



CrackingCHEM

GCSE | A-LEVEL

UNDERSTAND • APPLY • SUCCEED

OCR A H432

Amount of Substance I

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

SPECIFICATION-LED. PROGRESSIVE. EXAM-FOCUSED.

OCR A SPECIFICATION

2.1.1(c,e) | 2.1.3(a,e(i))

TEST IT

8

EXAM STYLE

10

HARDER MIXED

5

STRETCH

1

24 ORIGINAL QUESTIONS

148 TOTAL MARKS

FINAL NOTES-ALIGNED EDITION | MASS • MOLES • SPECIFIED PARTICLES

Independent practice material. Every question is original and stays within the finished Amount of Substance I notes.



START HERE

How to use this pack

Name the entity, choose the route, show the units, check the answer

- 1 Complete TEST IT without the notes. Correct any gaps before moving on.
- 2 Write the stated substance and the requested entity before using a formula or Avogadro's constant.
- 3 Show the route. Mass and particle number are connected through amount in moles.
- 4 Round once at the end, then attach the correct unit or particle label.

✓ **OCR A boundary:** This pack covers OCR A 2.1.1(c,e) and 2.1.3(a,e(i)). It does not assess balanced-equation stoichiometry, reacting masses, empirical or molecular formulae, water of crystallisation, concentration, gases, yield or atom economy.

Entity first: Use atoms for monatomic elements, molecules for simple molecular substances, formula units for ionic or giant structures, and the exact ion or electron requested by the question.

Core route: $n = m/M$ and $N = nN_a$. Use $N_a = 6.02 \times 10^{23} \text{ mol}^{-1}$. Formula subscripts give the multiplier between formula units or molecules and the requested atoms or ions.

Definition boundary: OCR requires the definitions of relative isotopic mass and relative atomic mass. It requires use and calculation of M_r and relative formula mass, but not their formal definitions.

Notes alignment: Every question has been mapped directly to the completed CrackingChem OCR A Amount of Substance I notes and the current OCR A H432 specification.



SECTION A

TEST IT

Eight direct checks of the finished-notes mastery outcomes

QUESTION 1 | TEST IT

(a) State the definition of relative isotopic mass.

[2 marks]

(b) State the definition of relative atomic mass, A_r .

[2 marks]

QUESTION 2 | TEST IT

Use $H = 1.0$, $C = 12.0$, $N = 14.0$, $O = 16.0$ and $Mg = 24.3$.

(a) Calculate M_r of C_2H_5OH .

[2 marks]

(b) Calculate the relative formula mass of $Mg(NO_3)_2$.

[3 marks]

(c) State why neither answer has a unit.

[1 mark]

QUESTION 3 | TEST IT

Use $Ca = 40.1$, $O = 16.0$ and $H = 1.0$ for calcium hydroxide, $Ca(OH)_2$.

(a) Calculate its relative formula mass.

[2 marks]

(b) State its molar mass, including the unit.

[1 mark]

(c) Explain why the two numerical values are equal but the units are different.

[2 marks]

**QUESTION 4** | TEST IT

(a) State the symbol and unit used for amount of substance.

[2 marks]

(b) State what one mole contains and give the value and unit of the Avogadro constant.

[2 marks]

(c) Complete each equation.

Relationship	Equation
mass $\rightarrow$ amount	$n =$
amount $\rightarrow$ mass	$m =$
amount $\rightarrow$ particles	$N =$
particles $\rightarrow$ amount	$n =$

[4 marks]

QUESTION 5 | TEST IT

(a) Calculate the amount of HCl in 7.30 g. $M(\text{HCl}) = 36.5 \text{ g mol}^{-1}$.

[2 marks]

(b) Calculate the mass of 0.0750 mol Na_2CO_3 . $M(\text{Na}_2\text{CO}_3) = 106 \text{ g mol}^{-1}$.

[2 marks]

QUESTION 6 | TEST IT

(a) Calculate the number of MgCl_2 formula units in 0.0350 mol MgCl_2 .

[2 marks]

(b) Calculate the amount of Ne represented by 9.03×10^{22} Ne atoms.

[2 marks]

**QUESTION 7** | TEST IT

Complete the entity and multiplier table. A multiplier converts amount of the stated substance into amount of the requested particle.

Stated substance	Basic entity	Requested particle	Multiplier
Ne		Ne atoms	
O ₂		O atoms	
MgCl ₂		Cl ⁻ ions	
MgCl ₂	formula unit	total ions	
Al ³⁺	ion	electrons	

[8 marks]**QUESTION 8** | TEST IT

Calculate the number of sulfate ions in 3.42 g Al₂(SO₄)₃. $M(\text{Al}_2(\text{SO}_4)_3) = 342 \text{ g mol}^{-1}$.

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[5 marks]**SECTION B****EXAM STYLE**

Ten original structured questions using OCR A quantitative conventions

✓ **Route check:** Write the formula, identify the entity, show the amount in mol and round only the final answer.

**QUESTION 9** | EXAM STYLE

Iron(III) sulfate is $\text{Fe}_2(\text{SO}_4)_3$. Use $\text{Fe} = 55.8$, $\text{S} = 32.1$ and $\text{O} = 16.0$.

(a) Calculate its relative formula mass.

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.....

[3 marks]

(b) State its molar mass, including the unit.

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[1 mark]

(c) Calculate the mass of 0.0250 mol $\text{Fe}_2(\text{SO}_4)_3$. Give the answer to three significant figures.

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.....

[2 marks]

QUESTION 10 | EXAM STYLE

A sample contains 0.0350 mol MgCl_2 .

(a) Calculate the number of MgCl_2 formula units.

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.....

[2 marks]

(b) Calculate the number of chloride ions represented by the sample.

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[2 marks]

(c) Explain the factor linking your answers to (a) and (b).

.....

.....

[1 mark]

**QUESTION 11** | EXAM STYLE

A sample contains 0.240 mol ethanol, $\text{C}_2\text{H}_5\text{OH}$.

- (a) Calculate the number of ethanol molecules.

[2 marks]

- (b) Calculate the number of oxygen atoms.

[2 marks]

- (c) Calculate the total number of atoms represented by the sample.

[3 marks]

QUESTION 12 | EXAM STYLE

A sample of sodium chloride has mass 5.85 g. $M(\text{NaCl}) = 58.5 \text{ g mol}^{-1}$.

- (a) Calculate the amount of NaCl.

[2 marks]

- (b) Calculate the number of NaCl formula units.

[2 marks]

- (c) Calculate the total number of ions represented by the sample.

[2 marks]

QUESTION 13 | EXAM STYLE

A sample contains 3.01×10^{22} carbon dioxide molecules. $M(\text{CO}_2) = 44.0 \text{ g mol}^{-1}$.

- (a) Calculate the amount of CO_2 .

[2 marks]

- (b) Calculate the mass of the sample.

[2 marks]

**QUESTION 14** | EXAM STYLE

A sample contains 0.0200 mol $\text{Al}_2(\text{SO}_4)_3$.

- (a) Calculate the number of sulfate ions represented by the sample.

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[3 marks]

- (b) Calculate the total number of ions represented by the sample.

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[3 marks]

- (c) Explain why one sulfate ion is counted as one ion in part (b).

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[1 mark]

QUESTION 15 | EXAM STYLE

A sample contains 0.0150 mol Al^{3+} ions. Each Al^{3+} ion has 10 electrons.

- (a) State the number of electrons per ion.

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[1 mark]

- (b) Calculate the amount of electrons represented by the ions.

.....

[1 mark]

- (c) Calculate the number of electrons represented by the ions.

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.....

[2 marks]

QUESTION 16 | EXAM STYLE

A 4.40 g sample of molecular substance X contains 6.02×10^{22} molecules.

- (a) Calculate the amount of X.

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[2 marks]

- (b) Calculate the molar mass of X, including the unit.

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[2 marks]

**QUESTION 17** | EXAM STYLE

Three samples are shown. Use the stated molar masses.

Sample	Substance	Mass / g	M / g mol ⁻¹
A	He	2.00	4.00
B	O ₂	16.0	32.0
C	NaCl	29.25	58.5

(a) Compare the numbers of basic entities in A, B and C. Support your conclusion with calculations.

[3 marks]

(b) Compare the number of O atoms in B with the total number of ions in C.

[3 marks]

QUESTION 18 | EXAM STYLE

A student calculates the number of sulfate ions in 3.42 g Al₂(SO₄)₃. M = 342 g mol⁻¹.

Student working: $n(\text{Al}_2(\text{SO}_4)_3) = 3.42/342 = 0.0100 \text{ mol}$; $N = 0.0100 \times 6.02 \times 10^{23} = 6.02 \times 10^{21} \text{ particles}$.

(a) Identify the chemical error in the student's route.

[2 marks]

(b) Calculate the correct number of sulfate ions.

[3 marks]

(c) Explain why the label particles is not precise enough for the final answer.

[1 mark]



SECTION C

HARDER MIXED

Five unfamiliar applications with less scaffolding

Independent thinking: Choose the route yourself. Keep the chemical multiplier separate from the Avogadro step.

QUESTION 19 | HARDER MIXED

Separate 5.00 g samples of NaCl and MgCl₂ are compared. $M(\text{NaCl}) = 58.5 \text{ g mol}^{-1}$ and $M(\text{MgCl}_2) = 95.3 \text{ g mol}^{-1}$.

(a) Calculate the amount of chloride ions represented by the NaCl sample.

[2 marks]

(b) Calculate the amount of chloride ions represented by the MgCl₂ sample.

[3 marks]

(c) Calculate the number of chloride ions in each sample.

[2 marks]

(d) State which sample represents more chloride ions.

[1 mark]

QUESTION 20 | HARDER MIXED

A sample of Ca(NO₃)₂ represents 1.806×10^{23} nitrate ions. $M(\text{Ca(NO}_3)_2) = 164.1 \text{ g mol}^{-1}$.

(a) Calculate the amount of nitrate ions.

[2 marks]

(b) Calculate the amount of Ca(NO₃)₂.

[2 marks]

(c) Calculate the mass of the sample to three significant figures.

[2 marks]

**QUESTION 21 | HARDER MIXED**

A 16.0 g sample of X_2O_3 represents 1.806×10^{23} oxygen atoms. Use $O = 16.0$.

(a) Calculate the amount of oxygen atoms.

[2 marks]

(b) Calculate the amount of X_2O_3 .

[1 mark]

(c) Calculate the molar mass of X_2O_3 .

[2 marks]

(d) Calculate $A_r(X)$ and identify X.

[3 marks]

QUESTION 22 | HARDER MIXED

A 0.970 g sample of caffeine, $C_8H_{10}N_4O_2$, has molar mass 194 g mol^{-1} .

(a) Calculate the amount of caffeine.

[2 marks]

(b) Calculate the number of caffeine molecules.

[2 marks]

(c) Calculate the number of nitrogen atoms represented by the sample.

[2 marks]

(d) Calculate the total number of atoms represented by the sample.

[2 marks]

**QUESTION 23 | HARDER MIXED**

One aspirin tablet contains 0.325 g aspirin, $\text{C}_9\text{H}_8\text{O}_4$. $M(\text{C}_9\text{H}_8\text{O}_4) = 180 \text{ g mol}^{-1}$. A student claims that the tablet represents more than 4.00×10^{21} oxygen atoms.

(a) Calculate the amount of aspirin.

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[2 marks]

(b) Calculate the number of aspirin molecules.

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[2 marks]

(c) Calculate the number of oxygen atoms.

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[2 marks]

(d) Evaluate the student's claim.

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[1 mark]

**QUESTION 24 | STRETCH / SYNOPTIC**

Stretch note: This question connects ion electron counts from Atomic Structure I with the mass-mole-particle route from this pack.

Ion X^{2+} has 20 protons and 18 electrons. A 2.775 g sample of XCl_2 has molar mass 111 g mol^{-1} . Each Cl^- ion has 18 electrons.

(a) Identify X and use the particle counts to explain the $2+$ charge.

[2 marks]

(b) Calculate the amount of XCl_2 in the sample.

[2 marks]

(c) Calculate the number of XCl_2 formula units represented by the sample.

[2 marks]

(d) Calculate the number of chloride ions represented by the sample.

[1 mark]

(e) Calculate the total number of electrons represented by the ions in one formula unit of XCl_2 .

[2 marks]

(f) Calculate the total number of electrons represented by all the ions in the sample.

[3 marks]

✓ **DONE:** Mark the pack using the answer section. For every lost mark, identify whether the error came from the route, the multiplier, the unit or the final rounding.



CrackingCHEM

GCSE | A-LEVEL

UNDERSTAND • APPLY • SUCCEED

OCR A H432

Amount of Substance I

Fully worked answers | OCR A-style marking guidance

FULLY WORKED. PRECISELY MARKED. BUILT FOR IMPROVEMENT.

OCR A SPECIFICATION

2.1.1(c,e) | 2.1.3(a,e(i))

TEST IT

8

EXAM STYLE

10

HARDER MIXED

5

STRETCH

1

24 QUESTIONS MARKED

148 MARKS EXPLAINED

FINAL NOTES-ALIGNED EDITION | MASS • MOLES • SPECIFIED PARTICLES

Independent practice material. Every question is original and stays within the finished Amount of Substance I notes.



OCR A MAP

How this pack matches the finished notes

Full coverage of the assigned slice, with later quantitative chemistry kept out

Specification area	Recurring OCR A demand	Frequent trap	Questions
Relative mass	State the two required definitions; calculate M_r and relative formula mass from supplied A_r values.	Giving a unit to a relative mass or treating an average as a weighted mean.	1-3, 9
Mole and molar mass	Distinguish amount in mol from mass in g; use molar mass in g mol^{-1} and rearrange $n = m/M$.	Using an A_r instead of the molar mass of the whole formula.	3-5, 9, 12-13, 16, 19-24
Avogadro constant	Move between amount and a correctly named number of particles using $N = nN_A$.	Giving N a unit or writing only the vague label particles.	4, 6-8, 10-24
Entity and subscripts	Choose atoms, molecules, formula units, ions or electrons and apply the formula multiplier.	Multiplying ionic subscripts together or splitting a polyatomic ion into several ions.	7-8, 10-15, 17-24
Presentation	Use standard form, correct units, appropriate significant figures and a chemically labelled final answer.	Rounding intermediate values or copying calculator digits without checking precision.	5-6, 8-24

Research basis: The final design was checked against the completed CrackingChem OCR A Amount of Substance I notes, the CrackingChem Year 12 master specification map and OCR A Chemistry H432 Version 3.1. Every question in this pack is original.



SECTION A

TEST IT answers

Direct retrieval with exact OCR A terminology

TEST IT 1

- (a) Relative isotopic mass: the mass of an atom of an isotope compared with one-twelfth of the mass of an atom of carbon-12: atom of an isotope [1]; carbon-12 comparison [1]. [2]
- (b) Relative atomic mass: the weighted mean mass of an atom of an element compared with one-twelfth of the mass of an atom of carbon-12: weighted mean [1]; carbon-12 comparison [1]. [2]

Examiner guidance: For A_r , average on its own is not enough. OCR requires weighted mean. Do not attach a unit to either relative mass.

TEST IT 2

- (a) $M_r(\text{C}_2\text{H}_5\text{OH}) = (2 \times 12.0) + (6 \times 1.0) + 16.0$ [1] = 46.0 [1]. [2]
- (b) Relative formula mass of $\text{Mg}(\text{NO}_3)_2 = 24.3 + (2 \times 14.0) + (6 \times 16.0)$ [2] = 148.3 [1]. [3]
- (c) Relative masses are comparison values, so they have no unit. [1]

TEST IT 3

- (a) Relative formula mass = $40.1 + (2 \times 16.0) + (2 \times 1.0)$ [1] = 74.1 [1]. [2]
- (b) $M(\text{Ca}(\text{OH})_2) = 74.1 \text{ g mol}^{-1}$. [1]
- (c) The numerical value is the same because one mole has a mass in grams equal to the relative formula mass [1]. Relative formula mass is unitless, whereas molar mass is mass per mole in g mol^{-1} [1]. [2]

TEST IT 4

- (a) Amount of substance has symbol n [1] and unit mol [1]. [2]
- (b) One mole contains 6.02×10^{23} specified particles [1]; $N_a = 6.02 \times 10^{23} \text{ mol}^{-1}$ [1]. [2]
- mass $\rightarrow$ amount: $n = m/M$. [1]
- amount $\rightarrow$ mass: $m = nM$. [1]
- amount $\rightarrow$ particles: $N = nN_a$. [1]
- particles $\rightarrow$ amount: $n = N/N_a$. [1]

TEST IT 5

- (a) $n(\text{HCl}) = m/M = 7.30/36.5$ [1] = 0.200 mol [1]. [2]
- (b) $m(\text{Na}_2\text{CO}_3) = nM = 0.0750 \times 106$ [1] = 7.95 g [1]. [2]

TEST IT 6

- (a) $N = nN_a = 0.0350 \times 6.02 \times 10^{23}$ [1] = 2.11×10^{22} MgCl_2 formula units [1]. [2]
- (b) $n(\text{Ne}) = N/N_a = (9.03 \times 10^{22})/(6.02 \times 10^{23})$ [1] = 0.150 mol Ne [1]. [2]

TEST IT 7

- Ne: basic entity atom [1]; multiplier to Ne atoms $\times 1$ [1]. [2]
- O_2 : basic entity molecule [1]; multiplier to O atoms $\times 2$ [1]. [2]
- MgCl_2 : basic entity formula unit [1]; multiplier to Cl^- ions $\times 2$ [1]; multiplier to total ions $\times 3$ [1]. [3]
- Al^{3+} : each ion has 10 electrons, so the multiplier is $\times 10$. [1]

TEST IT 8

- $n(\text{Al}_2(\text{SO}_4)_3) = 3.42/342 = 0.0100 \text{ mol}$. [1]
- One formula unit contains 3 sulfate ions, so $n(\text{SO}_4^{2-}) = 0.0100 \times 3 = 0.0300 \text{ mol}$. [2]
- $N(\text{SO}_4^{2-}) = 0.0300 \times 6.02 \times 10^{23} = 1.806 \times 10^{22} = 1.81 \times 10^{22}$ sulfate ions. [2]



SECTION B

EXAM STYLE answers

Show the route, chemical multiplier and final check

EXAM STYLE 9

- (a) Relative formula mass = $(2 \times 55.8) + 3[(32.1) + (4 \times 16.0)]$ [2] = 399.9 [1]. [3]
- (b) $M(\text{Fe}_2(\text{SO}_4)_3) = 399.9 \text{ g mol}^{-1}$. [1]
- (c) $m = nM = 0.0250 \times 399.9$ [1] = 9.9975 g = 10.0 g to three significant figures [1]. [2]

EXAM STYLE 10

- (a) $N(\text{formula units}) = 0.0350 \times 6.02 \times 10^{23} = 2.11 \times 10^{22}$ formula units. [2]
- (b) Each formula unit contains 2 Cl^- ions, so $N(\text{Cl}^-) = 2 \times 2.107 \times 10^{22} = 4.21 \times 10^{22}$ chloride ions. [2]
- (c) The chloride-ion answer is twice the formula-unit answer because MgCl_2 contains two chloride ions per formula unit. [1]

EXAM STYLE 11

- (a) $N(\text{molecules}) = 0.240 \times 6.02 \times 10^{23} = 1.44 \times 10^{23}$ ethanol molecules. [2]
- (b) Each molecule contains one O atom, so $N(\text{O atoms}) = 1.44 \times 10^{23}$. [2]
- (c) $\text{C}_2\text{H}_5\text{OH}$ contains $2 + 6 + 1 = 9$ atoms per molecule [1]; $N(\text{total atoms}) = 9 \times 1.4448 \times 10^{23}$ [1] = 1.30×10^{24} atoms [1]. [3]

EXAM STYLE 12

- (a) $n(\text{NaCl}) = 5.85/58.5 = 0.100 \text{ mol}$. [2]
- (b) $N(\text{formula units}) = 0.100 \times 6.02 \times 10^{23} = 6.02 \times 10^{22}$ NaCl formula units. [2]
- (c) Each formula unit represents two ions, so $N(\text{total ions}) = 2 \times 6.02 \times 10^{22} = 1.20 \times 10^{23}$ ions. [2]

EXAM STYLE 13

- (a) $n(\text{CO}_2) = N/N_A = (3.01 \times 10^{22})/(6.02 \times 10^{23}) = 0.0500 \text{ mol}$. [2]
- (b) $m = nM = 0.0500 \times 44.0 = 2.20 \text{ g CO}_2$. [2]

EXAM STYLE 14

- (a) $n(\text{SO}_4^{2-}) = 0.0200 \times 3 = 0.0600 \text{ mol}$ [1]; $N = 0.0600 \times 6.02 \times 10^{23} = 3.61 \times 10^{22}$ sulfate ions [2]. [3]
- (b) Each formula unit represents $2 + 3 = 5$ ions [1]; $n(\text{total ions}) = 0.0200 \times 5 = 0.100 \text{ mol}$ [1]; $N = 6.02 \times 10^{22}$ ions [1]. [3]
- (c) SO_4^{2-} is one polyatomic ion. Its five atoms do not count as five separate ions. [1]

EXAM STYLE 15

- (a) Each Al^{3+} ion has 10 electrons. [1]
- (b) $n(\text{electrons}) = 0.0150 \times 10 = 0.150 \text{ mol electrons}$. [1]
- (c) $N(\text{electrons}) = 0.150 \times 6.02 \times 10^{23} = 9.03 \times 10^{22}$ electrons. [2]

EXAM STYLE 16

- (a) $n(\text{X}) = (6.02 \times 10^{22})/(6.02 \times 10^{23}) = 0.100 \text{ mol}$. [2]
- (b) $M(\text{X}) = m/n = 4.40/0.100 = 44.0 \text{ g mol}^{-1}$. [2]

EXAM STYLE 17

- (a) A: $2.00/4.00 = 0.500 \text{ mol He atoms}$; B: $16.0/32.0 = 0.500 \text{ mol O}_2$ molecules; C: $29.25/58.5 = 0.500 \text{ mol NaCl}$ formula units. All three contain the same number of basic entities, 3.01×10^{23} . [3]
- (b) B contains $0.500 \times 2 = 1.00 \text{ mol O atoms}$. C contains $0.500 \times 2 = 1.00 \text{ mol total ions}$. Each therefore represents 6.02×10^{23} requested particles. [3]

EXAM STYLE 18

- (a) The student counted formula units rather than sulfate ions [1], so the factor of 3 is missing [1]. [2] (b) $n(\text{SO}_4^{2-}) = 0.0100 \times 3 = 0.0300 \text{ mol}$ [1]; $N = 0.0300 \times 6.02 \times 10^{23}$ [1] = 1.81×10^{22} sulfate ions [1]. [3] (c) Particles is too vague; the final label must be sulfate ions. [1]



SECTION C

HARDER MIXED answers

Unfamiliar contexts, complete routes and justified comparisons

HARDER MIXED 19

- (a) $n(\text{NaCl}) = 5.00/58.5 = 0.085470\dots$ mol. One formula unit contains one Cl^- ion, so $n(\text{Cl}^-) = 0.085470\dots$ mol. [2]
- (b) $n(\text{MgCl}_2) = 5.00/95.3 = 0.052465\dots$ mol [1]. Each formula unit contains two Cl^- ions [1], so $n(\text{Cl}^-) = 0.10493\dots$ mol [1]. [3]
- (c) NaCl : $N(\text{Cl}^-) = 0.085470\dots \times 6.02 \times 10^{23} = 5.15 \times 10^{22}$. MgCl_2 : $N(\text{Cl}^-) = 0.10493\dots \times 6.02 \times 10^{23} = 6.32 \times 10^{22}$. [2]
- (d) The MgCl_2 sample represents more chloride ions. [1]

HARDER MIXED 20

- (a) $n(\text{NO}_3^-) = (1.806 \times 10^{23})/(6.02 \times 10^{23}) = 0.300$ mol. [2]
- (b) $\text{Ca}(\text{NO}_3)_2$ contains two nitrate ions per formula unit, so $n(\text{Ca}(\text{NO}_3)_2) = 0.300/2 = 0.150$ mol. [2]
- (c) $m = nM = 0.150 \times 164.1 = 24.615$ g = 24.6 g to three significant figures. [2]

HARDER MIXED 21

- (a) $n(\text{O atoms}) = (1.806 \times 10^{23})/(6.02 \times 10^{23}) = 0.300$ mol. [2]
- (b) X_2O_3 contains three O atoms per formula unit, so $n(\text{X}_2\text{O}_3) = 0.300/3 = 0.100$ mol. [1]
- (c) $M(\text{X}_2\text{O}_3) = m/n = 16.0/0.100 = 160$ g mol⁻¹. [2]
- (d) $2A_r(\text{X}) + (3 \times 16.0) = 160$ [1]; $A_r(\text{X}) = (160 - 48.0)/2 = 56.0$ [1], so X is iron, Fe [1]. [3]

HARDER MIXED 22

- (a) $n(\text{caffeine}) = 0.970/194 = 0.00500$ mol. [2]
- (b) $N(\text{molecules}) = 0.00500 \times 6.02 \times 10^{23} = 3.01 \times 10^{21}$ caffeine molecules. [2]
- (c) Each molecule contains four N atoms, so $N(\text{N atoms}) = 4 \times 3.01 \times 10^{21} = 1.20 \times 10^{22}$. [2]
- (d) Each molecule contains $8 + 10 + 4 + 2 = 24$ atoms, so $N(\text{total atoms}) = 24 \times 3.01 \times 10^{21} = 7.22 \times 10^{22}$ atoms. [2]

HARDER MIXED 23

- (a) $n(\text{aspirin}) = 0.325/180 = 0.0018055\dots$ mol. [2]
- (b) $N(\text{molecules}) = 0.0018055\dots \times 6.02 \times 10^{23} = 1.09 \times 10^{21}$ aspirin molecules. [2]
- (c) Each molecule contains four O atoms, so $N(\text{O atoms}) = 4 \times 1.0869\dots \times 10^{21} = 4.35 \times 10^{21}$ oxygen atoms. [2]
- (d) The claim is supported because 4.35×10^{21} is greater than 4.00×10^{21} . [1]

STRETCH / SYNOPTIC 24

- (a) Twenty protons identify calcium, Ca [1]. The ion has two fewer electrons than protons, so its charge is 2+ [1]. [2]
- (b) $n(\text{CaCl}_2) = 2.775/111 = 0.0250$ mol. [2]
- (c) $N(\text{formula units}) = 0.0250 \times 6.02 \times 10^{23} = 1.505 \times 10^{22} = 1.51 \times 10^{22}$ formula units. [2]
- (d) Each formula unit contains two Cl^- ions, so $N(\text{Cl}^-) = 2 \times 1.505 \times 10^{22} = 3.01 \times 10^{22}$ chloride ions. [1]
- (e) One Ca^{2+} ion has 18 electrons and two Cl^- ions have 2×18 electrons, giving $18 + 36 = 54$ electrons per formula unit. [2]
- (f) $N(\text{electrons}) = 54 \times 1.505 \times 10^{22}$ [1] = 8.127×10^{23} [1] = 8.13×10^{23} electrons [1]. [3]

Final check: Every calculation follows the finished notes' entity → amount → multiplier → particle route. Correct the earliest wrong step before reworking the rest.