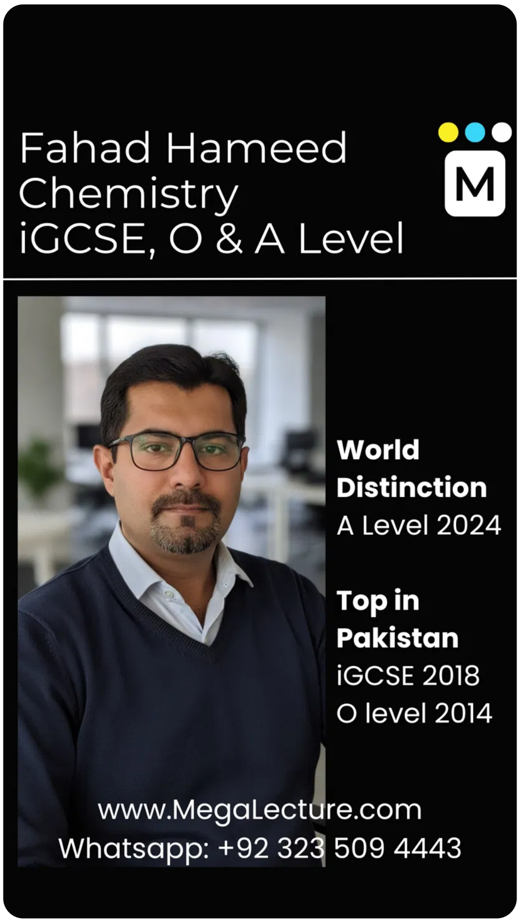
MEGA LECTURE · A LEVEL CHEMISTRY

Chapter 2: Atoms, Ions and Compounds

OCR A Level Chemistry A (H432) — Structured Practice Worksheet



SPECIFICATION	TOTAL MARKS	SUGGESTED TIME
2.1.1 Atomic structure & isotopes · 2.1.2 Relative mass · 2.1.3 Formulae & equations	100	2 hours

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Instructions to candidates

- Answer **all** questions in the spaces provided. Show all working in calculations.
- Give numerical answers to an appropriate number of significant figures.
- Marks are shown in brackets [ ] at the end of each part.
- You may use a scientific calculator and the periodic table on the OCR Data Sheet.

Question 1 — Atomic structure   2.1.1

a. Complete the table for the three subatomic particles. **[3]**

Particle	Relative mass	Relative charge
proton		
neutron		
electron		

b. Define the terms *atomic number* and *mass number*. **[2]**

c. Define the term *isotopes*. **[2]**

d. Explain why different isotopes of the same element have identical chemical properties. **[2]**

e. State the number of protons, neutrons and electrons in one ion of $^{34}S^{2-}$. **[2]**

Question 1 total: 11 marks

Question 2 — Relative masses   2.1.2

a.

Define the term *relative atomic mass*. **[2]**

b. Define the term *relative isotopic mass*. **[1]**

c. Explain why the relative atomic mass of chlorine (35.5) is not a whole number. **[2]**

d. A sample of silicon contains 92.2% ^{28}Si, 4.7% ^{29}Si and 3.1% ^{30}Si. Calculate the relative atomic mass of silicon in this sample to **3 significant figures**. **[3]**

Question 2 total: 8 marks

Question 3 — Isotopic abundance calculations 2.1.2

a. Copper has two isotopes, ^{63}Cu and ^{65}Cu, and a relative atomic mass of 63.55. Calculate the percentage abundance of each isotope. **[3]**

b. Gallium has two isotopes, ^{69}Ga and ^{71}Ga, and a relative atomic mass of 69.7. Calculate the percentage abundance of each isotope. **[4]**

Question 3 total: 7 marks

Question 4 — Mass spectra of elements 2.1.2

a. A mass spectrum of magnesium shows peaks at m/z = 24 (79.0%), 25 (10.0%) and 26 (11.0%). Calculate the relative atomic mass of magnesium to **3 significant figures**. **[3]**

b. State what the quantity *m/z* represents. **[1]**

c. Boron has a relative atomic mass of 10.8 and consists of the isotopes ^{10}B and ^{11}B. Calculate the percentage abundance of ^{11}B. **[2]**

Question 4 total: 6 marks

Question 5 — Mass spectra of molecules: chlorine and bromine 2.1.2

Chlorine exists as ^{35}Cl (75%) and ^{37}Cl (25%). Bromine exists as ^{79}Br and ^{81}Br in approximately equal (50:50) abundance.

a. The mass spectrum of Cl_2 shows three molecular ion peaks at m/z = 70, 72 and 74. Identify the isotopic composition of the molecule responsible for each peak. **[3]**

b. Explain why the peaks at m/z = 70, 72 and 74 occur in the ratio 9 : 6 : 1. **[2]**

c. Predict the m/z values and relative heights of the molecular ion peaks in the mass spectrum of Br_2. **[3]**

d. The same spectrum of Br_2 also shows two peaks at m/z = 79 and 81 of equal height. Identify the species responsible. **[2]**

Question 5 total: 10 marks

Question 6 — Ions: protons, neutrons and electrons 2.1.1

a.

Complete the table. **[6]**

Species	Protons	Neutrons	Electrons
$^{27}Al^{3+}$			
$^{79}Br^{-}$			
$^{58}Ni^{2+}$			

b. A positive ion has 19 protons, 20 neutrons and 18 electrons. Write the full symbol for this ion, including its mass number and charge. **[2]**

Question 6 total: 8 marks

Question 7 — Formulae of ionic compounds

2.1.3

a. Write the formula of each of the following compounds. **[10]**

Compound	Formula	Compound	Formula
ammonium sulfate		aluminium sulfate	
calcium nitrate		zinc phosphate	
iron(III) oxide		potassium dichromate(VI)	
magnesium hydroxide		copper(II) sulfate	
sodium carbonate		ammonium carbonate	

Question 7 total: 10 marks

Question 8 — Naming ionic compounds

2.1.3

a. Name each of the following compounds. **[6]**

Formula	Name	Formula	Name
KNO_3		NH_4Cl	
$Fe(OH)_2$		Cr_2O_3	
Na_2SO_3		$Cu(NO_3)_2$	

Question 8 total: 6 marks

Question 9 — Balancing equations

2.1.3

a. Balance each equation, adding state symbols. **[8]**

i. $Ca + HCl \rightarrow CaCl_2 + H_2$

ii. $Al + O_2 \rightarrow Al_2O_3$

iii. $Fe_2O_3 + CO \rightarrow Fe + CO_2$

iv. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$

b.

Write a balanced equation, with state symbols, for each reaction described below. **[6]**

i. Solid calcium carbonate decomposes on heating to form solid calcium oxide and carbon dioxide gas.

ii. Aqueous lead(II) nitrate reacts with aqueous potassium iodide to form a precipitate of lead(II) iodide and aqueous potassium nitrate.

iii. Magnesium reacts with steam to form solid magnesium oxide and hydrogen gas.

Question 9 total: 14 marks

Question 10 — Ionic equations

2.1.3

a. Write the ionic equation, with state symbols, for the precipitation reaction between aqueous silver nitrate and aqueous sodium chloride. **[2]**

b. Write the ionic equation for the neutralisation of any strong acid by any strong alkali. **[2]**

c. Write the ionic equation, with state symbols, for the precipitation reaction between aqueous barium chloride and aqueous sodium sulfate. **[2]**

d. Define the term *spectator ion* and identify the spectator ions in the reaction in (a). **[2]**

Question 10 total: 8 marks

Question 11 — Extended response

2.1.1 / 2.1.2

Explain how the mass spectrum of an element is used to determine its relative atomic mass, and explain why isotopes of an element are chemically identical but differ slightly in physical properties such as density and rate of diffusion. **[6]**

This question is marked using a level of response.

Question 11 total: 6 marks

Question 12 — Synoptic formulae check

2.1.3

a. Give the formula, including the charge, of each of the following ions: sulfate, nitrate, carbonate, hydroxide, ammonium, phosphate. **[6]**

Question 12 total: 6 marks

PAPER TOTAL: 100 MARKS

MARK SCHEME — Chapter 2: Atoms, Ions and Compounds

Award marks independently unless stated. ECF applies to calculations.

Q1 (a) [3]

- Proton: mass 1, charge +1. (1)
- Neutron: mass 1, charge 0. (1)
- Electron: mass 1/1836 (accept ~0 / negligible), charge −1. (1)

Q1 (b) [2]

- Atomic number: the number of protons in the nucleus. (1)
- Mass number: the total number of protons + neutrons in the nucleus. (1)

Q1 (c) [2]

- Atoms of the same element (same number of protons)... (1)
- ...with different numbers of neutrons / different masses. (1)

Q1 (d) [2]

- Chemical reactions involve electrons, and isotopes have the same number of electrons... (1)
- ...and the same electron configuration; neutrons do not affect chemical behaviour. (1)

Q1 (e) [2]

- 16 protons, 18 neutrons. (1)
- 18 electrons (2 gained by the 2− ion). (1)

Q2 (a) [2]

- The weighted mean mass of an atom of an element... (1)
- ...compared with 1/12 of the mass of an atom of carbon-12. (1)

Q2 (b) [1]

- The mass of an atom of a specific isotope compared with 1/12 of the mass of an atom of carbon-12. (1)

Q2 (c) [2]

- Chlorine is a mixture of isotopes (^{35}Cl and ^{37}Cl). (1)
- 35.5 is the weighted mean of the isotopic masses (75% × 35 + 25% × 37). (1)

Q2 (d) [3]

- $(28 \times 92.2) + (29 \times 4.7) + (30 \times 3.1) = 2581.6 + 136.3 + 93.0 = 2810.9$ (1)
- $\div 100 = 28.109$ (1)
- $= 28.1$ (3 s.f.) (1)

Q3 (a) [3]

- Let x = % of ^{63}Cu: $[63x + 65(100 - x)] / 100 = 63.55$ (1)
- $6500 - 2x = 6355$, so $x = 72.5$ (1)
- ^{63}Cu = 72.5%, ^{65}Cu = 27.5%. (1)

Q3 (b) [4]

- Let x = % of ^{69}Ga: $[69x + 71(100 - x)] / 100 = 69.7$ (1)
- $7100 - 2x = 6970$ (1)
- $x = 65.0$ (1)
- ^{69}Ga = 65%, ^{71}Ga = 35%. (1)

Q4 (a) [3]

- $(24 \times 79.0) + (25 \times 10.0) + (26 \times 11.0) = 1896 + 250 + 286 = 2432$ (1)
- $\div 100 = 24.32$ (1)
- $= 24.3$ (3 s.f.) (1)

Q4 (b) [1]

- Mass-to-charge ratio of the ion. (1)

Q4 (c) [2]

- Let x = % of ^{11}B: [10(100 − x) + 11x] / 100 = 10.8 → 1000 + x = 1080 (1)
- x = 80%. (1)

Q5 (a) [3]

- *m/z* 70 = $(^{35}Cl{-}^{35}Cl)^+$ (1)
- *m/z* 72 = $(^{35}Cl{-}^{37}Cl)^+$ (1)
- *m/z* 74 = $(^{37}Cl{-}^{37}Cl)^+$ (1)

Q5 (b) [2]

- Probabilities: 35–35 = 0.75 × 0.75 = 0.5625; 35–37 = 2 × 0.75 × 0.25 = 0.375; 37–37 = 0.25 × 0.25 = 0.0625. (1)
- 0.5625 : 0.375 : 0.0625 = 9 : 6 : 1. (1)

Q5 (c) [3]

- Peaks at *m/z* = 158, 160, 162. (1)
- Ratio 1 : 2 : 1 (probabilities 0.25 : 0.50 : 0.25 for a 50:50 mixture). (2 — award 1 for correct qualitative order)

Q5 (d) [2]

- $^{79}Br^+$ and $^{81}Br^+$ — fragment (atomic) bromine ions. (1)
- Equal heights because the two isotopes are equally abundant. (1)

Q6 (a) [6]

- $^{27}Al^{3+}$: 13 p, 14 n, 10 e. (2)
- $^{79}Br^-$: 35 p, 44 n, 36 e. (2)
- $^{58}Ni^{2+}$: 28 p, 30 n, 26 e. (2)

Q6 (b) [2]

- $^{39}K^+$ — potassium ion. (1 for K and charge +, 1 for mass number 39)

Q7 (a) [10] — 1 mark each

- $(NH_4)_2SO_4$ · $Ca(NO_3)_2$ · Fe_2O_3 · $Mg(OH)_2$ · Na_2CO_3
- $Al_2(SO_4)_3$ · $Zn_3(PO_4)_2$ · $K_2Cr_2O_7$ · $CuSO_4$ · $(NH_4)_2CO_3$

Q8 (a) [6] — 1 mark each

- Potassium nitrate · iron(II) hydroxide · sodium sulfite (accept sulfate(IV))
- Ammonium chloride · chromium(III) oxide · copper(II) nitrate

Q9 (a) [8] — 1 mark balancing + 1 mark state symbols per equation

- $Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$
- $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
- $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$
- $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ (accept (g) for water)

Q9 (b) [6] — 1 mark species + 1 mark balancing/states per equation

- $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
- $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$
- $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

Q10 (a) [2]

- $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ (1 species, 1 state symbols)

Q10 (b) [2]

- $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ (1 species, 1 state symbols)

Q10 (c) [2]

- $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ (1 species, 1 state symbols)

Q10 (d) [2]

- A spectator ion is present in the mixture but unchanged by / does not take part in the reaction. (1)
- In (a): Na^+ and NO_3^-. (1)

Q11 [6] — Level of response

- **Level 3 (5–6):** Full, well-organised account covering both the Ar determination and the isotope comparison with correct reasoning throughout.
- **Level 2 (3–4):** Covers both strands with minor omissions, or one strand fully and one partially.
- **Level 1 (1–2):** Fragmentary points; one strand only, with limited reasoning.

Indicative content: *the spectrum gives the isotopic mass (m/z of each peak, for 1+ ions) and percentage abundance (peak height/relative intensity); Ar = Σ(isotopic mass × abundance) ÷ 100 — weighted mean. Chemically identical: same number and arrangement of electrons, as reactions involve electron loss/gain/sharing. Physically different: different numbers of neutrons → different masses; heavier isotopes give higher density and diffuse/effuse more slowly at the same temperature (same kinetic energy, lower speed).*

Q12 (a) [6] — 1 mark each

- SO_4^{2-} · NO_3^- · CO_3^{2-} · OH^- · NH_4^+ · PO_4^{3-}

END OF MARK SCHEME · 100 marks