OCR A | Year 12 chemistry

Atomic structure

Questions & answers

45 original questions | 242 marks. Questions start on page 2. Work in the dotted spaces, then check the answers at the back. Use the values supplied in each question.

Atoms & ions Q1-Q5

Isotopes & relative masses Q6-Q11

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Atoms & ions

Question 1 | OCR A | 4 marks

(a) Explain how the discovery of electrons challenged Dalton’s indivisible-atom model. [2]

(b) State one feature of Bohr’s model and explain how it helps account for repeating chemical properties. [2]

Question 2 | OCR A | 9 marks

Complete the table for the three fundamental particles. [9]

Particle	Relative charge	Relative mass	Location
Proton	…	…	…
Neutron	…	…	…
Electron	…	…	…

Question 3 | OCR A | 3 marks

An ion is represented as $^{56}Fe^{2+}$. The atomic number of iron is 26. State the numbers of protons, neutrons and electrons. [3]

Question 4 | OCR A | 3 marks

An ion contains 17 protons, 18 neutrons and 18 electrons. State its element, mass number and charge. Use atomic numbers S = 16, Cl = 17 and Ar = 18. [3]

Question 5 | OCR A | 6 marks

Complete the missing entries. [6]

Species	Atomic number	Mass number	Protons	Neutrons	Electrons
$^{27}Al^{3+}$	13	27	...	...	...
$^{37}Cl^{-}$	17	37	...	...	...

Isotopes & relative masses

Question 6 | OCR A | 5 marks

(a) Define isotope. [2]

(b) Explain why isotopes of the same element have the same chemical properties. [1]

(c) Explain why they can have different physical properties. [2]

Question 7 | OCR A | 2 marks

Species	Protons	Neutrons	Electrons
A	17	18	18
B	17	20	17
C	18	20	18
D	18	22	20

(a) Identify both pairs that are species of different isotopes of the same element. [1]

(b) Justify the pairs using the particle data. [1]

Question 8 | OCR A | 4 marks

(a) Define atomic number. [1]

(b) Define mass number. [1]

(c) Explain why mass number is a whole number whereas relative atomic mass often is not. [2]

Question 9 | OCR A | 4 marks

(a) Define relative isotopic mass. [2]

(b) Define relative atomic mass, A_r. [2]

Question 10 | OCR A | 4 marks

Explain the difference between relative molecular mass and relative formula mass. State when each term is used and whether either quantity has a unit. [4]

Question 11 | OCR A | 4 marks

Use A_r: H 1.0, C 12.0, O 16.0, S 32.1, Ca 40.1.

(a) Calculate M_r of H_2SO_4. [2]

(b) Calculate the relative formula mass of $CaCO_3$. [2]

Mass spectra & calculations

Question 12 | OCR A | 4 marks

(a) State the quantity on the horizontal axis of a mass spectrum. [1]

(b) State the quantity on the vertical axis. [1]

(c) Explain why m/z is numerically equal to relative isotopic mass in a simple elemental spectrum of singly charged ions. [1]

(d) State what the relative abundance of a peak represents. [1]

Question 13 | OCR A | 4 marks

m/z	Relative abundance
24	79
25	10
26	11

Calculate A_r and identify the element. Reference A_r values: Na = 23.0, Mg = 24.3, Al = 27.0. [4]

Question 14 | OCR A | 4 marks

Two isotopes have accurate relative isotopic masses 78.918 and 80.916. The lighter : heavier abundance ratio is 4.35 : 1.00. Calculate A_r to three decimal places. [4]

Question 15 | OCR A | 4 marks

An isotope of relative isotopic mass 63 has abundance 69.0%. A second isotope has relative isotopic mass x and abundance 31.0%. A_r = 63.62. Calculate x. [4]

Question 16 | OCR A | 5 marks

An element has relative isotopic masses 24, 25 and 26. Mass 24 has abundance 79.0%, and A_r = 24.32. Let the abundance of mass 25 be x%. Calculate the abundances of masses 25 and 26. [5]

Question 17 | OCR A | 4 marks

An element has isotopes of relative isotopic mass 10 and 11. The mass-10 abundance is x%, and A_r = 10.81. Calculate each percentage abundance. [4]

Question 18 | OCR A | 5 marks

A student says the following data cannot be used because the intensities do not add to 100.

m/z	Relative intensity
90	74.0
91	15.0
92	24.5
94	25.0
96	4.0

(a) Explain why the student is incorrect. [1]

(b) Use the data to show that A_r = 91.32. [4]

Question 19 | OCR A | 6 marks

R has isotopes of relative isotopic mass 64, 66 and 68. Mass 68 has abundance 25.0%; the mass-64 : mass-66 abundance ratio is 3 : 2.

(a) Calculate each percentage abundance. [3]

(b) Calculate A_r. [3]

Question 20 | OCR A | 8 marks

The table gives the isotope data for element X.

Relative isotopic mass	58	60	61	62
Abundance / %	68.0	x	1.1	3.6

(a) Calculate x. [1]

(b) Calculate A_r of X to two decimal places. [4]

(c) X forms ionic XCl_2. Calculate its relative formula mass using $A_r(Cl) = 35.45$. [2]

(d) Explain why relative formula mass is used for XCl_2. [1]

Question 21 | OCR A | 3 marks

A compound's spectrum has an identified singly charged molecular-ion peak at m/z 86 and a base peak at m/z 43.

(a) State M_r. [1]

(b) State what is meant by the base peak. [1]

(c) Explain why the base peak is not necessarily used to determine M_r. [1]

Question 22 | OCR A | 8 marks

Stretch / crossover: this combines mass spectra with empirical and molecular formulae. A compound contains 54.5% C, 9.1% H and 36.4% O by mass. Its identified singly charged molecular-ion peak is at m/z 88; its base peak is at m/z 43. Use A_r: C 12.0, H 1.0, O 16.0.

(a) Determine its empirical formula. [4]

(b) State M_r. [1]

(c) Determine its molecular formula. [2]

(d) Explain why the m/z 43 peak is not used to determine M_r. [1]

Shells & orbitals

Question 23 | OCR A | 5 marks

(a) State the maximum number of electrons in each of the first four shells. [4]

(b) Use $2n^2$ to calculate the fourth-shell capacity. [1]

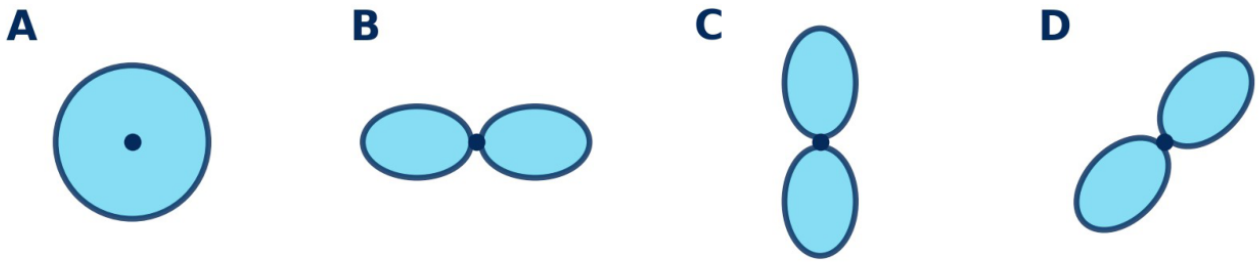
Question 24 | OCR A | 6 marks

(a) Define atomic orbital. [2]

(b) Identify the type of orbital shown by A and by B–D. [2]

(c) Describe the shape and relative arrangement of the three p orbitals. [2]

One s orbital and three p orbitals (not to scale)



Question 25 | OCR A | 6 marks

Complete the table. [6]

Subshell	Number of orbitals	Maximum electrons
s	...	...
p	...	...
d	...	...

Question 26 | OCR A | 4 marks

Complete an electrons-in-box diagram for each arrangement. Draw three p-orbital boxes on paper and show spins clearly.

(a) Carbon: $2p^2$. [2]

(b) Fluorine: $2p^5$. [2]



Question 27 | OCR A | 5 marks

Nitrogen and oxygen have $2p^3$ and $2p^4$ arrangements.

(a) Draw their 2p electrons-in-box diagrams. [2]

(b) Use the diagrams to explain the singly-before-pairing rule. [2]

(c) State the spin requirement for two electrons in the same orbital. [1]

Question 28 | OCR A | 5 marks

Three proposed $2p^4$ arrangements are shown. Two arrows in the same cell occupy one orbital.

Diagram	Orbital 1	Orbital 2	Orbital 3
A	↑↓	↑	↑
B	↑↓	↑↓	Empty
C	↑↑	↑	↑

(a) Identify the correct diagram. [1]

(b) Explain the error in each other diagram. [4]

Electron configurations

Question 29 | OCR A | 5 marks

(a) Write the subshell filling order from 1s to 4p. [2]

(b) Which subshell fills immediately before 3d, and which immediately after it? [2]

(c) Explain why 4s fills before 3d in the building-up order. [1]

Question 30 | OCR A | 4 marks

(a) Write the full configuration of Ca, Z = 20, and check its electron total. [2]

(b) Write the full configuration of Kr, Z = 36, and check its electron total. [2]

Question 31 | OCR A | 8 marks

Atomic numbers: K 19, Ca 20, Zn 30, Kr 36.

Each student configuration contains an error.

Species	Student configuration
K	[Ar] $3d^1$
Ca	[Ar] $3d^2$
Zn	[Ar] $3d^8$ $4s^4$
Kr	[Ar] $3d^{10}$ $4s^2$ $4p^5$

(a) Write the correct configuration for each. [4]

(b) For each correction, state the rule broken. [4]

Question 32 | OCR A | 6 marks

A student writes selenium as [Ar] $3d^{10}$ $4s^2$ $4p^4$ and says this proves that 3d fills before 4s.

(a) State the filling sequence immediately after 3p. [1]

(b) Write selenium's full configuration. [2]

(c) Explain why the written order does not prove the filling order. [2]

(d) Check its electron total. [1]

Question 33 | OCR A | 4 marks

For each atom, write the simple predicted configuration and the observed configuration using [Ar].

(a) Cr, Z = 24. [2]

(b) Cu, Z = 29. [2]

Question 34 | OCR A | 7 marks

Neutral atom Y contains 29 electrons.

Atomic numbers: Ni 28, Cu 29, Zn 30.

(a) Write the simple predicted configuration using [Ar]. [2]

(b) Identify Y and write its observed configuration. [2]

(c) Represent the 3d and 4s electrons of the observed atom in boxes. [3]

Question 35 | OCR A | 6 marks

Atomic numbers: Al 13, S 16, Br 35.

Calculate the electron count and write the noble-gas configuration for each ion.

(a) Al^{3+}. [2]

(b) S^{2-}. [2]

(c) Br^{-}. [2]

Question 36 | OCR A | 6 marks

Gallium has Z = 31.

(a) Write the configuration of Ga using [Ar]. [2]

(b) Calculate the electron count of Ga^{3+}. [1]

(c) Write its configuration using [Ar]. [1]

(d) Identify the three electrons removed. [2]

Question 37 | OCR A | 6 marks

A 2− ion of a p-block element has 18 electrons.

Atomic numbers: Si 14, P 15, S 16, Cl 17, Ar 18.

(a) Calculate the neutral atom’s Z and identify it. [2]

(b) Write the ion’s full configuration. [2]

(c) Draw the ion’s 3p box diagram. [2]

Question 38 | OCR A | 5 marks

A^{2-}, B^{-}, C and D^{+} each contain 18 electrons. A–D are consecutive elements in increasing atomic number.

Atomic numbers: Si 14, P 15, S 16, Cl 17, Ar 18, K 19, Ca 20.

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

(b) Write their shared configuration. [1]

Question 39 | OCR A | 7 marks

Gallium has Z = 31; germanium has Z = 32.

(a) Write each neutral configuration using [Ar]. [2]

(b) Calculate the electron counts of Ga^{3+} and Ge^{4+}. [2]

(c) Write each ion’s configuration. [2]

(d) Explain why these ions have the same configuration. [1]

Question 40 | OCR A | 6 marks

Atom X has configuration [Ar] $3d^{10}$ $4s^2$ $4p^3$.

Atomic numbers: Ge 32, As 33, Se 34, Br 35, Kr 36.

(a) Calculate Z and identify X. [2]

(b) Give the electron count and configuration of X^{3-}. [2]

(c) Draw X's $4p^3$ box diagram. [2]

Question 41 | OCR A | 6 marks

An atom has configuration $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^4$.

Atomic numbers: Ge 32, As 33, Se 34, Br 35, Kr 36.

(a) Deduce Z and identify the element. [1]

(b) Write the configuration using [Ar]. [1]

(c) Give the count and configuration of its 2− ion. [2]

(d) Draw the neutral atom's 4p box diagram. [2]

Question 42 | OCR A | 10 marks

Stretch: combine particle counting with configurations. X^- contains 35 protons, 44 neutrons and 36 electrons.

Atomic numbers: As 33, Se 34, Br 35, Kr 36.

(a) Identify the element and write the full nuclide symbol, with mass number, atomic number and charge. [2]

(b) Write the full ion configuration and check its total. [2]

(c) Write the neutral atom using [Ar]. [2]

(d) Draw the 4p diagrams of the neutral atom and the ion. [4]

Ionisation energies

Question 43 | OCR A | 6 marks

(a) Define first ionisation energy. [3]

(b) Write the first-ionisation equation for potassium, including state symbols. [1]

(c) State the units and whether the process is endothermic or exothermic. [2]

Question 44 | OCR A | 9 marks

Be is $1s^2\ 2s^2$; B is $1s^2\ 2s^2\ 2p^1$. N ends in $2p^3$; O ends in $2p^4$.

(a) Explain why B has a lower first ionisation energy than Be. [3]

(b) Explain why O has a lower first ionisation energy than N. [2]

(c) Explain why first ionisation energy generally decreases down a group. [4]

Question 45 | OCR A | 7 marks

A Period 3 element has successive ionisation energies 738, 1451, 7733 and 10 543 kJ mol^{-1}. Period 3 elements: Na, Mg, Al, Si, P, S, Cl, Ar.

(a) Locate the large jump and state the outer-shell electron count. [2]

(b) Identify the element. [1]

(c) Explain the jump. [3]

(d) Write the equation for its third ionisation energy. [1]

Answers & marking points

Equivalent correct chemistry and working are acceptable. Use the question number to find the matching answer.

Atoms & ions

Question 1 | OCR A | 4 marks

(a) Atoms contain smaller negatively charged particles [1], so they are not indivisible [1].

(b) Electrons occupy fixed energy levels [1]; repeating outer-shell arrangements help explain repeating chemical properties [1].

Question 2 | OCR A | 9 marks

Particle	Relative charge	Relative mass	Location
Proton	+1	1	Nucleus
Neutron	0	1	Nucleus
Electron	−1	Approximately 1/1840	Region around the nucleus

One mark for each correct entry: 9 marks. The electron has a very small mass, not zero mass.

Question 3 | OCR A | 3 marks

- Protons = 26. [1]
- Neutrons = 56 − 26 = 30. [1]
- Electrons = 26 − 2 = 24. [1]

Question 4 | OCR A | 3 marks

- Chlorine: Z = 17. [1]
- Mass number = 17 + 18 = 35. [1]
- Charge = −1: one more electron than proton. [1]

Question 5 | OCR A | 6 marks

Species	Protons	Neutrons	Electrons
$^{27}Al^{3+}$	13	14	10
$^{37}Cl^{-}$	17	20	18

One mark for each correct particle count: 6 marks.

Isotopes & relative masses

Question 6 | OCR A | 5 marks

(a) Atoms of the same element with the same number of protons but different numbers of neutrons and different masses. [2]

(b) Their neutral atoms have the same electron configuration. [1]

(c) Different neutron numbers give different masses [1], so mass-dependent physical properties can differ [1].

Question 7 | OCR A | 2 marks

(a) A and B; C and D. Both pairs required. [1]

(b) Each pair has the same number of protons but different numbers of neutrons. Ionic charge does not change isotope identity. [1]

Question 8 | OCR A | 4 marks

(a) The number of protons in the nucleus of an atom. [1]

(b) The total number of protons and neutrons in the nucleus of one atom. [1]

(c) Mass number counts whole particles in one isotope [1]. Relative atomic mass is a weighted mean including isotope abundances [1].

Question 9 | OCR A | 4 marks

(a) The mass of an atom of one isotope compared with one-twelfth of the mass of a carbon-12 atom. [2]

(b) The weighted mean mass of an atom of an element compared with one-twelfth of the mass of a carbon-12 atom. [2]

Question 10 | OCR A | 4 marks

- Relative molecular mass sums the A_r values in one molecule and is used for discrete molecules. [1]
- Relative formula mass sums the A_r values in one formula unit. [1]
- Use relative formula mass for ionic compounds or giant structures without discrete molecules. [1]
- Neither has units. [1]

Question 11 | OCR A | 4 marks

(a) 2(1.0) + 32.1 + 4(16.0) [1] = **98.1** [1].

(b) 40.1 + 12.0 + 3(16.0) [1] = **100.1** [1].

Mass spectra & calculations

Question 12 | OCR A | 4 marks

(a) Mass-to-charge ratio, m/z. [1]

(b) Relative abundance or relative intensity. [1]

(c) The charge number z = 1, so dividing by z does not alter the numerical mass value. [1]

(d) The abundance of that isotope ion relative to the others detected. [1]

Question 13 | OCR A | 4 marks

1. Weighted numerator = 24(79) + 25(10) + 26(11) = 2432. [1]

2. Total abundance = 79 + 10 + 11 = 100. [1]

3. A_r = Σ(isotopic mass × abundance)/Σ(abundance)
A_r = 2432/100 = **24.32**. [1]

4. Magnesium. [1]

Question 14 | OCR A | 4 marks

1. Use the mass–ratio products: 78.918(4.35) + 80.916(1.00). [1]

2. Divide by 4.35 + 1.00 = 5.35. [1]

3. A_r = Σ(isotopic mass × abundance)/Σ(abundance)
A_r = 424.2093/5.35 = 79.2914579... [1]

4. A_r = **79.291**. [1]

Question 15 | OCR A | 4 marks

1. 63.62 = [63(69.0) + 31.0x]/100. [1]

2. 6362 = 4347 + 31x. [1]

3. 31x = 2015. [1]

4. x = **65**. [1]

Question 16 | OCR A | 5 marks

1. Mass 26 has abundance (21 − x)%. [1]

2. 24.32 = [24(79) + 25x + 26(21 − x)]/100. [1]

3. 2432 = 2442 − x. [1]

4. Mass 25: x = **10.0%**. [1]

5. Mass 26: **11.0%**. [1]

Question 17 | OCR A | 4 marks

1. Mass 11 has abundance (100 − x)%. [1]

2. 10.81 = [10x + 11(100 − x)]/100. [1]

3. 1081 = 1100 − x, so x = 19. [1]

4. Mass 10: **19%**; mass 11: **81%**. [1]

Question 18 | OCR A | 5 marks

(a) Relative intensities are a comparative scale. They need not total 100; use their actual total. [1]

(b) Total intensity 142.5 [1]; weighted numerator 13013.0 [1]; divide 13013.0/142.5 = 91.319298… [1]; A_r = **91.32** [1].

Question 19 | OCR A | 6 marks

(a) 75.0% remains [1]. Divide this in the ratio 3 : 2, so one part is 15.0% [1]. Abundances are 45.0%, 30.0%, 25.0% for masses 64, 66, 68 respectively [1].

(b) Weighted numerator = 64(45.0) + 66(30.0) + 68(25.0) [1]. Divide by 100 [1] to obtain **65.60** [1].

Question 20 | OCR A | 8 marks

(a) x = 100 − 68.0 − 1.1 − 3.6 = **27.3%**. [1]

(b) Use all four weighted mass–abundance products [1]: 58(68.0) + 60(27.3) + 61(1.1) + 62(3.6) = 5872.3 [1]. Divide by 100 [1]: A_r = 58.723 = **58.72** [1].

(c) Use the unrounded A_r: 58.723 + 2(35.45) [1] = 129.623 = **129.62** [1].

(d) XCl_2 has a repeating ionic lattice, not discrete molecules. [1]

Question 21 | OCR A | 3 marks

(a) M_r = **86**. [1]

(b) The most intense peak, conventionally assigned relative intensity 100. [1]

(c) It may be a fragment ion and therefore may not represent the intact molecule. [1]

Question 22 | OCR A | 8 marks

(a) Divide by A_r: C 54.5/12 = 4.5417…, H 9.1/1 = 9.10, O 36.4/16 = 2.275 [1]. Divide all by 2.275 [1] to obtain approximately 2 : 4 : 1 [1]. Empirical formula **C_2H_4O** [1].

(b) M_r = **88**. [1]

(c) Empirical-formula mass = 44, so multiplier = 88/44 = 2 [1]. Molecular formula **$C_4H_8O_2$** [1].

(d) The m/z 43 base peak represents a fragment rather than the intact molecular ion. [1]

Shells & orbitals

Question 23 | OCR A | 5 marks

(a) Shells 1–4: **2, 8, 18, 32** respectively. [4]

(b) $2 \times 4^2 = 32$ electrons. [1]

Question 24 | OCR A | 6 marks

(a) A region around the nucleus [1] that can hold up to two electrons with opposite spins [1].

(b) A is an s orbital; B–D are p orbitals. [2]

(c) Each p orbital is dumb-bell shaped [1]; the three have the same shape and energy and point in directions at right angles [1].

Question 25 | OCR A | 6 marks

Subshell	Orbitals	Maximum electrons
s	1	2
p	3	6
d	5	10

One mark for each correct entry: 6 marks.

Question 26 | OCR A | 4 marks

(a)

Carbon: separate orbitals [1] with parallel spins [1].

Subshell	Orbital 1	Orbital 2	Orbital 3
$2p^2$	↑	↑	Empty

(b)

Fluorine: two pairs and one single electron [1], with opposite spins within each pair [1].

Subshell	Orbital 1	Orbital 2	Orbital 3
$2p^5$	↑↓	↑↓	↑

Question 27 | OCR A | 5 marks

(a)

Subshell	Orbital 1	Orbital 2	Orbital 3
N, $2p^3$	↑	↑	↑

Subshell	Orbital 1	Orbital 2	Orbital 3
O, $2p^4$	↑↓	↑	↑

(b) Equal-energy orbitals are occupied singly before pairing [1]. Nitrogen has one electron in each; oxygen pairs only after all three are occupied [1].

(c) Opposite spins. [1]

Question 28 | OCR A | 5 marks

(a) A. [1]

(b) B pairs electrons while one equal-energy orbital is empty [1], breaking singly-before-pairing [1]. C places same-spin electrons in one orbital [1]; a pair must have opposite spins [1].

Electron configurations

Question 29 | OCR A | 5 marks

(a) 1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p. [2]

(b) Before: 4s; after: 4p. [2]

(c) For building up these neutral-atom configurations, 4s is filled before 3d because it is initially lower in energy. [1]

Question 30 | OCR A | 4 marks

(a) Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$ [1]; total 20 [1].

(b) Kr: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$ [1]; total 36 [1].

Question 31 | OCR A | 8 marks

Species	Correct configuration [1 each]	Rule [1 each]
K	[Ar] $4s^1$	4s fills before 3d.
Ca	[Ar] $4s^2$	4s fills before 3d.
Zn	[Ar] $3d^{10}\ 4s^2$	An s subshell holds at most two electrons.
Kr	[Ar] $3d^{10}\ 4s^2\ 4p^6$	Neutral Kr must have 36 electrons.

Question 32 | OCR A | 6 marks

(a) 4s → 3d → 4p. [1]

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

(c) Writing 3d before 4s is a convention [1]. The writing order does not change the building-up sequence, in which 4s fills before 3d [1].

(d) 2 + 2 + 6 + 2 + 6 + 2 + 10 + 4 = 34. [1]

Question 33 | OCR A | 4 marks

(a) Predicted [Ar] $3d^4\ 4s^2$ [1]; observed **[Ar] $3d^5\ 4s^1$** [1].

(b) Predicted [Ar] $3d^9\ 4s^2$ [1]; observed **[Ar] $3d^{10}\ 4s^1$** [1].

Question 34 | OCR A | 7 marks

(a) [Ar] $3d^9\ 4s^2$. [2]

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

(c)

Subshell	Orbital 1	Orbital 2	Orbital 3	Orbital 4	Orbital 5
3d	↑↓	↑↓	↑↓	↑↓	↑↓

Subshell	Orbital 1
4s	↑

Question 35 | OCR A | 6 marks

(a) 13 − 3 = 10 electrons [1]; [Ne] [1].

(b) 16 + 2 = 18 electrons [1]; [Ar] [1].

(c) 35 + 1 = 36 electrons [1]; [Kr] [1].

Question 36 | OCR A | 6 marks

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

(b) 31 − 3 = 28. [1]

(c) Ga^{3+}: [Ar] $3d^{10}$. [1]

(d) Remove $4p^1$ [1] and then $4s^2$ [1].

Question 37 | OCR A | 6 marks

(a) Z = 18 − 2 = 16 [1]; sulfur [1].

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

(c)

Subshell	Orbital 1	Orbital 2	Orbital 3
$3p^6$	↑↓	↑↓	↑↓

Question 38 | OCR A | 5 marks

(a) A = S; B = Cl; C = Ar; D = K. [4]

(b) [Ar]. [1]

Question 39 | OCR A | 7 marks

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

(b) Ga^{3+}: 31 − 3 = 28; Ge^{4+}: 32 − 4 = 28. [2]

(c) Both are [Ar] $3d^{10}$. [2]

(d) Both lose their occupied outer 4p and 4s electrons and retain the same 28-electron arrangement. [1]

Question 40 | OCR A | 6 marks

(a) 18 + 10 + 2 + 3 = 33 [1]; arsenic, As [1].

(b) 36 electrons [1]; [Kr] [1].

(c)

Subshell	Orbital 1	Orbital 2	Orbital 3
$4p^3$	↑	↑	↑

Question 41 | OCR A | 6 marks

(a) Z = 34: selenium, Se. [1]

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

(c) 36 electrons [1]; [Kr] [1].

(d)

Subshell	Orbital 1	Orbital 2	Orbital 3
$4p^4$	↑↓	↑	↑

Question 42 | OCR A | 10 marks

(a) Bromine [1]: $^{79}_{35}Br^-$, since 35 + 44 = 79 [1].

(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$ [1]; total 36 [1].

(c) [Ar] $3d^{10}\ 4s^2\ 4p^5$. [2]

(d)

Subshell	Orbital 1	Orbital 2	Orbital 3
Br, $4p^5$	↑↓	↑↓	↑

Subshell	Orbital 1	Orbital 2	Orbital 3
Br^-, $4p^6$	↑↓	↑↓	↑↓

Ionisation energies

Question 43 | OCR A | 6 marks

(a) Energy to remove one electron from each atom [1] in one mole of gaseous atoms [1], forming one mole of gaseous 1+ ions [1].

(b) $K(g) \rightarrow K^+(g) + e^-$. [1]

(c) kJ mol^{-1} [1]; endothermic [1].

Question 44 | OCR A | 9 marks

(a) B loses a 2p electron rather than a 2s electron [1]. It is higher in energy / more shielded [1], so less strongly attracted and easier to remove [1].

(b) O has a paired 2p orbital [1]; repulsion within that pair makes an electron easier to remove [1].

(c) The outer electron occupies a higher shell [1], further from the nucleus [1], with greater shielding [1]. These effects outweigh the greater nuclear charge, reducing attraction and energy needed [1].

Question 45 | OCR A | 7 marks

(a) Between IE_2 and IE_3 [1]; two outer-shell electrons [1].

(b) Magnesium. [1]

(c) The third electron comes from an inner shell [1], closer to the nucleus with less shielding [1], so it is much more strongly attracted and harder to remove [1].

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