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AQA 7405

Atomic Structure II

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

SPECIFICATION-LED. PROGRESSIVE. EXAM-FOCUSED.

AQA SPECIFICATION LINKS	3.1.1.3 | 3.2.1.1 | IE links: 3.2.1.2 + 3.2.2

TEST IT	EXAM STYLE	HARDER MIXED	STRETCH
9	9	3	1

22 ORIGINAL QUESTIONS **127 TOTAL MARKS**

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

Mapped to AQA Chemistry 7405, version 1.2 (July 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. For every configuration: count electrons, follow the filling order, then check the superscripts.
3. For ions: apply the charge before writing the configuration and remove 4s electrons before 3d electrons.
4. Complete HARDER MIXED and STRETCH last. These questions make you choose the chemistry.

Configuration check

1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p. Capacities: s^2, p^6, d^{10}. For a neutral atom, the superscripts must add to the proton number.

Ionisation-energy explanations

Build a cause-and-effect chain: structural change → attraction to the electron changes → energy required changes.

Write or type

The pale blue 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

Build secure knowledge before moving to exam application

QUESTION 1 | TEST IT

(a) State the maximum number of electrons in an s sub-shell, a p sub-shell and a d sub-shell. (3 marks)

(b) Explain why a p sub-shell can hold a maximum of six electrons. (2 marks)

QUESTION 2 | TEST IT

(a) Put 3p, 4s, 3d and 4p in the order in which they fill. (1 mark)

(b) State the maximum number of electrons in the 3d sub-shell. (1 mark)

(c) State the principal energy level number of an electron in a 4p sub-shell. (1 mark)

QUESTION 3 | TEST IT

(a) Write the full electron configuration of phosphorus. (1 mark)

(b) Write the full electron configuration of calcium. (1 mark)

(c) Write the full electron configuration of selenium. (1 mark)

(d) Write the electron configuration of selenium using [Ar] shorthand. (1 mark)

QUESTION 4 | TEST IT

(a) Write the electron configuration of chromium using [Ar] shorthand. (1 mark)

(b) Write the electron configuration of copper using [Ar] shorthand. (1 mark)

(c) State the feature of the 3d sub-shell in chromium and in copper. (2 marks)

QUESTION 5 | TEST IT

(a) Write the electron configuration of O^{2-}. (1 mark)

(b) Write the electron configuration of Ca^{2+}. (1 mark)

(c) Write the electron configuration of Fe^{2+}. (1 mark)

(d) Write the electron configuration of Fe^{3+}. (1 mark)

(e) State which sub-shell loses electrons first when an iron atom forms a positive ion. (1 mark)

QUESTION 6 | TEST IT

An ion X^{3+} has electron configuration [Ar] $3d^2$.

(a) Determine the number of electrons in X^{3+}. (1 mark)

(b) Identify X. (1 mark)

(c) Write the electron configuration of the neutral X atom. (1 mark)

(d) Explain how you reconstructed the neutral atom from X^{3+}. (1 mark)

QUESTION 7 | TEST IT

(a) Define first ionisation energy. (3 marks)

(b) Write an equation, including state symbols, for the first ionisation energy of magnesium. (1 mark)

(c) State the units used for ionisation energy. (1 mark)

QUESTION 8 | TEST IT

(a) Write an equation for the second ionisation energy of magnesium. (1 mark)

(b) Write an equation for the third ionisation energy of aluminium. (1 mark)

(c) State whether ionisation is endothermic or exothermic. (1 mark)

QUESTION 9 | TEST IT

(a) State the three main factors that control the attraction between the nucleus and the electron being removed. (3 marks)

(b) Explain why an electron in a higher-energy sub-shell is easier to remove. (2 marks)

SECTION B

EXAM STYLE

Apply the topic using AQA-style command words and data

QUESTION 10 | EXAM STYLE

Element E has proton number 34 and forms the ion E^{2-}.

(a) Identify element E. (1 mark)

(b) Write the full electron configuration of an E atom. (1 mark)

(c) Write the full electron configuration of E^{2-}. (1 mark)

(d) State the number of electrons in E^{2-}. (1 mark)

(e) The final electron added to four different atoms enters a 3s, 3p, 3d and 4f sub-shell respectively. State the block of each atom. (4 marks)

(f) State how the block name of an element is chosen from its electron configuration. (1 mark)

QUESTION 11 | EXAM STYLE

Table 1 shows first ionisation energies for the Period 3 elements.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
IE_1 / kJ mol^{-1}	496	738	578	787	1012	1000	1251	1521

(a) Describe the general trend in first ionisation energy across Period 3. (1 mark)

(b) Explain this general trend. (3 marks)

(c) Identify the two places where first ionisation energy decreases. (1 mark)

(d) State what these decreases show about electron arrangement. (1 mark)

QUESTION 12 | EXAM STYLE

Magnesium is [Ne] $3s^2$ and aluminium is [Ne] $3s^2$ $3p^1$.

(a) State the sub-shell from which the first electron is removed from aluminium. (1 mark)

(b) Explain why the first ionisation energy of aluminium is lower than that of magnesium. (3 marks)

QUESTION 13 | EXAM STYLE

(a) State the final sub-shell occupancy in phosphorus and sulfur. (2 marks)

(b) Explain why sulfur has a slightly lower first ionisation energy than phosphorus. (2 marks)

QUESTION 14 | EXAM STYLE

Table 2 shows first ionisation energies for Group 2 elements.

Element	Be	Mg	Ca	Sr	Ba
IE_1 / kJ mol^{-1}	900	738	590	550	503

(a) Describe the trend down Group 2. (1 mark)

(b) Explain the trend. (4 marks)

QUESTION 15 | EXAM STYLE

Table 3 shows the first five successive ionisation energies of an element in Period 3.

Ionisation number	1	2	3	4	5
IE / kJ mol^{-1}	786	1577	3232	4356	16091

(a) Identify where the large jump occurs. (1 mark)

(b) State the number of electrons in the outer shell. (1 mark)

(c) Identify the element. (1 mark)

(d) Write its full electron configuration. (1 mark)

(e) Explain the large jump. (1 mark)

QUESTION 16 | EXAM STYLE

The first and second ionisation energies of sodium are 496 and 4562 kJ mol^{-1}. The corresponding values for magnesium are 738 and 1451 kJ mol^{-1}.

Explain why the second ionisation energy of sodium is much greater than the second ionisation energy of magnesium. (4 marks)

QUESTION 17 | EXAM STYLE

Table 4 shows successive ionisation energies for another Period 3 element.

Ionisation number	1	2	3	4	5	6	7	8
IE / kJ mol^{-1}	1000	2250	3360	4560	7000	8500	27100	31800

(a) Identify the largest jump in the data. (1 mark)

(b) State the number of electrons in the outer shell. (1 mark)

(c) Identify the element. (1 mark)

(d) Write its full electron configuration. (1 mark)

(e) Explain why the ionisation energy rises so sharply at this point. (3 marks)

QUESTION 18 | EXAM STYLE

The first four successive ionisation energies of aluminium are 578, 1817, 2745 and 11 578 kJ mol^{-1}.

(a) Write an equation, including state symbols, for the fourth ionisation energy of aluminium. (1 mark)

(b) Explain why the fourth ionisation energy is much greater than the third. (3 marks)

(c) Calculate the factor by which the fourth ionisation energy is greater than the third. Give your answer to three significant figures. (1 mark)

(d) State what the data show about the number of outer-shell electrons in aluminium. (1 mark)

SECTION C — HARDER MIXED

No route is given: select and connect the chemistry

QUESTION 19 | HARDER MIXED

An ion Y^{2+} has electron configuration [Ar] $3d^5$. Element Y has proton number no greater than 36.

(a) State the number of electrons in Y^{2+}. (1 mark)

(b) Determine the proton number and identity of Y. (2 marks)

(c) Write the electron configuration of the neutral Y atom. (1 mark)

(d) Write the electron configuration of Y^{3+}. (1 mark)

(e) Explain which sub-shell loses electrons first when Y forms positive ions. (1 mark)

(f) A student identifies Y as iron because Fe^{3+} also has configuration [Ar] $3d^5$. Explain the student's error. (2 marks)

QUESTION 20 | HARDER MIXED

Four Period 3 elements have the configurations and first ionisation energies shown in Table 5.

Species	Electron configuration	IE_1 / kJ mol^{-1}
A	[Ne] $3s^2$	738
B	[Ne] $3s^2$ $3p^1$	578
C	[Ne] $3s^2$ $3p^3$	1012
D	[Ne] $3s^2$ $3p^4$	1000

(a) Identify A, B, C and D. (4 marks)

(b) Explain why B has a lower first ionisation energy than A. (3 marks)

(c) Explain why D has a lower first ionisation energy than C. (2 marks)

QUESTION 21 | HARDER MIXED

Figure 1 shows all thirteen successive ionisation energies of an unknown Period 3 element.

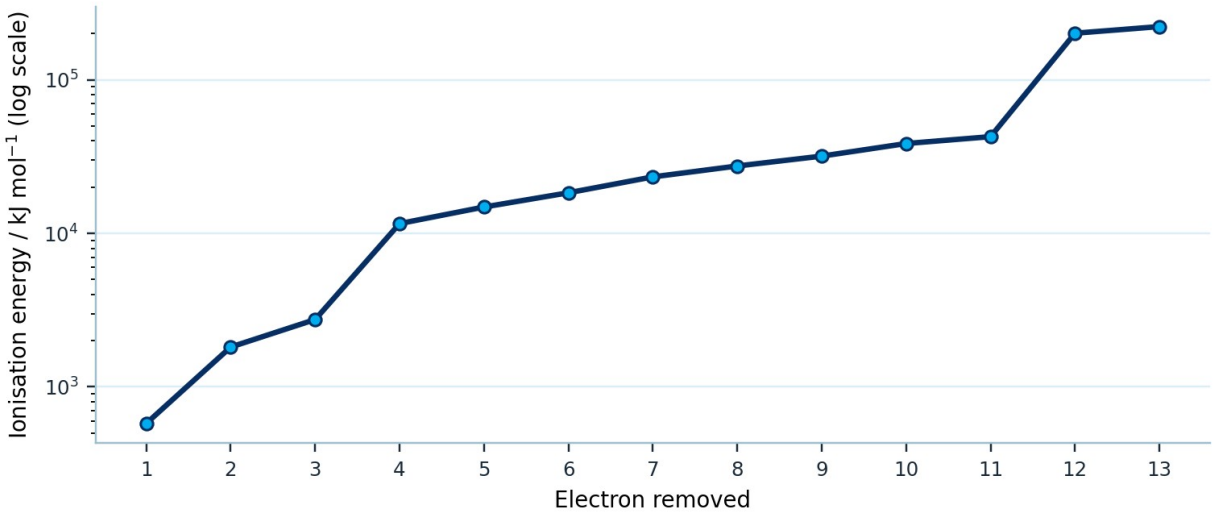

Figure 1. Successive ionisation energies of an unknown Period 3 element.

(a) Identify the positions of the two large jumps that show removal has begun from a new shell. (2 marks)

(b) Use the graph to state the number of electrons in the outer shell and in the second shell. (2 marks)

(c) Deduce the shell arrangement and identify the element. (2 marks)

(d) Write the full electron configuration of the element. (1 mark)

(e) Explain the first large jump. (2 marks)

(f) Explain why successive ionisation energies increase even before a new shell is reached. (1 mark)

SECTION D — STRETCH / SYNOPTIC

Connect Atomic Structure I evidence with Atomic Structure II reasoning

QUESTION 22 | STRETCH / SYNOPTIC

A sample of element M contains three isotopes. Its mass spectrum gives the data in Table 6.

m/z	24	25	26
Relative abundance / %	78.99	10.00	11.01

(a) Calculate the relative atomic mass of M. Give your answer to two decimal places. (2 marks)

(b) Identify M. (1 mark)

(c) Write the full electron configuration of M. (1 mark)

(d) Write the electron configuration of M^{2+}. (1 mark)

(e) Write an equation for the third ionisation energy of M. (1 mark)

The first three successive ionisation energies of M are 738, 1451 and 7733 kJ mol^{-1}.

(f) Use these values to explain what the data show about the outer-shell electrons and the position of the next electron removed. (4 marks)

(g) The first ionisation energy of calcium is 590 kJ mol^{-1}. Explain why this is lower than the first ionisation energy of M. (2 marks)

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AQA 7405

Atomic Structure II

Fully worked answers | AQA-style marking guidance

FULLY WORKED. PRECISELY MARKED. BUILT FOR IMPROVEMENT.

AQA SPECIFICATION LINKS	3.1.1.3 | 3.2.1.1 | IE links: 3.2.1.2 + 3.2.2

TEST IT	EXAM STYLE	HARDER MIXED	STRETCH
9	9	3	1

22 QUESTIONS MARKED **127 MARKS EXPLAINED**

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

Mapped to AQA Chemistry 7405, version 1.2 (July 2026)

AQA MAP

How AQA assesses this topic

Recurring demand patterns and the traps that lose marks

Specification area	Recurring AQA demand	Frequent trap	Questions
Shells, sub-shells and configurations	Construct and interpret configurations up to Z = 36; apply charge; handle Cr/Cu and 4s removal.	Counting charge in the wrong direction; using predicted Cr/Cu configurations; removing 3d before 4s.	1-6, 10, 19
Periodic Table blocks	Classify elements as s, p, d or f block from the sub-shell receiving the differentiating electron.	Assuming the principal-shell number names the block; forgetting that f-block recognition is required even though configurations stop at Z = 36.	10
Ionisation definitions and equations	Give the precise first-ionisation definition and write first or successive gaseous-ion equations.	Starting a successive equation with the neutral atom; missing gaseous state symbols; incomplete one-mole wording.	7-9, 18, 22
Period 3 first-ionisation evidence	Explain the general rise and the Mg→Al and P→S decreases using sub-shell energy and electron pairing.	Naming a factor without linking it to attraction and energy; calling the P→S change extra shielding.	11-13, 20
Group 2 first-ionisation evidence	Explain the decrease down the group using distance and shielding that outweigh nuclear charge.	Saying only that atoms are larger or contain more electrons.	14, 22
Successive-ionisation data	Locate large jumps, infer outer-shell count, identify an element and justify shell structure.	Calling every increase a shell jump; identifying an element without explaining the position of the jump.	15-18, 21, 22

Research basis

Scope checked against AQA Chemistry 7405 specification version 1.2 (July 2026): 3.1.1.3, 3.2.1.1, and the first-ionisation-energy links in 3.2.1.2 and 3.2.2. Wording and demand were calibrated against official AQA assessment resources. No past-paper question has been reproduced or closely paraphrased.

SECTION A

TEST IT answers

Secure the core language, configurations and equations

TEST IT 1

(a) s: 2 electrons; p: 6 electrons; d: 10 electrons. [3]

(b) A p sub-shell contains three orbitals [1] and each orbital holds a maximum of two electrons [1], so 3 × 2 = 6.

Examiner insight

Do not say that a p orbital holds six electrons. The two marking points are three orbitals in a p sub-shell and a maximum of two electrons in each orbital.

TEST IT 2

(a) 3p → 4s → 3d → 4p. [1]

(b) 10 electrons. [1]

(c) Principal energy level 4. [1]

TEST IT 3

(a) P: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$. [1]

(b) Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$. [1]

(c) Se: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$. [1]

(d) Se: [Ar] $3d^{10}\ 4s^2\ 4p^4$. [1]

Examiner insight

Either 4s before 3d or 3d before 4s is commonly accepted when the occupancy is correct. The filling route used in this pack is 4s then 3d.

TEST IT 4

(a) Cr: [Ar] $3d^5\ 4s^1$. [1]

(b) Cu: [Ar] $3d^{10}\ 4s^1$. [1]

(c) Chromium has a half-filled 3d sub-shell. [1] Copper has a full 3d sub-shell. [1]

Common trap

[Ar] $3d^4\ 4s^2$ and [Ar] $3d^9\ 4s^2$ are the simple predictions, not the observed configurations that must be used.

TEST IT 5

(a) O^{2-}: $1s^2\ 2s^2\ 2p^6$. [1]
(b) Ca^{2+}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ or [Ar]. [1]
(c) Fe^{2+}: [Ar] $3d^6$. [1]
(d) Fe^{3+}: [Ar] $3d^5$. [1]
(e) The 4s sub-shell loses electrons before the 3d sub-shell. [1]

Common trap

Do not remove 3d electrons first just because 3d is written before 4s in shorthand configurations.

TEST IT 6

(a) X^{3+} has 18 + 2 = 20 electrons. [1]
(b) The neutral atom has 23 electrons, so X is vanadium, V. [1]
(c) V: [Ar] $3d^3\ 4s^2$. [1]
(d) Add three electrons to reverse the 3+ charge: one returns to 3d and two return to 4s. [1]

TEST IT 7

(a) First ionisation energy is the energy required to remove one electron from each atom [1] in one mole of gaseous atoms [1] to form one mole of gaseous 1+ ions. [1]
(b) $Mg(g) \rightarrow Mg^+(g) + e^-$. [1]
(c) kJ mol^{-1}. [1]

Examiner insight

The words gaseous and one mole are marking points. A definition about removing one electron from a single atom is incomplete.

TEST IT 8

(a) $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$. [1]
(b) $Al^{2+}(g) \rightarrow Al^{3+}(g) + e^-$. [1]
(c) Endothermic. [1]

Common trap

For the nth ionisation energy, the starting ion has charge (n - 1)+ and the product ion has charge n+.

TEST IT 9

(a) Nuclear charge [1]; distance of the electron from the nucleus [1]; shielding by inner electrons. [1]
(b) The electron already has more energy / is less strongly attracted to the nucleus [1], so less additional energy is required to remove it. [1]

SECTION B

EXAM STYLE answers

Full marking points and targeted examiner guidance

EXAM STYLE 10

(a) E is selenium, Se. [1]

(b) Se: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$. [1]

(c) Se^{2-}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$. [1]

(d) 36 electrons. [1]

(e) 3s: s block [1]; 3p: p block [1]; 3d: d block [1]; 4f: f block. [1]

(f) The block is named after the type of sub-shell receiving the differentiating / final electron. [1]

Examiner insight

The f block must still be recognised from the Periodic Table even though AQA electron configurations in this topic are limited to Z = 36 and therefore use only s, p and d sub-shells.

EXAM STYLE 11

(a) First ionisation energy generally increases from sodium to argon. [1]

(b) Nuclear charge increases [1]. Electrons are added to the same principal shell, so inner-shell shielding is broadly similar [1]. Attraction to the outer electron becomes stronger and more energy is required to remove it. [1]

(c) Mg → Al and P → S. Both required. [1]

(d) The Mg → Al decrease is evidence for different sub-shell energies; the P → S decrease is evidence for electron pairing within orbitals. [1]

Examiner insight

A description of the trend earns no explanation marks. Link nuclear charge and shielding to attraction, then to the energy required.

EXAM STYLE 12

(a) The 3p sub-shell. [1]

(b) The 3p electron is in a higher-energy sub-shell than a 3s electron [1] and is slightly more shielded [1]. It is less strongly attracted / easier to remove, so aluminium has the lower first ionisation energy. [1]

EXAM STYLE 13

(a) P: $3p^3$. [1] S: $3p^4$. [1]

(b) Sulfur has a pair of electrons in one 3p orbital [1]. Repulsion within the pair makes one electron easier to remove. [1]

Common trap

Do not claim that sulfur has more shielding because it has one more electron. The key difference is paired-electron repulsion in the same 3p sub-shell.

SECTION B

EXAM STYLE answers - continued

Questions 14-16

EXAM STYLE 14

(a) First ionisation energy decreases down Group 2. [1]

(b) The outer electron occupies a higher principal shell [1], so it is further from the nucleus [1] and experiences more shielding [1]. These effects outweigh the increased nuclear charge, so attraction is weaker and less energy is required. [1]

EXAM STYLE 15

(a) The large jump is between the fourth and fifth ionisation energies. [1]

(b) Four outer-shell electrons. [1]

(c) Silicon, Si. [1]

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$. [1]

(e) After four electrons have been removed, the next electron comes from an inner shell and is more strongly attracted to the nucleus. [1]

EXAM STYLE 16

Na^+ is $1s^2\ 2s^2\ 2p^6$, so its second electron is removed from the n = 2 shell. [1]

Mg^+ is $1s^2\ 2s^2\ 2p^6\ 3s^1$, so its second electron is removed from the 3s sub-shell. [1]

The electron removed from Na^+ is closer to the nucleus and less shielded. [1]

It is therefore more strongly attracted and requires much more energy to remove. [1]

Examiner insight

Compare the ions immediately before the second electron is removed: Na^+ and Mg^+, not the neutral atoms.

SECTION B

EXAM STYLE answers - continued

Questions 17-18

EXAM STYLE 17

(a) The largest jump is between the sixth and seventh ionisation energies. [1]

(b) Six outer-shell electrons. [1]

(c) Sulfur, S. [1]

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$. [1]

(e) The seventh electron is removed from the n = 2 shell [1], where it is closer to the nucleus and less shielded [1], so attraction is much stronger and far more energy is required. [1]

EXAM STYLE 18

(a) $Al^{3+}(g) \rightarrow Al^{4+}(g) + e^-$. [1]

(b) Three outer-shell electrons have already been removed [1]. The fourth electron is removed from an inner shell, so it is closer to the nucleus / less shielded [1] and much more strongly attracted. [1]

(c) 11 578 ÷ 2745 = 4.22 to three significant figures. [1]

(d) Aluminium has three outer-shell electrons. [1]

SECTION C

HARDER MIXED answers

Use electron counts, configurations and data as one connected argument

HARDER MIXED 19

(a) Y^{2+} has 18 + 5 = 23 electrons. [1]

(b) Neutral Y has 25 electrons / proton number 25 [1], so Y is manganese, Mn. [1]

(c) Mn: [Ar] $3d^5$ $4s^2$. [1]

(d) Mn^{3+}: [Ar] $3d^4$. [1]

(e) The 4s electrons are removed before 3d electrons. [1]

(f) The charge must be used as well as the configuration [1]. Fe^{3+} is [Ar] $3d^5$, but Fe^{2+} is [Ar] $3d^6$, so Y^{2+} cannot be Fe^{2+}. [1]

Common trap

An electron configuration identifies the number of electrons, not the proton number, unless the charge is also used.

HARDER MIXED 20

(a) A = Mg [1]; B = Al [1]; C = P [1]; D = S. [1]

(b) B loses a 3p electron rather than a 3s electron [1]. The 3p electron is higher in energy / slightly more shielded [1], so it is easier to remove. [1]

(c) D has a pair of electrons in one 3p orbital [1]. Repulsion within the pair makes one electron easier to remove. [1]

HARDER MIXED 21

(a) The two shell-boundary jumps are after IE_3 and after IE_{11}. [2]

(b) Three electrons are in the outer shell [1] and eight electrons are in the second shell. [1]

(c) Shell arrangement 2,8,3 [1], so the Period 3 element is aluminium. [1]

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$. [1]

(e) After three electrons are removed, the next electron comes from the n = 2 shell [1], where it is closer / less shielded and therefore more strongly attracted. [1]

(f) Each electron is removed from an increasingly positive ion, so the remaining electrons are attracted more strongly. [1]

Examiner insight

Use the first major jump to find outer-shell electrons. A second major jump can reveal the size of the next shell and therefore the full shell arrangement.

SECTION D

STRETCH / SYNOPTIC answer

Connect mass-spectral evidence with configuration and ionisation reasoning

STRETCH / SYNOPTIC 22

(a) A_r = [(24 × 78.99) + (25 × 10.00) + (26 × 11.01)] ÷ 100 [1] = 24.32. [1]

(b) M is magnesium, Mg. [1]

(c) Mg: $1s^2\ 2s^2\ 2p^6\ 3s^2$. [1]

(d) Mg^{2+}: $1s^2\ 2s^2\ 2p^6$ or [Ne]. [1]

(e) $Mg^{2+}(g) \rightarrow Mg^{3+}(g) + e^-$. [1]

(f) The large jump is between the second and third ionisation energies [1], so magnesium has two outer-shell electrons. [1] The third electron is removed from an inner shell [1], where it is closer / less shielded and much more strongly attracted. [1]

(g) Calcium has an additional occupied shell, so its outer electron is further from the nucleus and more shielded [1]. Attraction is weaker, so less energy is required to remove it. [1]

Examiner insight

This question crosses from Atomic Structure I to II: mass-spectral evidence identifies the element, then electron configuration and ionisation data test whether the identification is chemically consistent.

Final review

A correct final statement is not enough. Check that every configuration, charge, state symbol and cause-and-effect link would earn the intended mark.