



FREE IB RESOURCES BY IBLAUREL

IB Chemistry Paper 1A Practice Pack

Structure 1 — Models of the particulate nature of matter

1.1 Particulate nature · 1.2 The nuclear atom · 1.3 Electron configurations

1.4 The mole · 1.5 Ideal gases

Questions	40 multiple-choice questions, 1 mark each
Section A	Q1–30 · SL <i>and</i> HL · a complete SL Paper 1A
Section B	Q31–40 · HL only (AHL material)
Suggested time	SL 45 minutes (Q1–30) · HL 60 minutes (Q1–40)
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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How to use this pack

This pack covers the whole of **Structure 1 — Models of the particulate nature of matter**, from Structure 1.1 to Structure 1.5, in the format of **Paper 1A** of 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 a wrong answer, so never leave a question blank.

- **Standard Level students** answer Section A only (Q1–30). That is exactly the length of a real SL Paper 1A. Allow 45 minutes.
- **Higher Level students** answer Sections A and B (Q1–40) — exactly the length of a real HL Paper 1A. Allow 60 minutes.
- Record your answers on the grid on page 4, then mark using the scheme from page 9.
- A calculator and a clean copy of the IB Chemistry data booklet are permitted, as they are in the real examination. You will need Section 2 (constants), Section 3 (sub-atomic particles) and Section 7 (periodic table).

Data you may need. $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$ · $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ · $h = 6.63 \times 10^{-34} \text{ J s}$ · molar volume at STP = $22.7 \text{ dm}^3 \text{ mol}^{-1}$ · $n = m/M$ · $n = cV$ · $PV = nRT$ · $E = hf$. All of these are in the data booklet.

Where the AHL material sits

Across the whole of Structure 1 there are only **three** additional higher level points: Structure 1.2.3 (mass spectra), 1.3.6 (ionisation energy and the convergence limit) and 1.3.7 (successive ionisation energies). Structure 1.1, 1.4 and 1.5 are common to SL and HL in their entirety. Section B of this pack is built from those three points only.

A note on using A-level worksheets for this topic

Material written for A-level (AQA, OCR, Edexcel) overlaps heavily with Structure 1, but several areas are *not* assessed by the IB and should not be revised from those sheets:

- **Time-of-flight calculations.** Flight-tube equations are AQA content. The IB guide states 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 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 Q36.
- **Named gas laws.** The guide states that the names of specific gas laws (Boyle, Charles, Gay-Lussac) will not be assessed — you need the relationships, not the names. Pressure and volume must be handled in *SI units only* when using $PV = nRT$.
- **Molar volume at STP is $22.7 \text{ dm}^3 \text{ mol}^{-1}$** in the current data booklet (100 kPa, 273 K), not the 22.4 used in many older books.

Syllabus coverage map

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

Question	Syllabus point	Level
1–2	S1.1.1	SL + HL
3	S1.1.2	SL + HL
4	S1.1.3	SL + HL
5–6	S1.2.1	SL + HL
7–9	S1.2.2	SL + HL
10	S1.3.1	SL + HL
11	S1.3.1, S1.3.2	SL + HL
12–13	S1.3.2	SL + HL
14	S1.3.3	SL + HL
15	S1.3.4, S1.3.5	SL + HL
16–18	S1.3.5	SL + HL
19	S1.4.1	SL + HL
20	S1.4.2	SL + HL
21	S1.4.3	SL + HL
22–23	S1.4.4	SL + HL
24	S1.4.5	SL + HL
25	S1.4.6	SL + HL
26	S1.5.1	SL + HL
27	S1.5.2	SL + HL
28	S1.5.3	SL + HL
29–30	S1.5.4	SL + HL
31–33	S1.2.3	HL only
34	S1.2.3 (links to S3.2.8)	HL only
35	S1.3.6	HL only
36	S1.3.6 (links to S3.1.7)	HL only
37–38	S1.3.6	HL only
39–40	S1.3.7	HL only

Syllabus points assessed

S1.1.1	Elements cannot be chemically broken down; compounds are different elements bonded in fixed ratio; mixtures are not bonded and can be separated physically. Separation methods include solvation, filtration, recrystallization, evaporation, distillation and chromatography.
S1.1.2	The kinetic molecular theory as a model for the physical properties of solids, liquids and gases and for changes of state; use of state symbols (s), (l), (g) and (aq).
S1.1.3	Temperature T in kelvin is a measure of average kinetic energy E_k of particles; interpret changes in physical properties and temperature during changes of state; convert between Celsius and kelvin.
S1.2.1	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.
S1.2.2	Isotopes are atoms of the same element with different numbers of neutrons. Perform calculations involving non-integer relative atomic masses and isotopic abundance.
S1.2.3 HL	Mass spectra are used to determine relative atomic masses from isotopic composition; interpret spectra in terms of identity and relative abundance of isotopes.
S1.3.1	Emission spectra are produced when electrons in excited states return to lower levels. Relate colour, wavelength, frequency and energy; distinguish continuous from line spectra.
S1.3.2	The line emission spectrum of hydrogen gives evidence for discrete energy levels that converge at higher energy.
S1.3.3–1.3.4	Main energy level n holds a maximum of $2n^2$ electrons; sublevels s, p, d and f of successively higher energies; shape and orientation of s and p orbitals.
S1.3.5	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.
S1.3.6 HL	The convergence limit corresponds to ionisation. Explain trends and discontinuities in first ionisation energy; calculate the first ionisation energy from the convergence limit.
S1.3.7 HL	Successive ionisation energy data give information about electron configuration; deduce the group of an element from successive ionisation data.
S1.4.1	The mole is the SI unit of amount of substance; convert between amount and number of elementary entities using N_A .
S1.4.2	Masses of atoms are compared on a scale relative to ^{12}C ; determine M_r from A_r values (both unitless).
S1.4.3	Solve problems relating number of particles, amount in mol and mass in grams using $n = m/M$.
S1.4.4	Empirical formula gives the simplest ratio of atoms; molecular formula gives the actual number. Interconvert the two.
S1.4.5	Molar concentration from amount of solute and volume of solution; solve problems involving concentration, volume and amount.
S1.4.6	Avogadro's law: equal volumes of gases under the same conditions contain equal numbers of molecules. Solve problems involving mole ratios and gas volumes.
S1.5.1–1.5.2	Assumptions of the ideal gas model (negligible particle volume, no intermolecular forces, elastic collisions) and the limitations of the model at low temperature and high pressure.
S1.5.3	The molar volume of an ideal gas is constant at a given temperature and pressure; analyse graphs relating P , V and T .
S1.5.4	Solve problems using $PV = nRT$ and the combined gas law, in SI units.

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
21	22	23	24	25	26	27	28	29	30

Section B — HL only

31	32	33	34	35	36	37	38	39	40

Marking. Section A: ____ / 30 · Section B (HL): ____ / 10 · Total: ____ / 40. Aim for 80 % or better before moving on to Structure 2.

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

Section A — Questions 1 to 30 (SL and HL)

All candidates answer this section

Structure 1.1, 1.2.1–1.2.2, 1.3.1–1.3.5, 1.4 and 1.5 · 30 marks · 45 minutes

1. Which sample consists of a single compound?

- | | |
|-------------------|--------------|
| A. Air | B. Sea water |
| C. Carbon dioxide | D. Brass |

2. Which technique is most suitable for separating two miscible liquids with different boiling points?

- | | |
|----------------------|-----------------|
| A. Filtration | B. Distillation |
| C. Recrystallization | D. Solvation |

3. Compared with the same substance in the gaseous state at the same temperature, the particles in the liquid state

- A. have a greater average kinetic energy
- B. are closer together and experience stronger attractive forces
- C. are stationary
- D. are larger in volume

4. The temperature of a sample of gas is raised from 27 °C to 327 °C. By what factor does the average kinetic energy of the particles increase?

- | | |
|--------|--------|
| A. 1.5 | B. 2.0 |
| C. 12 | D. 300 |

5. 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 |

6. 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. $^{34}_{17}\text{Cl}^{-}$ |

7. 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 |

8. 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 |

9. Boron has a relative atomic mass of 10.81 and consists only of ^{10}B and ^{11}B . What is the percentage abundance of ^{11}B ?

- A. 19 % B. 20 %
C. 80 % D. 81 %

10. Which type of electromagnetic radiation consists of photons with the highest energy?

- A. Microwave
B. Infrared
C. Red light
D. Ultraviolet

11. 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.

12. 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. $n = \infty$

13. 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.

14. What is the maximum number of electrons that can occupy the main energy level $n = 4$?

- A. 8
B. 18
C. 32
D. 50

15. 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.

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 Cu^{2+} ion ($Z = 29$)?

- A. $[\text{Ar}]3d^9$ B. $[\text{Ar}]3d^84s^1$
C. $[\text{Ar}]3d^74s^2$ D. $[\text{Ar}]3d^{10}$

28. What volume is occupied by 0.500 mol of an ideal gas at STP? (Molar volume at STP = $22.7 \text{ dm}^3 \text{ mol}^{-1}$)

A. 5.60 dm^3

B. 11.2 dm^3

C. 11.4 dm^3

D. 22.7 dm^3

29. What amount of an ideal gas occupies 5.00 dm^3 at 300 K and $1.00 \times 10^5 \text{ Pa}$? ($R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

A. 0.0201 mol

B. 0.201 mol

C. 2.01 mol

D. 20.1 mol

30. A fixed mass of an ideal gas occupies 300 cm^3 at 27°C and 100 kPa. What volume will it occupy at 127°C and 200 kPa?

A. 150 cm^3

B. 200 cm^3

C. 225 cm^3

D. 400 cm^3

39. The first five ionisation energies of an element, in 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

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

A. Al

B. Si

C. P

D. S

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	C	A compound contains atoms of different elements chemically bonded in a fixed ratio. Air and sea water are mixtures of compounds; brass is a mixture of two metals. EXAMINER'S NOTE Fixed ratio and chemical bonding are the two tests. Anything separable by physical means is a mixture.	S1.1.1
2	B	Distillation separates liquids by exploiting the difference in their boiling points. Filtration separates an insoluble solid from a liquid, and recrystallization purifies a solid. EXAMINER'S NOTE The guide names solvation, filtration, recrystallization, evaporation, distillation and chromatography — know what each one separates.	S1.1.1
3	B	At a given temperature the average kinetic energy is the same in both states. The difference is spacing: in a liquid the particles are close together and the inter-particle forces are strong enough to keep them in contact, though they can still move past one another. EXAMINER'S NOTE Temperature fixes average kinetic energy; the state is set by the strength of inter-particle forces relative to that energy.	S1.1.2
4	B	Average kinetic energy is proportional to temperature <i>in kelvin</i>: $27\text{ }^{\circ}\text{C} = 300\text{ K}$ and $327\text{ }^{\circ}\text{C} = 600\text{ K}$, so the factor is $600/300 = 2.0$. EXAMINER'S NOTE Never use Celsius in a ratio. $327/27 = 12$ is placed as a distractor for exactly this error.	S1.1.3
5	A	Protons = $Z = 26$. Neutrons = $A - Z = 56 - 26 = 30$. A $3+$ charge means three electrons have been <i>lost</i>: $26 - 3 = 23$. EXAMINER'S NOTE Forming an ion never changes the proton number — only the electron count.	S1.2.1
6	A	16 protons identifies sulfur. Mass number = $16 + 18 = 34$. Two more electrons than protons gives a $2-$ charge. EXAMINER'S NOTE Work in order: protons → element, protons + neutrons → mass number, electrons – protons → charge.	S1.2.1
7	C	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. EXAMINER'S NOTE The guide expects you to know that physical properties differ while chemical properties are essentially identical.	S1.2.2
8	B	$(69 \times 0.600) + (71 \times 0.400) = 41.4 + 28.4 = 69.8$. EXAMINER'S NOTE The weighted mean always lies nearer the more abundant isotope — a fast way to eliminate options.	S1.2.2

Q	Ans	Reasoning	Syllabus
9	D	Let the abundance of ^{10}B be x: $[10x + 11(100 - x)] / 100 = 10.81$, so $1100 - x = 1081$ and $x = 19$. Therefore $^{11}\text{B} = 81\%$. EXAMINER'S NOTE Read the question — the algebra gives the <i>lighter</i> isotope first, and 19 % is placed as a distractor.	S1.2.2
10	D	Energy increases with frequency ($E = hf$) and therefore with decreasing wavelength. Of these, ultraviolet has the shortest wavelength and highest frequency. EXAMINER'S NOTE Only a qualitative understanding of the electromagnetic spectrum is required — but the order must be secure.	S1.3.1
11	C	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. EXAMINER'S NOTE “Line spectrum → discrete energy levels” is the single most examined idea in Structure 1.3.	S1.3.1, S1.3.2
12	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. EXAMINER'S NOTE The guide asks specifically for transitions to the first, second and third energy levels — UV, visible, IR respectively.	S1.3.2
13	A	The spacing between successive energy levels decreases as n increases, so the photon energies emitted become progressively closer together until they converge. EXAMINER'S NOTE Convergence is the visual evidence that the energy levels themselves converge — and at HL, that the limit corresponds to ionisation.	S1.3.2
14	C	Maximum = $2n^2 = 2 \times 4^2 = 32$. EXAMINER'S NOTE $2n^2$ is stated explicitly in the syllabus — learn it as a formula, not as a list.	S1.3.3
15	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. EXAMINER'S NOTE You are required to recognise the shape and orientation of s and p orbitals only.	S1.3.4, S1.3.5
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 $3d^44s^2$. EXAMINER'S NOTE 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 $[\text{Ar}]3d^9$. EXAMINER'S NOTE 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 Ti^{2+} ($[\text{Ar}]3d^2$) has two. EXAMINER'S NOTE Sketch the arrow-in-box diagram — it takes five seconds and prevents errors.	S1.3.5

Q	Ans	Reasoning	Syllabus
19	B	Each CO₂ molecule contains two oxygen atoms, so 0.50 mol of CO₂ contains 1.0 mol of O atoms = 6.02 × 10²³ atoms. EXAMINER'S NOTE Always check which elementary entity is asked for: molecules, atoms, ions or formula units.	S1.4.1
20	C	40.08 + 2 × [14.01 + (3 × 16.00)] = 40.08 + (2 × 62.01) = 164.10. EXAMINER'S NOTE The bracket subscript multiplies everything inside it. Option A is the answer if you forget to double the nitrate.	S1.4.2
21	A	M(NaOH) = 22.99 + 16.00 + 1.01 = 40.00 g mol⁻¹. $n = m/M = 10.0 / 40.00 = \mathbf{0.250 \text{ mol}}$. EXAMINER'S NOTE $n = m/M$ is in the data booklet. If your answer looks like M/m, you have inverted it.	S1.4.3
22	B	Divide by relative atomic masses: C 40.0/12.01 = 3.33; H 6.7/1.01 = 6.63; O 53.3/16.00 = 3.33. Dividing by the smallest gives 1 : 2 : 1, so the empirical formula is CH₂O. EXAMINER'S NOTE C₂H₄O₂ has the same ratio but is not the <i>simplest</i> ratio — it is a molecular formula, not an empirical one.	S1.4.4
23	C	The empirical formula mass of CH₂O is 12.01 + 2.02 + 16.00 = 30.03. 180 / 30.03 = 6, so the molecular formula is C₆H₁₂O₆. EXAMINER'S NOTE Multiply every subscript by the whole-number factor, hydrogen included.	S1.4.4
24	B	$n = cV = 0.200 \times 0.250 \text{ dm}^3 = 0.0500 \text{ mol}$. $m = nM = 0.0500 \times 58.44 = \mathbf{2.92 \text{ g}}$. EXAMINER'S NOTE Convert cm³ to dm³ by dividing by 1000 <i>before</i> anything else. Option D is the answer if you forget.	S1.4.5
25	B	By Avogadro's law, volumes of gases at the same temperature and pressure are in the same ratio as their amounts in mol. The CO : CO₂ ratio is 2 : 2, so 2.0 dm³ is produced. EXAMINER'S NOTE Only gases count in a volume ratio. Never convert to mol first — the ratio does the work.	S1.4.6
26	B	The model assumes moving particles of negligible volume, no intermolecular forces, and perfectly elastic collisions, so no kinetic energy is lost. Particles have a <i>distribution</i> of speeds, not a single speed. EXAMINER'S NOTE Three assumptions, three marks in a Paper 2 answer: negligible volume, no intermolecular forces, elastic collisions.	S1.5.1
27	C	At high pressure the particles are close together, so their own volume is no longer negligible. At low temperature the particles move more slowly, so intermolecular attractions have a significant effect. Both assumptions of the model break down. EXAMINER'S NOTE Ideal behaviour is approached at high temperature and low pressure — the opposite corner.	S1.5.2
28	C	$V = 0.500 \times 22.7 = \mathbf{11.4 \text{ dm}^3}$. EXAMINER'S NOTE The current data booklet gives 22.7 dm³ mol⁻¹ at STP (100 kPa, 273 K). Older textbooks use 22.4 dm³ mol⁻¹ at 101.3 kPa — that is why 11.2 appears as a distractor.	S1.5.3

Q	Ans	Reasoning	Syllabus
29	B	$n = PV/RT$. Converting to SI, $V = 5.00 \times 10^{-3} \text{ m}^3$: $n = (1.00 \times 10^5 \times 5.00 \times 10^{-3}) / (8.31 \times 300)$ $= 500 / 2493 = \mathbf{0.201 \text{ mol}}$. EXAMINER'S NOTE The guide states that units of volume and pressure should be SI only: m^3 and Pa. Leaving the volume in dm^3 gives 201 mol.	S1.5.4
30	B	Using $P_1 V_1 / T_1 = P_2 V_2 / T_2$ with T in kelvin (300 K and 400 K): $V_2 = 300 \times (100/200) \times (400/300)$ $= \mathbf{200 \text{ cm}^3}$. EXAMINER'S NOTE Units of V cancel in the combined gas law, so cm^3 is safe here — but temperature must still be in kelvin.	S1.5.4

Mark scheme — Section B (HL only)

Q	Ans	Reasoning	Syllabus
31	B	$[(24 \times 78.6) + (25 \times 10.1) + (26 \times 11.3)] / 100 = 2432.7 / 100 = \mathbf{24.33}$ (magnesium). EXAMINER'S NOTE Divide by the <i>total</i> abundance, not by the number of isotopes.	S1.2.3
32	B	Position on the m/z axis gives the isotopic mass; peak height (or area) gives relative abundance. EXAMINER'S NOTE The operational details of the mass spectrometer are explicitly <i>not</i> assessed — only interpretation of the spectrum.	S1.2.3
33	B	$(63 \times 0.69) + (65 \times 0.31) = 43.5 + 20.2 = 63.6$, which matches copper in the data booklet periodic table. EXAMINER'S NOTE Identity questions are answered by calculating the weighted mean first, then reading the periodic table.	S1.2.3
34	B	The combinations are 79+79 (one way), 79+81 or 81+79 (two ways) and 81+81 (one way), giving 1 : 2 : 1 . EXAMINER'S NOTE 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)
35	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 ionisation energies; option D is the second. EXAMINER'S NOTE State symbols are worth marks here — (g) on both sides, every time.	S1.3.6
36	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. EXAMINER'S NOTE 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)
37	B	Each successive element has an additional occupied main energy level, so the outer electron is further from the nucleus and shielded by more inner shells. These effects outweigh the increase in nuclear charge, so the attraction on the outer electron weakens. EXAMINER'S NOTE Nuclear charge <i>increases</i> down a group — the trend is explained by radius and shielding winning out.	S1.3.6
38	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 ⁻¹ = 1.31×10^3 kJ mol⁻¹ . EXAMINER'S NOTE Two steps are always needed: multiply by N_A , then divide by 1000. Option C is the answer left in J mol ⁻¹ .	S1.3.6
39	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 ⇒ group 2 . EXAMINER'S NOTE 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
40	B	A jump after the 4th ionisation means the element has four valence electrons. Silicon is $[\text{Ne}]3s^23p^2$, so the fifth electron must be removed from the filled $n = 2$ level. EXAMINER'S NOTE Match the position of the jump to the group: Al jumps after 3, Si after 4, P after 5, S after 6.	S1.3.7

Where students lose marks in Structure 1

- **Using Celsius in a ratio or in $PV = nRT$.** Temperature must be in kelvin every time.
- **Leaving volume in dm^3 or cm^3** in the ideal gas equation. SI units only: m^3 and Pa.
- **Forgetting to convert cm^3 to dm^3** in concentration calculations — a factor-of-1000 error that is easy to spot and easy to avoid.
- **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 explanation must be based on the energy of the electron removed.
- **Writing 4s after 3d when removing electrons.** 4s fills first but empties first.
- **Rounding too early** in weighted-average and empirical formula calculations.
- **Giving a molecular formula when an empirical formula is asked for**, or vice versa.

Need to go further?

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