

Converting Concentrations

Mark Scheme



www.scienceexamssorted.co.uk

Task 1: converting g/dm³ to mol/dm³

1. Convert the concentrations of the following substances from g/dm³ to mol/dm³.

a. A solution of sodium chloride (NaCl) has a concentration of 29.25 g/dm³.
Calculate the concentration in mol/dm³.

Step 1: Calculate the relative formula mass (Mr) of NaCl. Mr of NaCl = 23 + 35.5 = 58.5	1 mark
Step 2: Calculate the concentration in mol/dm³. concentration (mol/dm ³) = concentration (g/dm ³) ÷ Mr concentration = 29.25 ÷ 58.5 = 0.5 mol/dm ³ Concentration = 0.500 mol/dm ³	1 mark
	Total: 2 marks

b. A solution of potassium hydroxide (KOH) has a concentration of 14.0 g/dm³.
Calculate the concentration in mol/dm³.

Mr of KOH = 39 + 16 + 1 = 56	1 mark
Concentration = concentration (g/dm ³) ÷ Mr Concentration = 14.0 ÷ 56 = 0.25 mol/dm ³ Concentration = 0.250 mol/dm ³	1 mark
	Total: 2 marks

c. A solution of hydrogen fluoride (HF) has a concentration of 4.0 g/dm³.
Calculate the concentration in mol/dm³.

Mr of HF = 1 + 19 = 20	1 mark
Concentration = concentration (g/dm ³) ÷ Mr Concentration = 4.0 ÷ 20 = 0.2 mol/dm ³ Concentration = 0.20 mol/dm ³	1 mark
	Total: 2 marks

d. A solution of pure water (H₂O) has a concentration of 1000 g/dm³.
Calculate its concentration in mol/dm³.

Mr of H ₂ O = (2 × 1) + 16 = 18	1 mark
Concentration (mol/dm ³) = concentration (g/dm ³) ÷ Mr Concentration = 1000 ÷ 18 = 55.555 mol/dm ³ Concentration = 55.6 mol/dm ³ (to 3 significant figures)	1 mark
	Total: 2 marks

- e. A solution of nitric acid (HNO_3) has a concentration of 31.5 g/dm^3 .
Calculate the concentration in mol/dm^3 .

Mr of $\text{HNO}_3 = 1 + 14 + (3 \times 16) = 63$	1 mark
Concentration (mol/dm^3) = concentration (g/dm^3) $\div$ Mr Concentration = $31.5 \div 63 = 0.5 \text{ mol/dm}^3$ Concentration = 0.500 mol/dm^3	1 mark
	Total: 2 marks

- f. A solution of sulfuric acid (H_2SO_4) has a concentration of 49.0 g/dm^3 .
Calculate the concentration in mol/dm^3 .

Mr of $\text{H}_2\text{SO}_4 = (2 \times 1) + 32 + (4 \times 16) = 98$	1 mark
Concentration (mol/dm^3) = concentration (g/dm^3) $\div$ Mr Concentration = $49.0 \div 98 = 0.5 \text{ mol/dm}^3$ Concentration = 0.500 mol/dm^3	1 mark
	Total: 2 marks

- g. A solution of calcium hydroxide (Ca(OH)_2) has a concentration of 3.7 g/dm^3 .
Calculate the concentration in mol/dm^3 .

Mr of $\text{Ca(OH)}_2 = 40 + 2 \times (16 + 1) = 74$	1 mark
Concentration (mol/dm^3) = concentration (g/dm^3) $\div$ Mr Concentration = $3.7 \div 74 = 0.05 \text{ mol/dm}^3$ Concentration = 0.050 mol/dm^3	1 mark
	Total: 2 marks

- h. A solution of magnesium nitrate ($\text{Mg(NO}_3)_2$) has a concentration of 14.8 g/dm^3 .
Calculate the concentration in mol/dm^3 .

Mr of $\text{Mg(NO}_3)_2 = 24 + 2 \times (14 + (3 \times 16)) = 148$	1 mark
Concentration (mol/dm^3) = concentration (g/dm^3) $\div$ Mr Concentration = $14.8 \div 148 = 0.1 \text{ mol/dm}^3$ Concentration = 0.100 mol/dm^3	1 mark
	Total: 2 marks

- i. A solution of ammonium sulfate ($(\text{NH}_4)_2\text{SO}_4$) has a concentration of 198 g/dm^3 .
Calculate the concentration in mol/dm^3 .

Mr of $(\text{NH}_4)_2\text{SO}_4 = 2 \times (14 + (4 \times 1)) + 32 + (4 \times 16) = 132$	1 mark
Concentration = $198 \div 132 = 1.5 \text{ mol/dm}^3$ Concentration = 1.50 mol/dm^3	1 mark
	Total: 2 marks

- j. A solution of hydrated copper(II) sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) has a concentration of 49.9 g/dm^3 .
Calculate the concentration in mol/dm^3 .

Mr of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 63.5 + 32 + (4 \times 16) + 5 \times ((2 \times 1) + 16) = 249.5$	1 mark
Concentration = $49.9 \div 249.5 = 0.2 \text{ mol/dm}^3$ Concentration = 0.200 mol/dm	1 mark
	Total: 2 marks

(Total for Question 1 is 20 marks)

Task 2: converting mol/dm³ to g/dm³

2. Convert the concentrations of the following substances from mol/dm³ to g/dm³.

a. A solution of sodium fluoride (NaF) has a concentration of 2.0 mol/dm³.

Calculate the concentration in g/dm³.

Mr of NaF = 23 + 19 = 42	1 mark
Concentration (g/dm ³) = concentration (mol/dm ³) × Mr Concentration = 2.0 × 42 = 84 g/dm ³ Concentration = 84.0 g/dm ³	1 mark
	Total: 2 marks

b. A solution of potassium bromide (KBr) has a concentration of 0.5 mol/dm³.

Calculate the concentration in g/dm³.

Mr of KBr = 39 + 80 = 119	1 mark
Concentration (g/dm ³) = concentration (mol/dm ³) × Mr Concentration = 0.5 × 119 = 59.5 g/dm ³ Concentration = 59.5 g/dm ³	1 mark
	Total: 2 marks

c. A solution of hydrochloric acid (HCl) has a concentration of 1.5 mol/dm³.

Calculate the concentration in g/dm³.

Mr of HCl = 1 + 35.5 = 36.5	1 mark
Concentration (g/dm ³) = concentration (mol/dm ³) × Mr Concentration = 1.5 × 36.5 = 54.75 g/dm ³ Concentration = 54.8 g/dm ³ (or 54.75)	1 mark
	Total: 2 marks

d. A solution of nitric acid (HNO₃) has a concentration of 0.2 mol/dm³.

Calculate the concentration in g/dm³.

Mr of HNO ₃ = 1 + 14 + (3 × 16) = 63	1 mark
Concentration (g/dm ³) = concentration (mol/dm ³) × Mr Concentration = 0.2 × 63 = 12.6 g/dm ³ Concentration = 12.6 g/dm ³	1 mark
	Total: 2 marks

e. A solution of calcium chloride (CaCl₂) has a concentration of 0.1 mol/dm³.

Calculate the concentration in g/dm³.

Mr of CaCl ₂ = 40 + (2 × 35.5) = 111	1 mark
Concentration (g/dm ³) = concentration (mol/dm ³) × Mr Concentration = 0.1 × 111 = 11.1 g/dm ³ Concentration = 11.1 g/dm ³	1 mark
	Total: 2 marks

- f. A solution of dissolved carbon dioxide (CO_2) has a concentration of 0.05 mol/dm^3 .
Calculate the concentration in g/dm^3 .

Mr of $\text{CO}_2 = 12 + (2 \times 16) = 44$	1 mark
Concentration (g/dm^3) = concentration (mol/dm^3) $\times$ Mr Concentration = $0.05 \times 44 = 2.2 \text{ g/dm}^3$ Concentration = 2.20 g/dm^3	1 mark
	Total: 2 marks

- g. A solution of magnesium hydroxide (Mg(OH)_2) has a concentration of 0.25 mol/dm^3 .
Calculate the concentration in g/dm^3 .

Mr of $\text{Mg(OH)}_2 = 24 + 2 \times (16 + 1) = 58$	1 mark
Concentration (g/dm^3) = concentration (mol/dm^3) $\times$ Mr Concentration = $0.25 \times 58 = 14.5 \text{ g/dm}^3$ Concentration = 14.5 g/dm^3	1 mark
	Total: 2 marks

- h. A solution of calcium nitrate ($\text{Ca(NO}_3)_2$) has a concentration of 0.15 mol/dm^3 .
Calculate the concentration in g/dm^3 .

Mr of $\text{Ca(NO}_3)_2 = 40 + 2 \times (14 + (3 \times 16)) = 164$	1 mark
Concentration (g/dm^3) = concentration (mol/dm^3) $\times$ Mr Concentration = $0.15 \times 164 = 24.6 \text{ g/dm}^3$ Concentration = 24.6 g/dm^3	1 mark
	Total: 2 marks

- i. A solution of ammonium carbonate ($(\text{NH}_4)_2\text{CO}_3$) has a concentration of 0.020 mol/dm^3 .
Calculate the concentration in g/dm^3 .

Mr of $(\text{NH}_4)_2\text{CO}_3 = 2 \times (14 + (4 \times 1)) + 12 + (3 \times 16) = 96$	1 mark
Concentration (g/dm^3) = concentration (mol/dm^3) $\times$ Mr Concentration = $0.020 \times 96 = 1.92 \text{ g/dm}^3$ Concentration = 1.92 g/dm^3	1 mark
	Total: 2 marks

- j. A solution of hydrated magnesium chloride ($\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$) has a concentration of 0.1 mol/dm^3 .
Calculate the concentration in g/dm^3 .

Mr of $\text{MgCl}_2 \cdot 6\text{H}_2\text{O} = 24 + (2 \times 35.5) + 6 \times ((2 \times 1) + 16) = 203$	1 mark
Step 2: Calculate the concentration in g/dm^3 . Concentration (g/dm^3) = concentration (mol/dm^3) $\times$ Mr Concentration = $0.1 \times 203 = 20.3 \text{ g/dm}^3$ Concentration = 20.3 g/dm^3	1 mark
	Total: 2 marks

(Total for Question 2 is 20 marks)

Exam Style Questions

3. A student is preparing and analysing different salt solutions in the laboratory.

Relative Atomic Masses (Ar): H = 1, O = 16, Na = 23, S = 32, Cl = 35.5, K = 39

To perform these calculations, the student must first find the relative formula mass (Mr) of the compounds.

- a. Calculate the relative formula mass (Mr) of potassium sulfate (K_2SO_4).

Mr of $K_2SO_4 = (2 \times 39) + 32 + (4 \times 16)$	1 mark
Mr = $78 + 32 + 64 = 174$	1 mark
	Total: 2 marks

- b. The student finds a bottle of sodium chloride solution with the concentration written on the label.

The concentration of the sodium chloride (NaCl) solution is 70.2 g/dm^3 .

Calculate the concentration of this solution in mol/dm^3 .

Mr of NaCl = $23 + 35.5 = 58.5$	1 mark
Concentration (mol/dm^3) = concentration (g/dm^3) $\div$ Mr	
Concentration = $70.2 \div 58.5 = 1.2 \text{ mol/dm}^3$	1 mark
Concentration = 1.20 mol/dm^3	
	Total: 2 marks

- c. The student needs to prepare a standard solution of sodium hydroxide.

Calculate the mass of sodium hydroxide (NaOH) required to make 1 dm^3 of a 0.50 mol/dm^3 solution.

moles = concentration $\times$ volume (dm^3)	1 mark
moles = $0.50 \times 1 = 0.50 \text{ mol}$	
First, find the Mr of NaOH = $23 + 16 + 1 = 40$	
mass = moles $\times$ Mr	
mass = $0.50 \times 40 = 20 \text{ g}$	1 mark
	Total: 2 marks

- d. In another experiment, the student dissolves 4.9 g of sulfuric acid (H_2SO_4) in water. The final volume of the solution is 200 cm^3 .

Calculate the concentration of this sulfuric acid solution in mol/dm^3 .

Mr of $H_2SO_4 = (2 \times 1) + 32 + (4 \times 16) = 98$	1 mark
moles = mass $\div$ Mr	
moles = $4.9 \div 98 = 0.05 \text{ mol}$	1 mark
Volume = $200 \div 1000 = 0.200 \text{ dm}^3$	1 mark
Concentration = moles $\div$ volume (dm^3)	
Concentration = $0.05 \div 0.200 = 0.25 \text{ mol/dm}^3$	
Concentration = 0.250 mol/dm^3	1 mark
	Total: 4 marks

(Total for Question 3 is 10 marks)

4. A student needs to prepare an accurate solution of sodium carbonate to use in a titration.

Relative Atomic Masses (Ar): H = 1, C = 12, O = 16, N = 14, Na = 23, Ca = 40

- a. The student needs to make 250 cm³ of a 0.10 mol/dm³ solution of sodium carbonate (Na₂CO₃). Calculate the mass of sodium carbonate the student needs to weigh out.

First, convert the volume from cm ³ to dm ³ : Volume = 250 ÷ 1000 = 0.250 dm ³ moles = concentration × volume (dm ³) moles = 0.10 × 0.250 = 0.025 mol	1 mark
Mr of Na ₂ CO ₃ = (2 × 23) + 12 + (3 × 16) = 106	1 mark
mass = moles × Mr mass = 0.025 × 106 = 2.65 g	1 mark
	Total: 3 marks

- b. After the titration, the student needs to analyse a solution of nitric acid (HNO₃). Calculate the concentration of this nitric acid solution in mol/dm³.

Mr of HNO ₃ = 1 + 14 + (3 × 16) = 63	1 mark
Concentration (mol/dm ³) = concentration (g/dm ³) ÷ Mr Concentration = 9.45 ÷ 63 = 0.15 mol/dm ³ Concentration = 0.150 mol/dm ³	1 mark
	Total: 2 marks

- c. The student is then asked to calculate the concentration of a limewater solution. Limewater is a solution of calcium hydroxide, Ca(OH)₂.

A sample of limewater with a volume of 50.0 cm³ was found to contain 0.037 g of dissolved calcium hydroxide. Calculate the concentration of the calcium hydroxide solution in mol/dm³.

Mr of Ca(OH) ₂ = 40 + 2 × (16 + 1) = 74	1 mark
moles = mass ÷ Mr moles = 0.037 ÷ 74 = 0.0005 mol	1 mark
Volume = 50.0 ÷ 1000 = 0.0500 dm ³	1 mark
Concentration = moles ÷ volume (dm ³) Concentration = 0.0005 ÷ 0.0500 = 0.01 mol/dm ³ Concentration = 0.0100 mol/dm ³	1 mark
	Total: 4 marks

- d. Describe the key steps a student should take to prepare the 250 cm³ solution in part (a) accurately, after they have weighed the correct mass of sodium carbonate.

Step 1: Transfer the weighed solid to a beaker and dissolve in a small amount of distilled water, stirring with a glass rod.	1 mark
Step 2: Transfer the solution into a 250 cm ³ volumetric flask using a funnel. Rinse the beaker, rod, and funnel with distilled water, adding the washings to the flask.	1 mark
Step 3: Carefully add distilled water until the bottom of the meniscus is on the graduation line. Stopper the flask and invert several times to mix thoroughly.	1 mark
	Total: 3 marks

(Total for Question 4 is 12 marks)

5. A student performs a titration to find the concentration of a sulfuric acid solution.

Relative Atomic Masses (Ar): H = 1, O = 16, Na = 23, S = 32

- a. First, the student prepares a standard solution of sodium hydroxide (NaOH). They dissolve 4.0 g of solid NaOH in water to make a 250 cm³ solution.
- i. Calculate the concentration of this sodium hydroxide solution in g/dm³.

Step 1: Understand the unit g/dm ³ . The target unit is grams per 1 dm ³ , which is grams per 1000 cm ³ .	1 mark
The student has 4.0 g in 250 cm ³ . To find the mass in 1000 cm ³ , we scale up the volume and mass. Scaling factor = 1000 cm ³ / 250 cm ³ = 4 Concentration = 4.0 g × 4 = 16.0 g/dm ³	1 mark
	Total: 2 marks

- ii. Now calculate the concentration of the sodium hydroxide solution in mol/dm³. This value will be used in a later calculation.

Mr of NaOH = 23 + 16 + 1 = 40	1 mark
Concentration (mol/dm ³) = concentration (g/dm ³) ÷ Mr Concentration = 16.0 ÷ 40 = 0.4 mol/dm ³ Concentration = 0.400 mol/dm ³	1 mark
	Total: 2 marks

- b. The student then titrates 25.0 cm³ portions of the sulfuric acid (H₂SO₄) with their sodium hydroxide solution. The results are shown in the table.

Titration	Volume of NaOH added (cm ³)
Rough	25.60
1	25.10
2	25.00
3	25.10

- i. Calculate the mean titre of sodium hydroxide that should be used in the calculation. Show your working.

Step 1: Identify the concordant results. Concordant results are those that are close to each other (usually within 0.10 cm ³). The concordant titres are 25.10 cm ³ , 25.00 cm ³ , and 25.10 cm ³ .	1 mark
Step 2: Calculate the mean of the concordant results. Mean Titre = (25.10 + 25.00 + 25.10) ÷ 3 (1 mark for selecting and adding concordant results). Mean Titre = 25.07 cm ³ (or 25.1 cm ³ if only titres 1 and 3 are used, which is also acceptable).	1 mark
	Total: 2 marks

- ii. Write the **balanced** symbol equation for the reaction between sodium hydroxide and sulfuric acid.

$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	2 marks
	Total: 2 marks

- c. Using your answers from (a)(ii) and (b)(i), calculate the concentration of the sulfuric acid in mol/dm^3 .

Step 1: Calculate the moles of sodium hydroxide (NaOH) used. From a(ii), concentration of NaOH = 0.400 mol/dm^3 From b(i), mean titre of NaOH = 25.07 cm^3 First, convert the mean titre volume from cm^3 to dm^3 : Volume = $25.07 \div 1000 = 0.02507 \text{ dm}^3$ moles = concentration $\times$ volume (dm^3) moles of NaOH = $0.400 \times 0.02507 = 0.010028 \text{ mol}$	1 mark
Step 2: Use the balanced equation to find the moles of sulfuric acid (H_2SO_4). From b(ii), the ratio of NaOH to H_2SO_4 is 2 : 1.	1 mark
moles of H_2SO_4 = moles of NaOH $\div$ 2 moles of H_2SO_4 = $0.010028 \div 2 = 0.005014 \text{ mol}$	1 mark
Step 3: Calculate the concentration of the sulfuric acid (H_2SO_4) solution. The volume of H_2SO_4 used was 25.0 cm^3 , which is 0.0250 dm^3 . Concentration = moles $\div$ volume (dm^3) Concentration of H_2SO_4 = $0.005014 \div 0.0250 = 0.20056 \text{ mol/dm}^3$ Concentration = 0.201 mol/dm^3 (to 3 significant figures)	1 mark
	Total: 4 marks

- d. Convert the concentration of sulfuric acid you calculated in part (c) into g/dm^3 .

Mr of H_2SO_4 = $(2 \times 1) + 32 + (4 \times 16) = 98$	1 mark
Concentration (g/dm^3) = concentration (mol/dm^3) $\times$ Mr Concentration = $0.20056 \times 98 = 19.654 \text{ g/dm}^3$ Concentration = 19.7 g/dm^3 (to 3 significant figures)	1 mark
	Total: 2 marks

(Total for Question 5 is 14 marks)