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# IB Chemistry Paper 1A Practice Pack

Structure 1.2 — The nuclear atom  
Structure 1.3 — Electron configurations

|                |                                                    |
|----------------|----------------------------------------------------|
| Questions      | 30 multiple-choice questions, 1 mark each          |
| Section A      | Q1–20 · SL <i>and</i> HL                           |
| Section B      | Q21–30 · HL only (AHL material)                    |
| Suggested time | SL 30 minutes (Q1–20) · HL 45 minutes (Q1–30)      |
| Allowed        | Calculator and IB Chemistry data booklet           |
| Syllabus       | IB DP Chemistry, first assessment 2025             |
| Includes       | Full mark scheme with reasoning and examiner notes |

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Written by Waseem Ahmad · Premium one-to-one IB tuition in Physics, Chemistry and Maths

## How to use this pack

This pack follows the format of **Paper 1A** in the current IB Diploma Programme Chemistry course (first assessment 2025). Every question has four options, A to D, and is worth one mark. No marks are deducted for an incorrect answer, so never leave a question blank.

- **Standard Level students** answer Section A only (Q1–20). Allow 30 minutes.
- **Higher Level students** answer Sections A and B (Q1–30). Allow 45 minutes.
- Record your answers on the grid on page 4, then mark using the scheme from page 8.
- A calculator and a clean copy of the IB Chemistry data booklet are permitted, as they are in the real examination. Section 2 (constants) and Section 7 (periodic table) are the ones you will need here.

**Data you may need.** Planck constant  $h = 6.63 \times 10^{-34} \text{ J s}$  · speed of light  $c = 3.00 \times 10^8 \text{ m s}^{-1}$  · Avogadro constant  $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$  ·  $E = hf$  ·  $c = \lambda f$ . All of these are in the data booklet.

## How the real Paper 1A is structured

Paper 1 is sat as two booklets in one sitting: Paper 1A (multiple choice) and Paper 1B (data-based). At SL, Paper 1A contains 30 questions; at HL it contains 40 questions covering both SL and additional higher level (AHL) material. Under the current syllabus a calculator and the data booklet are permitted in every paper — this pack is written on that basis.

## A note on using A-level worksheets for IB

Material written for A-level (AQA, OCR, Edexcel) overlaps heavily with this topic, but three areas are *not* assessed by the IB and should not be revised from those sheets:

- **Time-of-flight calculations.** Flight-tube equations ( $KE = \frac{1}{2}mv^2$ ,  $t = d/\sqrt{m/2KE}$ ) are AQA content. The IB guide states explicitly that the operational details of the mass spectrometer will not be assessed.
- **The historical sequence of atomic models** (Dalton, Thomson, Rutherford, Bohr, Chadwick) is useful context for the nature of science, but is not an assessed learning outcome in Structure 1.2.
- **“Special stability” explanations** of ionisation-energy dips. The IB requires explanations based on the energy of the electron removed — see the note to Q26.

## Syllabus coverage map

Each question is mapped to the syllabus point it assesses, so you can turn a wrong answer straight into a revision target.

| Question | Syllabus point           | Level   |
|----------|--------------------------|---------|
| 1–3      | S1.2.1                   | SL + HL |
| 4–7      | S1.2.2                   | SL + HL |
| 8        | S1.3.1                   | SL + HL |
| 9        | S1.3.1, S1.3.2           | SL + HL |
| 10–12    | S1.3.2                   | SL + HL |
| 13       | S1.3.3                   | SL + HL |
| 14       | S1.3.4, S1.3.5           | SL + HL |
| 15       | S1.3.3, S1.3.4           | SL + HL |
| 16–20    | S1.3.5                   | SL + HL |
| 21–23    | S1.2.3                   | HL only |
| 24       | S1.2.3 (links to S3.2.8) | HL only |
| 25       | S1.3.6                   | HL only |
| 26       | S1.3.6 (links to S3.1.7) | HL only |
| 27–28    | S1.3.6                   | HL only |
| 29–30    | S1.3.7                   | HL only |

## Syllabus points assessed

|                     |                                                                                                                                                                                                                         |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>S1.2.1</b>       | Atoms contain a dense, positively charged nucleus of protons and neutrons, with electrons outside it. Use the nuclear symbol to deduce protons, neutrons and electrons in atoms and ions.                               |
| <b>S1.2.2</b>       | Isotopes are atoms of the same element with different numbers of neutrons. Perform calculations involving non-integer relative atomic masses and isotopic abundance.                                                    |
| <b>S1.2.3</b> HL    | Mass spectra are used to determine relative atomic masses from isotopic composition; interpret spectra in terms of identity and relative abundance of isotopes.                                                         |
| <b>S1.3.1</b>       | Emission spectra are produced when electrons in excited states return to lower levels. Describe colour, wavelength, frequency and energy across the electromagnetic spectrum; distinguish continuous from line spectra. |
| <b>S1.3.2</b>       | The line emission spectrum of hydrogen gives evidence for discrete energy levels that converge at higher energy.                                                                                                        |
| <b>S1.3.3–1.3.4</b> | Main energy level $n$ holds a maximum of $2n^2$ electrons; sublevels s, p, d and f of successively higher energy; shape and orientation of s and p orbitals.                                                            |
| <b>S1.3.5</b>       | Apply the Aufbau principle, Hund's rule and the Pauli exclusion principle to deduce configurations for atoms and ions up to $Z = 36$ , including Cr and Cu.                                                             |
| <b>S1.3.6</b> HL    | The convergence limit corresponds to ionisation. Explain trends and discontinuities in first ionisation energy; calculate the first ionisation energy from the convergence limit.                                       |
| <b>S1.3.7</b> HL    | Successive ionisation energy data give information about electron configuration; deduce the group of an element from successive ionisation data.                                                                        |

## Answer grid

Write A, B, C or D in each box. Section A is for all candidates; Section B is for HL candidates only.

### Section A — SL and HL

|    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|
| 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|    |    |    |    |    |    |    |    |    |    |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|    |    |    |    |    |    |    |    |    |    |

### Section B — HL only

|    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|    |    |    |    |    |    |    |    |    |    |

**Marking.** Section A: \_\_\_\_ / 20 · Section B (HL): \_\_\_\_ / 10 · Total: \_\_\_\_ / 30. Aim for 80 % or better before moving on to Structure 1.4.

**Before you start.** Work without notes and to time. Multiple choice rewards precision rather than recognition, so decide on your answer before you read the options wherever you can.

## Section A — Questions 1 to 20 (SL and HL)

### All candidates answer this section

Structure 1.2.1, 1.2.2 and Structure 1.3.1–1.3.5 · 20 marks · 30 minutes

1. How many protons, neutrons and electrons are present in one ion of  $^{56}_{26}\text{Fe}^{3+}$ ?
- A. 26 p, 30 n, 23 e  
B. 26 p, 30 n, 29 e  
C. 26 p, 26 n, 23 e  
D. 23 p, 30 n, 26 e
2. A particle contains 16 protons, 18 neutrons and 18 electrons. What is the particle?
- A.  $^{34}_{16}\text{S}^{2-}$   
B.  $^{32}_{16}\text{S}^{2-}$   
C.  $^{34}_{18}\text{Ar}$   
D.  $^{34}_{17}\text{Cl}^{-}$
3. Which statement about sub-atomic particles is correct?
- A. A proton and a neutron carry the same relative charge.  
B. The mass of an electron is approximately 1/1836 of the mass of a proton.  
C. Electrons are found within the nucleus.  
D. The number of neutrons determines which element an atom is.
4. Two isotopes of the same element always differ in their
- A. number of protons  
B. number of electrons in the neutral atom  
C. rate of diffusion  
D. chemical properties
5. An element consists of 60.0 % of the isotope of mass 69 and 40.0 % of the isotope of mass 71. What is its relative atomic mass?
- A. 69.4  
B. 69.8  
C. 70.0  
D. 70.2
6. Boron has a relative atomic mass of 10.81 and consists only of  $^{10}\text{B}$  and  $^{11}\text{B}$ . What is the percentage abundance of  $^{11}\text{B}$ ?
- A. 19 %  
B. 20 %  
C. 80 %  
D. 81 %
7. A sample of an element contains 90.5 % of mass 20, 0.3 % of mass 21 and 9.2 % of mass 22. What is its relative atomic mass?
- A. 20.00  
B. 20.19  
C. 20.28  
D. 21.00
8. Which type of electromagnetic radiation has photons of the highest energy?
- A. Microwave  
B. Infrared  
C. Red light  
D. Ultraviolet

9. Which statement about atomic emission spectra is correct?
- A. A line emission spectrum contains every wavelength within a region.
  - B. A continuous spectrum is produced when excited electrons fall to the ground state.
  - C. A line emission spectrum is evidence that electron energies are quantized.
  - D. The lines in an emission spectrum become further apart as frequency increases.
- 
10. The lines in the visible region of the hydrogen emission spectrum correspond to electron transitions to which energy level?
- A.  $n = 1$
  - B.  $n = 2$
  - C.  $n = 3$
  - D.  $n = \infty$
- 
11. Why do the lines in the emission spectrum of hydrogen converge at higher frequency?
- A. The energy levels become closer together as  $n$  increases.
  - B. The electron moves faster in higher energy levels.
  - C. Fewer electrons are available for transitions at high energy.
  - D. The energy of a photon decreases as its frequency increases.
- 
12. Which electron transition in a hydrogen atom emits the photon of longest wavelength?
- A.  $n = 2 \rightarrow n = 1$
  - B.  $n = 3 \rightarrow n = 1$
  - C.  $n = 3 \rightarrow n = 2$
  - D.  $n = 4 \rightarrow n = 1$
- 
13. What is the maximum number of electrons that can occupy the main energy level  $n = 4$ ?
- A. 8
  - B. 18
  - C. 32
  - D. 50
- 
14. Which statement about atomic orbitals is correct?
- A. A 2p orbital is spherical.
  - B. The three 2p orbitals are mutually perpendicular.
  - C. A 2s orbital can hold six electrons.
  - D. A d sublevel contains three orbitals.
- 
15. How many orbitals are there in the main energy level  $n = 3$ ?
- A. 3
  - B. 5
  - C. 9
  - D. 18
- 
16. What is the electron configuration of a chromium atom ( $Z = 24$ )?
- A.  $[\text{Ar}]3d^44s^2$
  - B.  $[\text{Ar}]3d^54s^1$
  - C.  $[\text{Ar}]3d^6$
  - D.  $[\text{Ar}]3d^34s^24p^1$
- 
17. What is the electron configuration of the  $\text{Cu}^{2+}$  ion ( $Z = 29$ )?
- A.  $[\text{Ar}]3d^9$
  - B.  $[\text{Ar}]3d^84s^1$
  - C.  $[\text{Ar}]3d^74s^2$
  - D.  $[\text{Ar}]3d^{10}$
-

18. Which species contains exactly three unpaired electrons in its ground state?

- |       |                     |
|-------|---------------------|
| A. N  | B. O                |
| C. Ne | D. $\text{Ti}^{2+}$ |
- 

19. Which rule or principle states that electrons occupy orbitals of the same energy singly before pairing?

- |                         |                                  |
|-------------------------|----------------------------------|
| A. The Aufbau principle | B. The Pauli exclusion principle |
| C. Hund's rule          | D. Avogadro's law                |
- 

20. The 2p sublevel of a ground-state oxygen atom contains

- A. two pairs of electrons and no unpaired electrons
  - B. one pair of electrons and two unpaired electrons
  - C. four unpaired electrons in four orbitals
  - D. three unpaired electrons and one empty orbital
-

## Section B — Questions 21 to 30 (HL only)

## Higher Level candidates only

21. The mass spectrum of an element shows peaks at  $m/z$  24 (78.6 %), 25 (10.1 %) and 26 (11.3 %). What is the relative atomic mass of the element?

- A. 24.00  
B. 24.33  
C. 25.00  
D. 25.33

**22.** In the mass spectrum of an element, the height of each peak indicates the

- A. mass of the isotope  
B. relative abundance of the isotope  
C. charge on the ion  
D. ionisation energy of the isotope

**23.** A mass spectrum of an element shows only two peaks, at  $m/z$  63 (69 %) and  $m/z$  65 (31 %). Which element is it?

- A. Ni
- B. Cu
- C. Zn
- D. Ga

**24.** Bromine exists as diatomic molecules and has two isotopes,  $^{79}\text{Br}$  and  $^{81}\text{Br}$ , in approximately equal abundance. The mass spectrum of  $\text{Br}_2$  shows molecular ion peaks at  $m/z$  158, 160 and 162. What is the ratio of their intensities?

- A. 1:1:1  
B. 1:2:1  
C. 3:4:1  
D. 1:3:3

**25.** Which equation represents the first ionisation energy of magnesium?

- A.  $\text{Mg(s)} \rightarrow \text{Mg}^+(\text{g}) + \text{e}^-$       B.  $\text{Mg(g)} \rightarrow \text{Mg}^+(\text{g}) + \text{e}^-$   
C.  $\text{Mg(g)} \rightarrow \text{Mg}^{2+}(\text{g}) + 2\text{e}^-$       D.  $\text{Mg}^+(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{e}^-$

**26.** The first ionisation energy of sulfur is lower than that of phosphorus. The best explanation is that

- A.** sulfur has a smaller atomic radius than phosphorus
- B.** the electron removed from sulfur comes from a 3p orbital already containing two electrons, and repulsion between them lowers the energy needed
- C.** phosphorus has more protons than sulfur
- D.** the electron removed from sulfur comes from a 3s orbital

**27.** First ionisation energy decreases down group 1. This is because, going down the group,

- A. the nuclear charge decreases
- B. the atomic radius increases and shielding increases
- C. the number of occupied main energy levels decreases
- D. repulsion between the outer electrons increases

**28.** The convergence limit in the Lyman series of hydrogen occurs at a frequency of  $3.28 \times 10^{15} \text{ s}^{-1}$ . What is the first ionisation energy of hydrogen? ( $h = 6.63 \times 10^{-34} \text{ J s}$ ;  $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$ )

- A.  $2.17 \times 10^{-18} \text{ kJ mol}^{-1}$       B.  $1.31 \times 10^3 \text{ kJ mol}^{-1}$   
C.  $1.31 \times 10^6 \text{ kJ mol}^{-1}$       D.  $2.17 \times 10^3 \text{ kJ mol}^{-1}$

**29.** The first five ionisation energies of an element, in  $\text{kJ mol}^{-1}$ , are 738, 1451, 7733, 10 543 and 13 630. In which group of the periodic table is this element?

A. Group 1

B. Group 2

C. Group 13

D. Group 15

---

**30.** For which element would the largest increase occur between the fourth and fifth successive ionisation energies?

A. Al

B. Si

C. P

D. S

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## Mark scheme — Section A (SL and HL)

One mark per question. The reasoning column is what you should be able to reconstruct in about thirty seconds; if you cannot, that syllabus point needs another pass.

| Q | Ans | Reasoning                                                                                                                                                                                                                                                                                                                                                                                       | Syllabus       |
|---|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 1 | A   | <p>Protons = <math>Z = 26</math>. Neutrons = <math>A - Z = 56 - 26 = 30</math>. A 3+ charge means three electrons have been <i>lost</i>: <math>26 - 3 = 23</math>.</p> <p><b>EXAMINER'S NOTE</b> Forming an ion never changes the proton number — only the electron count.</p>                                                                                                                  | S1.2.1         |
| 2 | A   | <p>16 protons identifies sulfur. Mass number = <math>16 + 18 = 34</math>. Two more electrons than protons gives a 2- charge.</p> <p><b>EXAMINER'S NOTE</b> Work in the order: protons → element, protons + neutrons → mass number, electrons – protons → charge.</p>                                                                                                                            | S1.2.1         |
| 3 | B   | <p>Relative masses and charges are given in the data booklet: proton +1, neutron 0, electron –1 with a relative mass of about <math>5 \times 10^{-4}</math> (<math>\approx 1/1836</math>). The element is fixed by the proton number, and electrons occupy the space outside the nucleus.</p> <p><b>EXAMINER'S NOTE</b> Never write that an electron has zero mass — write “negligible”.</p>    | S1.2.1         |
| 4 | C   | <p>Isotopes differ only in neutron number, so they differ in mass-dependent <i>physical</i> properties such as density, boiling point and rate of diffusion. Proton number, electron number and therefore chemical behaviour are the same.</p> <p><b>EXAMINER'S NOTE</b> The guide expects you to know that physical properties differ while chemical properties are essentially identical.</p> | S1.2.2         |
| 5 | B   | <p><math>(69 \times 0.600) + (71 \times 0.400) = 41.4 + 28.4 = \mathbf{69.8}</math>.</p> <p><b>EXAMINER'S NOTE</b> The weighted mean always lies nearer the more abundant isotope — a fast way to eliminate options.</p>                                                                                                                                                                        | S1.2.2         |
| 6 | D   | <p>Let the abundance of <math>^{10}\text{B}</math> be <math>x</math>: <math>[10x + 11(100 - x)] / 100 = 10.81</math>, so <math>1100 - x = 1081</math> and <math>x = 19</math>. Therefore <math>^{11}\text{B} = \mathbf{81\%}</math>.</p> <p><b>EXAMINER'S NOTE</b> Read the question — the algebra gives the <i>lighter</i> isotope first, and 19 % is placed as a distractor.</p>              | S1.2.2         |
| 7 | B   | <p><math>(20 \times 0.905) + (21 \times 0.003) + (22 \times 0.092) = 18.10 + 0.063 + 2.024 = \mathbf{20.19}</math>.</p> <p><b>EXAMINER'S NOTE</b> Keep full figures through the calculation and round only at the end.</p>                                                                                                                                                                      | S1.2.2         |
| 8 | D   | <p>Energy increases with frequency (<math>E = hf</math>) and therefore with decreasing wavelength. Of these, ultraviolet has the shortest wavelength and highest frequency.</p> <p><b>EXAMINER'S NOTE</b> Learn the order of the electromagnetic spectrum — it is assessed qualitatively only.</p>                                                                                              | S1.3.1         |
| 9 | C   | <p>Discrete lines can only arise if electrons occupy fixed (quantized) energy levels, so only certain photon energies can be emitted. Continuous spectra contain all wavelengths; emission lines <i>converge</i> at higher frequency.</p> <p><b>EXAMINER'S NOTE</b> “Line spectrum → discrete energy levels” is the single most examined idea in Structure 1.3.</p>                             | S1.3.1, S1.3.2 |

| Q  | Ans | Reasoning                                                                                                                                                                                                                                                                                                    | Syllabus       |
|----|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 10 | B   | Transitions ending at $n = 2$ give the visible series; transitions to $n = 1$ lie in the ultraviolet and those to $n = 3$ in the infrared.<br><br><b>EXAMINER'S NOTE</b> The guide asks specifically for transitions to the first, second and third energy levels — UV, visible, IR respectively.            | S1.3.2         |
| 11 | A   | The spacing between successive energy levels decreases as $n$ increases, so the photon energies (and frequencies) emitted become progressively closer together until they converge.<br><br><b>EXAMINER'S NOTE</b> Convergence is the visual evidence for energy levels converging towards ionisation.        | S1.3.2         |
| 12 | C   | Longest wavelength = lowest photon energy = smallest gap between levels. The levels are closest together at higher $n$ , so $3 \rightarrow 2$ releases the least energy.<br><br><b>EXAMINER'S NOTE</b> Wavelength and energy are inversely related — check which one the question asks for.                  | S1.3.2         |
| 13 | C   | Maximum = $2n^2 = 2 \times 4^2 = 32$ .<br><br><b>EXAMINER'S NOTE</b> $2n^2$ is stated explicitly in the syllabus — learn it as a formula, not as a list.                                                                                                                                                     | S1.3.3         |
| 14 | B   | The three p orbitals are dumb-bell shaped and aligned along the mutually perpendicular x, y and z axes. s orbitals are spherical and hold two electrons; a d sublevel has five orbitals.<br><br><b>EXAMINER'S NOTE</b> You are only required to recognise the shape and orientation of s and p orbitals.     | S1.3.4, S1.3.5 |
| 15 | C   | One 3s + three 3p + five 3d = 9 orbitals (which holds 18 electrons, consistent with $2n^2$ ).<br><br><b>EXAMINER'S NOTE</b> Number of orbitals = $n^2$ ; maximum electrons = $2n^2$ .                                                                                                                        | S1.3.3, S1.3.4 |
| 16 | B   | Chromium is one of the two anomalous configurations named in the guide: the 4s and 3d sublevels are very close in energy, giving $[\text{Ar}]3d^54s^1$ rather than the expected $3d^44s^2$ .<br><br><b>EXAMINER'S NOTE</b> Only Cr and Cu are required as exceptions.                                        | S1.3.5         |
| 17 | A   | Copper is $[\text{Ar}]3d^{10}4s^1$ . Electrons are removed from the 4s sublevel first, then from 3d, giving $[\text{Ar}]3d^9$ .<br><br><b>EXAMINER'S NOTE</b> For transition elements, 4s fills first but empties first.                                                                                     | S1.3.5         |
| 18 | A   | Nitrogen is $1s^22s^22p^3$ ; by Hund's rule the three 2p electrons occupy separate orbitals with parallel spins. O has two unpaired, Ne none, and $\text{Ti}^{2+}$ ( $[\text{Ar}]3d^2$ ) has two.<br><br><b>EXAMINER'S NOTE</b> Sketch the arrow-in-box diagram — it takes five seconds and prevents errors. | S1.3.5         |
| 19 | C   | Hund's rule. Aufbau governs the order of filling (lowest energy first); Pauli limits an orbital to two electrons of opposite spin.<br><br><b>EXAMINER'S NOTE</b> All three are named explicitly in the learning outcome for S1.3.5 — be able to distinguish them.                                            | S1.3.5         |
| 20 | B   | Oxygen is $1s^22s^22p^4$ . The first three 2p electrons occupy the three orbitals singly (Hund); the fourth must pair up, leaving one pair and two unpaired electrons.<br><br><b>EXAMINER'S NOTE</b> There are only three p orbitals — option C is impossible.                                               | S1.3.5         |

## Mark scheme — Section B (HL only)

| Q  | Ans | Reasoning                                                                                                                                                                                                                                                                                                                                                                                                                                               | Syllabus                 |
|----|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| 21 | B   | $[(24 \times 78.6) + (25 \times 10.1) + (26 \times 11.3)] / 100 = 2432.7 / 100 = \mathbf{24.33}$ (magnesium).<br><b>EXAMINER'S NOTE</b> Divide by the <i>total</i> abundance, not by the number of isotopes.                                                                                                                                                                                                                                            | S1.2.3                   |
| 22 | B   | Position on the $m/z$ axis gives the isotopic mass; peak height (or area) gives relative abundance.<br><b>EXAMINER'S NOTE</b> The operational details of the mass spectrometer are explicitly <i>not</i> assessed — only interpretation of the spectrum.                                                                                                                                                                                                | S1.2.3                   |
| 23 | B   | $(63 \times 0.69) + (65 \times 0.31) = 43.5 + 20.2 = 63.6$ , which matches <b>copper</b> in the data booklet periodic table.<br><b>EXAMINER'S NOTE</b> Identity questions are answered by calculating the weighted mean first, then reading the periodic table.                                                                                                                                                                                         | S1.2.3                   |
| 24 | B   | The combinations are 79+79 (one way), 79+81 or 81+79 (two ways) and 81+81 (one way), giving <b>1 : 2 : 1</b> .<br><b>EXAMINER'S NOTE</b> Treat it as a probability question: the mixed molecule can form in two ways, so its peak is twice as tall.                                                                                                                                                                                                     | S1.2.3 (links to S3.2.8) |
| 25 | B   | First ionisation energy refers to one mole of <i>gaseous</i> atoms each losing <i>one</i> electron. Option C is the sum of the first two; option D is the second ionisation energy.<br><b>EXAMINER'S NOTE</b> State symbols are worth marks here — (g) on both sides, every time.                                                                                                                                                                       | S1.3.6                   |
| 26 | B   | In S ( $3p^4$ ) one 3p orbital holds a pair; electron–electron repulsion within that orbital raises the energy of the electron removed, so less energy is required than for P ( $3p^3$ ), where all three 3p electrons are unpaired.<br><b>EXAMINER'S NOTE</b> The guide requires explanations based on the <i>energy of the electron removed</i> — not on the “special stability” of a half-filled sublevel. Marks are lost for the stability wording. | S1.3.6 (links to S3.1.7) |
| 27 | B   | Each successive element has an additional occupied main energy level, so the outer electron is further from the nucleus and is shielded by more inner shells. These effects outweigh the increase in nuclear charge, so the attraction on the outer electron weakens.<br><b>EXAMINER'S NOTE</b> Nuclear charge <i>increases</i> down a group — the trend is explained by radius and shielding winning out.                                              | S1.3.6                   |
| 28 | B   | $E = hf = (6.63 \times 10^{-34})(3.28 \times 10^{15}) = 2.17 \times 10^{-18}$ J per atom. Per mole: $\times 6.02 \times 10^{23} = 1.31 \times 10^6$ J mol <sup>-1</sup> = <b><math>1.31 \times 10^3</math> kJ mol<sup>-1</sup></b> .<br><b>EXAMINER'S NOTE</b> Two steps are always needed: multiply by $N_A$ , then divide by 1000. Option C is the answer in J mol <sup>-1</sup> .                                                                    | S1.3.6                   |
| 29 | B   | The large jump comes between the 2nd and 3rd values (1451 → 7733), showing that two electrons are relatively easy to remove before the third must come from a shell closer to the nucleus with less shielding. Two valence electrons ⇒ <b>group 2</b> .<br><b>EXAMINER'S NOTE</b> Count how many values come <i>before</i> the big jump — that is the number of outer electrons.                                                                        | S1.3.7                   |

| Q  | Ans | Reasoning                                                                                                                                                                                                                                                                                                                                               | Syllabus |
|----|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 30 | B   | <p>A jump after the 4th ionisation means the element has four valence electrons. Silicon is <math>[\text{Ne}]3s^23p^2</math>, so the fifth electron must be removed from the filled <math>n = 2</math> level.</p> <p><b>EXAMINER'S NOTE</b> Match the position of the jump to the group number: Al jumps after 3, Si after 4, P after 5, S after 6.</p> | S1.3.7   |

## Where students lose marks on this topic

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- **Changing the proton number when forming an ion.** Only electrons are gained or lost.
- **Quoting “stability of a half-filled sublevel”** for the dip between groups 15 and 16. The IB requires the explanation to be based on the energy of the electron removed — here, repulsion between the paired electrons in one p orbital.
- **Forgetting  $N_A$  or the factor of 1000** in convergence-limit calculations. The answer is expected in  $\text{kJ mol}^{-1}$ .
- **Missing state symbols** in ionisation energy equations. Both species must be (g).
- **Writing 4s after 3d when removing electrons.** 4s fills first but is removed first.
- **Rounding too early** in weighted-average calculations, which shifts the second decimal place.

## Need to go further?

### One-to-one specialist IB tuition



If a particular syllabus point in this pack is still not landing — ionisation energy explanations and mass spectra reasoning are the two that most often cost grade 7 candidates their marks — targeted one-to-one teaching fixes it far faster than more worksheets.

iBLaurel offers premium one-to-one tuition in **IB Physics, Chemistry and Mathematics** at SL and HL, online worldwide and in person in London. Sessions are taught personally by Waseem Ahmad, with around thirty years of IB and university-level teaching experience across the UK and the UAE.

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Book a consultation to discuss a study plan built around your next assessment.

Waseem Ahmad

Founder and Director, iBLaurel (Innovative Learning Support Ltd)

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