volume of solution in dm^3.

Grade 6 — **Calculate moles from concentration and volume**

Moles = concentration (mol/dm^3) × volume (dm^3).

Grade 7 — **Convert between mol/dm^3 and g/dm^3**

Multiply mol/dm^3 by M_r to get g/dm^3; divide by M_r to go back.

Grade 7 — **Explain how amount and volume affect concentration**

More solute in the same volume gives a higher concentration; the same solute in more volume gives a lower one.

Grade 8 — **Find a concentration from titration results**

Moles of the known solution → mole ratio → moles of the unknown → divide by its volume.

Grade 9 — **Solve multi-step titration problems**

Use ratios other than 1 : 1 and convert the final answer to g/dm^3 when asked.

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