



CrackingCHEM

GCSE | A-LEVEL

UNDERSTAND • APPLY • SUCCEED

AQA 7405

Amount of Substance I

Original exam questions | TEST IT → EXAM STYLE → HARDER MIXED

SPECIFICATION-LED. PROGRESSIVE. EXAM-FOCUSED.

**AQA SPECIFICATION
LINKS**

3.1.2.1 | 3.1.2.2 (mole, mass and particles)

TEST IT

9

EXAM STYLE

9

HARDER MIXED

3

STRETCH

1

22 ORIGINAL QUESTIONS

137 TOTAL MARKS

Independent practice material. Every question is original and designed from recurring AQA assessment patterns.

Mapped to AQA Chemistry 7405 | specification checked August 2026

START HERE

How to use this pack

A deliberate progression from recall to independent problem solving

- 1 Complete TEST IT without the notes. Correct gaps before moving on.
- 2 Name the entity being counted before selecting an equation: atoms, molecules, ions, formula units or electrons.
- 3 Route every mass-particle calculation through moles and apply a formula subscript only when the target requires it.
- 4 Complete HARDER MIXED and STRETCH last. These questions make you select and connect the route.

Core equations

$n = m \div M$ | $m = n \times M$ | $N = n \times N_a$ | $n = N \div N_a$. Use $N_a = 6.02 \times 10^{23} \text{ mol}^{-1}$ unless a question states otherwise.

Equation symbols

Symbol	Meaning	Unit
n	amount of substance	mol
m	mass	g
M	molar mass	g mol^{-1}
N	number of specified entities	no unit
N_a	Avogadro constant: number of entities per mole	mol^{-1}
A_r	relative atomic mass	no unit
M_r / RFM	relative molecular mass / relative formula mass	no unit

Entity rule: always label N as atoms, molecules, ions, formula units or electrons.

Write or type

The grey dotted response lines are designed for printing and electronic completion. In Word, click a line and type directly onto it.

Originality and exam fit

The questions are original. Their command words, structure and mark allocations are calibrated against current AQA assessment practice, not copied from any past-paper item.

SECTION A

TEST IT

Secure the language and the one-step routes

QUESTION 1 | TEST IT

(a) Define relative atomic mass, A_r . (2 marks)

(b) Define relative molecular mass, M_r . (2 marks)

(c) State the relative-mass term used for an ionic compound. (1 mark)

(d) State the unit of A_r , M_r and relative formula mass. (1 mark)

(e) Explain the difference between relative molecular mass and molar mass. (2 marks)

QUESTION 2 | TEST IT

Use $H = 1.0$, $N = 14.0$, $O = 16.0$, $Al = 27.0$ and $S = 32.1$.

(a) Calculate the relative molecular mass of HNO_3 . (2 marks)

(b) Calculate the relative formula mass of $Al_2(SO_4)_3$. (3 marks)

QUESTION 3 | TEST IT

Element X contains 75.0% ^{35}X and 25.0% ^{37}X .

(a) Calculate the relative atomic mass of X. (2 marks)

(b) A student calculates $(35 + 37) \div 2$. Identify the error and state how the calculation should be corrected. (2 marks)

QUESTION 4 | TEST IT

(a) State what one mole represents and what the Avogadro constant represents. (2 marks)

(b) Name the best entity to count in each case: Fe, O_2 , NaCl, Cl^- and transferred charge in a half-equation. (5 marks)

QUESTION 5 | TEST IT

(a) Calculate the amount in moles in 11.7 g NaCl. $M(\text{NaCl}) = 58.5 \text{ g mol}^{-1}$. (2 marks)

(b) Calculate the mass of 0.0750 mol CO_2 . $M(\text{CO}_2) = 44.0 \text{ g mol}^{-1}$. (2 marks)

(c) State the unit of molar mass. (1 mark)

QUESTION 6 | TEST IT

A molecular substance has a mass of 7.30 g and an amount of 0.125 mol.

(a) Calculate its molar mass. (2 marks)

(b) State its relative molecular mass and give the correct unit, if any. (2 marks)

QUESTION 7 | TEST IT

Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) Calculate the number of molecules in 0.250 mol of a molecular substance. (2 marks)

(b) Calculate the amount in moles represented by 9.03×10^{22} atoms. (2 marks)

QUESTION 8 | TEST IT

A sample contains 0.250 mol H_2SO_4 molecules. Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) Calculate the number of H_2SO_4 molecules. (2 marks)

.....

.....

(b) Calculate the number of hydrogen atoms. (2 marks)

.....

.....

(c) Calculate the total number of atoms of all elements. (3 marks)

.....

.....

.....

QUESTION 9 | TEST IT

Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) For 0.120 mol $\text{Al}_2(\text{SO}_4)_3$, calculate the amount in moles of Al^{3+} ions. (1 mark)

.....

.....

(b) Calculate the amount in moles of SO_4^{2-} ions. (1 mark)

.....

.....

(c) Calculate the total number of ions represented by this amount of $\text{Al}_2(\text{SO}_4)_3$. (2 marks)

.....

.....

(d) Al has atomic number 13. Calculate the number of electrons in 0.0200 mol Al^{3+} ions. (3 marks)

.....

.....

.....

SECTION B

EXAM STYLE

Apply the relationships in original AQA-style contexts

QUESTION 10 | EXAM STYLE

Copper has two isotopes. The data are shown in Table 1.

Relative isotopic mass	62.930	64.928
Relative abundance / %	69.15	30.85

- (a) Calculate the relative atomic mass of copper. Give your answer to four significant figures. (3 marks)

.....

.....

- (b) A student reports 63.929 by taking the unweighted mean of the two masses. Explain why this method is invalid. (2 marks)

.....

.....

- (c) State the unit of the relative atomic mass you calculated. (1 mark)

QUESTION 11 | EXAM STYLE

Use Fe = 55.8, N = 14.0 and O = 16.0.

- (a) Calculate the relative formula mass of $\text{Fe}(\text{NO}_3)_3$. (3 marks)

.....

.....

- (b) A student writes ' $M_r(\text{Fe}(\text{NO}_3)_3) = 241.8 \text{ g mol}^{-1}$ '. Identify and correct both errors. (2 marks)

.....

.....

QUESTION 12 | EXAM STYLE

A sample of water has a mass of 9.00 g. $M(\text{H}_2\text{O}) = 18.0 \text{ g mol}^{-1}$. Use $N_a = 6.02 \times 10^{23} \text{ mol}^{-1}$.Calculate the number of H_2O molecules in the sample. (5 marks)

.....

.....

.....

.....

.....

.....

QUESTION 13 | EXAM STYLE

A sample contains 4.40 g CO₂. $M(\text{CO}_2) = 44.0 \text{ g mol}^{-1}$. Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

Calculate the number of oxygen atoms in the sample. Give your answer to three significant figures. (6 marks)

QUESTION 14 | EXAM STYLE

A sample contains 7.525×10^{22} O₂ molecules. $M(\text{O}_2) = 32.0 \text{ g mol}^{-1}$. Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

Calculate the mass of the sample. Give your answer to an appropriate number of significant figures. (5 marks)

QUESTION 15 | EXAM STYLE

A sample contains 11.1 g CaCl_2 . $M(\text{CaCl}_2) = 111.0 \text{ g mol}^{-1}$. Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) Calculate the number of CaCl_2 formula units. (3 marks)

(b) Calculate the number of chloride ions represented by the formula units. (1 mark)

(c) Calculate the total number of ions represented by the formula units. (2 marks)

QUESTION 16 | EXAM STYLE

Magnesium has atomic number 12. A sample contains 0.0500 mol Mg^{2+} ions. Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) Calculate the number of electrons in the sample of Mg^{2+} ions. (4 marks)

(b) Explain why the electron count per ion is not 12. (1 mark)

QUESTION 17 | EXAM STYLE

Sample A contains 3.20 g O₂, M = 32.0 g mol⁻¹. Sample B contains 4.40 g CO₂, M = 44.0 g mol⁻¹. Use N_a = 6.02 × 10²³ mol⁻¹.

Determine which sample contains more oxygen atoms. Support your conclusion with calculations. (6 marks)

QUESTION 18 | EXAM STYLE

A student tries to find the number of CO₂ molecules in 2.50 g CO₂. M = 44.0 g mol⁻¹.

Student working

$$n = 2.50 \div 44.0 = 0.0568 \text{ mol}$$

$$N = 0.0568 \div (6.02 \times 10^{23}) = 9.44 \times 10^{-26}$$

(a) Identify the calculation error. (1 mark)

(b) Calculate the correct number of CO₂ molecules. (3 marks)

(c) Explain why the student should retain the unrounded value of n until the final answer and state the appropriate final precision. (2 marks)

SECTION C

HARDER MIXED

Select the route, control the entity and finish precisely

QUESTION 19 | HARDER MIXED

A molecular sample has a mass of 2.30 g and contains 3.01×10^{22} molecules. Use $N_a = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) Calculate the molar mass of the substance. (4 marks)

(b) State the relative molecular mass of the substance, including the correct unit if one is required. (2 marks)

(c) Give a numerical sense check for your molar-mass answer. (1 mark)

QUESTION 20 | HARDER MIXED

A sample contains 17.1 g $\text{Al}_2(\text{SO}_4)_3$. $M = 342 \text{ g mol}^{-1}$. Use $N_a = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) Calculate the amount in moles of $\text{Al}_2(\text{SO}_4)_3$. (2 marks)

(b) Calculate the number of sulfate ions represented by the sample. (2 marks)

(c) Calculate the number of oxygen atoms represented by the sample. (2 marks)

(d) Calculate the total number of ions represented by the sample. (3 marks)

QUESTION 21 | HARDER MIXED

Sample A contains 5.85 g NaCl, $M = 58.5 \text{ g mol}^{-1}$. Sample B contains 3.70 g Ca(OH)_2 , $M = 74.0 \text{ g mol}^{-1}$. Assume each formula unit is represented by its constituent ions. Use $N_a = 6.02 \times 10^{23} \text{ mol}^{-1}$.

(a) Calculate the total number of ions represented by sample A. (3 marks)

(b) Calculate the total number of ions represented by sample B. (3 marks)

(c) State which sample represents more ions and calculate the factor by which it is greater. (3 marks)

SECTION D

STRETCH / SYNOPTIC

Connect isotopic evidence with mass-mole-particle reasoning

QUESTION 22 | STRETCH / SYNOPTIC

A diatomic element X contains two isotopes. The data are shown in Table 2.

Isotope	^{35}X	^{37}X
Relative abundance / %	75.0	25.0

- (a) Calculate the relative atomic mass of X. (2 marks)

.....

.....

- (b) Calculate the relative molecular mass of
- X_2
- . (1 mark)

.....

A sample contains 17.75 g X_2 . Use $N_{\text{a}} = 6.02 \times 10^{23} \text{ mol}^{-1}$.

- (c) Calculate the amount in moles of
- X_2
- . (2 marks)

.....

.....

- (d) Calculate the number of
- X_2
- molecules. (2 marks)

.....

.....

- (e) Calculate the number of X atoms. (1 mark)

.....

- (f) A student uses
- $A_{\text{r}}(\text{X})$
- as the molar mass of
- X_2
- and obtains twice the correct molecule count. Explain the error. (2 marks)

.....

.....

- (g) Use the isotopic data and diatomic formula to identify X. (1 mark)

.....



CrackingCHEM

GCSE | A-LEVEL

UNDERSTAND • APPLY • SUCCEED

AQA 7405

Amount of Substance I

Fully worked answers | AQA-style marking guidance

FULLY WORKED. PRECISELY MARKED. BUILT FOR IMPROVEMENT.

AQA SPECIFICATION
LINKS

3.1.2.1 | 3.1.2.2 (mole, mass and particles)

TEST IT

9

EXAM STYLE

9

HARDER MIXED

3

STRETCH

1

22 QUESTIONS MARKED

137 MARKS EXPLAINED

Independent practice material. Every question is original and designed from recurring AQA assessment patterns.

Mapped to AQA Chemistry 7405 | specification checked August 2026

AQA MAP

Specification coverage audit

Every owned requirement mapped to deliberate practice

Specification area	What the pack tests	Frequent trap	Questions
A_r, M_r and formula mass	Precise carbon-12 definitions; weighted means; molecular and ionic relative-mass calculations; brackets.	Ordinary mean instead of weighted mean; calling an ionic quantity M _r .	1-3, 10-11, 22
Relative mass vs molar mass	Distinguish unitless relative quantities from M in g mol ⁻¹ ; find M by rearrangement.	Adding g mol ⁻¹ to M _r or omitting it from M.	1, 5-6, 11, 19, 22
Mole and Avogadro constant	Meaning of a mole; N _a as entities per mole; N = nN _a and n = N/N _a .	Multiplying or dividing in the wrong direction; missing the entity label.	4, 7-9, 12-22
Mass, moles and particles	n = m/M, m = nM, rearrangements and full mass ↔ mole ↔ particle routes.	Inventing a direct mass-particle equation; rounding between stages.	5-7, 12-15, 17-22
Specified entities and subscripts	Atoms, molecules, formula units, ions and electrons; component-particle and total-particle counts.	Writing ionic molecules; applying a formula multiplier twice or to the wrong entity.	4, 8-9, 12-17, 20-22
Interpretation and mathematical finish	Comparison, error spotting, standard form, units, significant figures and numerical sense checks.	Correct route but incomplete label, precision or unit; accepting an impossible magnitude.	3, 10-11, 14, 17-22

Boundary check

This pack owns AQA 3.1.2.1 and the mole, Avogadro, mass and particle part of 3.1.2.2. Concentration and solution volume are reserved for Amount of Substance III; equations, reacting masses, empirical and molecular formulae and water of crystallisation are reserved for Amount of Substance II. Gases, yield, atom economy and titration are also excluded.

Research basis

Scope checked against the current AQA Chemistry 7405 specification and the CrackingChem Year 12 master specification map. Question wording and demand were calibrated against official AQA assessment practice. No past-paper question has been reproduced or closely paraphrased.

SECTION A

TEST IT answers

Secure the language, entities and one-step routes

TEST IT 1

- (a) A_r is the weighted mean mass of an atom of an element [1] relative to one-twelfth of the mass of one carbon-12 atom. [1]
- (b) M_r is the mean mass of a molecule [1] relative to one-twelfth of the mass of one carbon-12 atom. [1]
- (c) Relative formula mass. [1]
- (d) A_r, M_r and relative formula mass have no unit. [1]
- (e) Molar mass is the mass of one mole of specified entities [1] and has unit g mol⁻¹. [1] Its numerical value is normally the same as the corresponding relative mass.

Examiner insight

Relative masses are ratios, so they have no unit. Molar mass is a mass per mole and must carry g mol⁻¹.

TEST IT 2

(a) $M_r(\text{HNO}_3) = 1.0 + 14.0 + 3(16.0)$ [1] = 63.0. [1]

(b) $\text{Al}_2(\text{SO}_4)_3$ contains $\text{Al}_2\text{S}_3\text{O}_{12}$. [1] Relative formula mass = $2(27.0) + 3(32.1) + 12(16.0)$ [1] = 342.3. [1]

TEST IT 3

(a) $A_r = [(35 \times 75.0) + (37 \times 25.0)] \div 100$ [1] = 35.5. [1]

(b) The student's method assumes the isotopes are equally abundant. [1] Each isotopic mass must be multiplied by its fractional or percentage abundance before the contributions are added. [1]

Common trap

A weighted mean is not the same as the ordinary mean unless the isotope abundances are equal.

TEST IT 4

(a) One mole is an amount containing 6.02×10^{23} specified entities. [1] The Avogadro constant is the number of specified entities per mole; its unit is mol^{-1} . [1]

(b) Fe: atoms [1]; O_2 : molecules [1]; NaCl: formula units [1]; Cl^- : ions [1]; transferred charge: electrons. [1]

Examiner insight

Always finish the phrase 'moles of ...'. The equation is chosen only after the entity has been named.

TEST IT 5

(a) $n = m \div M = 11.7 \div 58.5$ [1] = 0.200 mol NaCl. [1]

(b) $m = nM = 0.0750 \times 44.0$ [1] = 3.30 g CO_2 . [1]

(c) g mol^{-1} . [1]

TEST IT 6

(a) $M = m \div n = 7.30 \div 0.125$ [1] = 58.4 g mol^{-1} . [1]

(b) $M_r = 58.4$. [1] Relative molecular mass has no unit. [1]

TEST IT 7

(a) $N = nN_a = 0.250 \times 6.02 \times 10^{23}$ [1] = 1.51×10^{23} molecules. [1]

(b) $n = N \div N_a = (9.03 \times 10^{22}) \div (6.02 \times 10^{23})$ [1] = 0.150 mol atoms. [1]

TEST IT 8

(a) $N(\text{H}_2\text{SO}_4 \text{ molecules}) = 0.250 \times 6.02 \times 10^{23}$ [1] = 1.51×10^{23} molecules. [1]

(b) $n(\text{H atoms}) = 2 \times 0.250 = 0.500$ mol [1], so $N = 0.500 \times 6.02 \times 10^{23} = 3.01 \times 10^{23}$ H atoms. [1]

(c) One H_2SO_4 molecule contains $2 + 1 + 4 = 7$ atoms. [1] $n(\text{total atoms}) = 7 \times 0.250 = 1.75$ mol [1], so $N = 1.75 \times 6.02 \times 10^{23} = 1.05 \times 10^{24}$ atoms. [1]

Common trap

Apply the subscript or total-atom multiplier once. Do not multiply again after converting to moles of the target atom.

TEST IT 9

(a) $n(\text{Al}^{3+}) = 2 \times 0.120 = 0.240 \text{ mol}$. [1]

(b) $n(\text{SO}_4^{2-}) = 3 \times 0.120 = 0.360 \text{ mol}$. [1]

(c) Total ion amount = $(2 + 3) \times 0.120 = 0.600 \text{ mol}$ [1], so $N = 0.600 \times 6.02 \times 10^{23} = 3.61 \times 10^{23}$ ions. [1]

(d) Each Al^{3+} ion has $13 - 3 = 10$ electrons. [1] $n(\text{electrons}) = 10 \times 0.0200 = 0.200 \text{ mol}$ [1], so $N = 0.200 \times 6.02 \times 10^{23} = 1.20 \times 10^{23}$ electrons. [1]

SECTION B**EXAM STYLE answers**

Full routes, marking points and examiner guidance

EXAM STYLE 10

(a) $A_r = (62.930 \times 0.6915) + (64.928 \times 0.3085)$. [1] Calculator value = 63.546383. [1] To four significant figures, $A_r = 63.55$. [1]

(b) The isotope abundances are unequal, so an unweighted mean gives each isotope the same influence. [1] The masses must be multiplied by their fractional abundances and the contributions added. [1]

(c) No unit. [1]

Examiner insight

Keep the full calculator value until the final rounding step; otherwise a borderline digit can change.

EXAM STYLE 11

(a) $\text{Fe}(\text{NO}_3)_3$ contains $\text{Fe}_1\text{N}_3\text{O}_9$. [1] Relative formula mass = $55.8 + 3(14.0) + 9(16.0)$ [1] = 241.8. [1]

(b) $\text{Fe}(\text{NO}_3)_3$ is ionic, so the relative quantity is relative formula mass, not M_r . [1] Relative formula mass has no unit; 241.8 g mol^{-1} would instead be its molar mass, M . [1]

Common trap

Do not attach g mol^{-1} to a relative mass. Use g mol^{-1} only when the quantity is molar mass.

EXAM STYLE 12

$n(\text{H}_2\text{O}) = m \div M$. [1] $n = 9.00 \div 18.0 = 0.500 \text{ mol}$. [1]

$N = nN_A$ [1] = $0.500 \times 6.02 \times 10^{23} = 3.01 \times 10^{23}$. [1]

Final answer: 3.01×10^{23} H_2O molecules. [1]

EXAM STYLE 13

$n(\text{CO}_2) = 4.40 \div 44.0$ [1] = 0.100 mol CO_2 . [1]

Each molecule contains two O atoms, so $n(\text{O atoms}) = 2 \times 0.100 = 0.200 \text{ mol}$. [1]

$N(\text{O atoms}) = 0.200 \times 6.02 \times 10^{23}$. [1] Calculator value = 1.204×10^{23} . [1]

To three significant figures: 1.20×10^{23} oxygen atoms. [1]

Common trap

The target is oxygen atoms, not CO_2 molecules. The factor of two must be applied exactly once.

EXAM STYLE 14

$n(\text{O}_2) = N \div N_{\text{a}} = (7.525 \times 10^{22}) \div (6.02 \times 10^{23})$. [1] $n = 0.125 \text{ mol}$ to the precision of the supplied constant. [1]

$m = nM$ [1] $= 0.125 \times 32.0 = 4.00 \text{ g}$. [1]

The least precise supplied values have three significant figures, so 4.00 g is appropriate. [1]

EXAM STYLE 15

(a) $n(\text{CaCl}_2) = 11.1 \div 111.0 = 0.100 \text{ mol}$. [1] $N = 0.100 \times 6.02 \times 10^{23}$ [1] $= 6.02 \times 10^{22}$ CaCl_2 formula units. [1]

(b) Each formula unit represents two Cl^- ions, so $N(\text{Cl}^-) = 2 \times 6.02 \times 10^{22} = 1.204 \times 10^{23}$ chloride ions. [1]

(c) Each formula unit represents three ions in total. [1] $N(\text{total ions}) = 3 \times 6.02 \times 10^{22} = 1.81 \times 10^{23}$ ions. [1]

Examiner insight

CaCl_2 is counted in formula units. The formula then gives two chloride ions and three ions in total per formula unit.

EXAM STYLE 16

(a) Each Mg^{2+} ion has $12 - 2 = 10$ electrons. [1] $n(\text{electrons}) = 10 \times 0.0500 = 0.500 \text{ mol}$. [1] $N = 0.500 \times 6.02 \times 10^{23}$ [1] $= 3.01 \times 10^{23}$ electrons. [1]

(b) Forming Mg^{2+} removes two electrons from the neutral 12-electron atom. [1]

EXAM STYLE 17

Sample A: $n(\text{O}_2) = 3.20 \div 32.0 = 0.100 \text{ mol}$. [1] Therefore $n(\text{O atoms}) = 2 \times 0.100 = 0.200 \text{ mol}$. [1]

Sample B: $n(\text{CO}_2) = 4.40 \div 44.0 = 0.100 \text{ mol}$. [1] Therefore $n(\text{O atoms}) = 2 \times 0.100 = 0.200 \text{ mol}$. [1]

The samples contain equal numbers of oxygen atoms. [1] Each contains $0.200 \times 6.02 \times 10^{23} = 1.20 \times 10^{23}$ O atoms. [1]

EXAM STYLE 18

(a) The student divides by N_{a} when moving from moles to particles; this conversion requires multiplication. [1]

(b) $n(\text{CO}_2) = 2.50 \div 44.0 = 0.056818\dots \text{ mol}$. [1] $N = nN_{\text{a}} = 0.056818\dots \times 6.02 \times 10^{23}$ [1] $= 3.42 \times 10^{22}$ CO_2 molecules. [1]

(c) Retaining the full n value avoids compounding an intermediate rounding error. [1] The final answer should be three significant figures because the supplied values are given to three significant figures. [1]

Common trap

A particle count should normally be enormous. A result of 10^{-26} particles is also a strong direction and magnitude warning.

SECTION C**HARDER MIXED answers**

Select the route and keep the target entity visible

HARDER MIXED 19

(a) $n = N \div N_{\text{a}} = (3.01 \times 10^{22}) \div (6.02 \times 10^{23})$ [1] $= 0.0500 \text{ mol}$. [1] $M = m \div n = 2.30 \div 0.0500$ [1] $= 46.0 \text{ g mol}^{-1}$. [1]

(b) $M_{\text{r}} = 46.0$. [1] Relative molecular mass has no unit. [1]

(c) 0.0500 mol is one-twentieth of a mole, so the molar mass should be $20 \times 2.30 \text{ g} = 46.0 \text{ g mol}^{-1}$. [1]

Examiner insight

The route is particles → moles → molar mass. There is no valid direct particle-number-to-mass equation.

HARDER MIXED 20

(a) $n(\text{Al}_2(\text{SO}_4)_3) = 17.1 \div 342 \text{ [1]} = 0.0500 \text{ mol. [1]}$

(b) $n(\text{SO}_4^{2-}) = 3 \times 0.0500 = 0.150 \text{ mol [1]}$, so $N = 0.150 \times 6.02 \times 10^{23} = 9.03 \times 10^{22}$ sulfate ions. [1]

(c) $n(\text{O atoms}) = 12 \times 0.0500 = 0.600 \text{ mol [1]}$, so $N = 0.600 \times 6.02 \times 10^{23} = 3.61 \times 10^{23}$ oxygen atoms. [1]

(d) One formula unit represents $2 + 3 = 5$ ions, so $n(\text{total ions}) = 5 \times 0.0500 = 0.250 \text{ mol. [1]}$ $N = 0.250 \times 6.02 \times 10^{23}$ [1] $= 1.51 \times 10^{23}$ ions. [1]

Common trap

The formula contains three sulfate ions but twelve oxygen atoms. Read the requested entity before using a subscript.

HARDER MIXED 21

(a) $n(\text{NaCl}) = 5.85 \div 58.5 = 0.100 \text{ mol. [1]}$ Two ions are represented per formula unit, so $n(\text{ions}) = 0.200 \text{ mol. [1]}$ $N = 0.200 \times 6.02 \times 10^{23} = 1.204 \times 10^{23}$ ions. [1]

(b) $n(\text{Ca}(\text{OH})_2) = 3.70 \div 74.0 = 0.0500 \text{ mol. [1]}$ Three ions are represented per formula unit, so $n(\text{ions}) = 0.150 \text{ mol. [1]}$ $N = 0.150 \times 6.02 \times 10^{23} = 9.03 \times 10^{22}$ ions. [1]

(c) Sample A represents more ions. [1] Factor $= (1.204 \times 10^{23}) \div (9.03 \times 10^{22})$ [1] $= 1.33$. [1]

Examiner insight

A larger ion multiplier does not guarantee more ions overall; the mass and molar mass must first be used to find the amount of formula units.

SECTION D**STRETCH / SYNOPTIC answer**

Connect isotopic evidence with amount calculations

STRETCH / SYNOPTIC 22

(a) $A_r(\text{X}) = [(35 \times 75.0) + (37 \times 25.0)] \div 100$ [1] $= 35.5$. [1]

(b) $M_r(\text{X}_2) = 2 \times 35.5 = 71.0$. [1]

(c) $n(\text{X}_2) = 17.75 \div 71.0$ [1] $= 0.250 \text{ mol. [1]}$

(d) $N(\text{X}_2 \text{ molecules}) = 0.250 \times 6.02 \times 10^{23}$ [1] $= 1.51 \times 10^{23}$ molecules. [1]

(e) Each molecule contains two X atoms, so $N(\text{X atoms}) = 2 \times 1.505 \times 10^{23} = 3.01 \times 10^{23}$ atoms. [1]

(f) The sample contains diatomic X_2 , so its molar mass is based on $2A_r$, not A_r . [1] Using 35.5 g mol^{-1} halves the denominator, so the calculated amount and molecule count are doubled. [1]

(g) X is chlorine, Cl. [1]

Examiner insight

This synoptic question uses isotope data from Atomic Structure I, then tests whether the diatomic formula is carried correctly through the amount calculation.

Final review

Check the entity, direction, unit or label, standard form and final precision. A correct number with the wrong chemical meaning is not a complete answer.