PEARSON EDEXCEL A-LEVEL CHEMISTRY · 9CH0

CHEMISTRY



EXAM QUESTION PACK

TOPIC 1: ATOMIC STRUCTURE AND THE PERIODIC TABLE

SCORE	PERCENTAGE
/93	%

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Q1.

This is a question about atoms, isotopes and ions.

The percentage composition of the two bromine isotopes in a sample is given in the table.

Isotope	Relative isotopic mass	Percentage abundance
bromine-79	78.918	50.52
bromine-81	80.916	49.48

Calculate the relative atomic mass of bromine in this sample.
Give your answer to two decimal places.

(2)

(Total for question = 2 marks)

Q2.

A student stated that 'the elements scandium and zinc are d-block elements but are not transition metals'.

Discuss this statement, using appropriate electronic configurations to support your answer.

(4)

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(Total for question = 4 marks)

Q3.

This question is about compounds of Group 5 elements.

Phosphorus forms two chlorides with the formulae PCl_3 and PCl_5.

(i) Explain the shape of the PCl_3 molecule. The bond angle is not required.

(3)

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(ii) Draw a diagram to show the three-dimensional shape of the PCl_5 molecule in the gas phase.

Include bond angles and the name of the shape.

(3)

(iii) Explain why phosphorus forms PCl_5 but nitrogen does not form NCl_5.

(2)

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(Total for question = 8 marks)

Q4.

Ionisation energies provide information about the number of electrons and the arrangement of the electrons in an atom of an element.

A student's definition of first ionisation energy is shown.

> First ionisation energy is the energy released when one mole of gaseous atoms loses one mole of electrons to form one mole of gaseous 1+ ions.

There is one incorrect word in the student's definition.

Identify the word, giving the reason why this word is incorrect.

(2)

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(Total for question = 2 marks)

Q5.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

This is a question about atoms, isotopes and ions.

Which is a correct definition of relative isotopic mass?

(1)

☐ **A** the weighted mean mass of an atom of an element relative to one twelfth of the mass of an atom of the isotope carbon-12

☐ **B** the mass of one atom of an isotope relative to one twelfth of the mass of an atom of the

isotope carbon-12

☒ **C** the weighted mean mass of an atom of an element relative to 12 g of the isotope carbon-12

☒ **D** the mass of one atom of an isotope relative to the mass of 12 g of the isotope carbon-12

(Total for question = 1 mark)

Q6.

A group of students analysed a hydrated salt with the formula $KH_3(C_2O_4)_{\mathbf{y}}.\ \mathbf{z}H_2O$ where **y** and **z** are whole numbers.

The students carried out experiments to determine the values of **y** and **z**.

(a) Experiment 1 – to determine the value of **y**

One student was provided with a 0.0235 mol dm^{-3} solution of the salt.

25.0 cm^3 portions of the salt solution were acidified with excess dilute sulfuric acid and heated to about 60 °C.

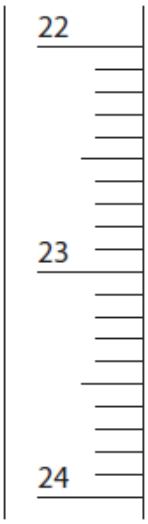
Each portion was titrated with 0.0203 mol dm^{-3} potassium manganate(VII).

The results of four titrations are shown in the table.

Titration number	1	2	3	4
Final burette reading / cm^3	23.85	47.20	24.05	48.10
Initial burette reading / cm^3	0.00	24.00	0.50	25.00
Titre / cm^3	23.85	23.20	23.55	23.10

(i) Complete the diagram to show the final burette reading in **Titration 1**.

(2)



(ii) Explain why this student should use a mean titre of 23.15 cm^3 and not

23.43 cm^3 in the calculation.

(2)

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(iii) The uncertainty in each burette reading is ±0.05 cm^3.

Calculate the percentage uncertainty in the titre volume of potassium manganate(VII) solution used in **Titration 2**.

(1)

(iv) The equation for the reaction is

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Deduce, by calculation, the value of **y**, to the nearest whole number, in the formula $KH_3(C_2O_4)_{\mathbf{y}}$. $\mathbf{z}H_2O$.

Use the mean titre of 23.15 cm^3 and other data from **Experiment 1**.

You **must** show your working.

(4)

(b) **Experiment 2** – to determine the value of **z**

Another student wrote an account of the method for this experiment.

A crucible was weighed.

A sample of the hydrated salt was added to the crucible and it was reweighed.

The crucible and salt were heated to remove the water of crystallisation and then allowed to cool.

The crucible and contents were weighed again.

Results

Mass of crucible	*= 19.56 g*
Mass of crucible + $KH_3(C_2O_4)_y.zH_2O$	*= 22.97 g*
Mass of crucible + $KH_3(C_2O_4)_y$	*= 22.52 g*

(i) Deduce, by calculation, the value of **z**, to the nearest whole number, in the formula $KH_3(C_2O_4)_y.zH_2O$.

You must use the data from **Experiment 2** and your value of **y** in (a)(iv).

You **must** show your working.

(3)

(ii) A third student carried out Experiment 2 and calculated a value of **z** that was lower than expected.

This student evaluated the experiment and gave two suggestions for **z** being lower.

Suggestion **1**
"Some of the crystals jumped out of the crucible while it was being heated."

Suggestion **2**
"It was difficult to tell when all the water of crystallisation had been lost."

Evaluate these two suggestions to decide whether they could account for the lower value of **z** obtained from the experimental results.

Include an explanation of the effect each suggestion would have on the calculated value of **z** and how the method could be improved to prevent these errors.

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(Total for question = 17 marks)

Q7.

This question is about aluminium chloride.

Complete the electronic configuration of an aluminium atom.

(1)

$1s^2$ .....

(Total for question = 1 mark)

Q8.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about atoms, molecules and ions.

The total number of electrons in **all** the occupied **p** orbitals in a chloride ion, Cl^-, is

(1)

☐ **A** 5

☐ **B** 6

☐ **C** 12

☐ **D** 18

(Total for question = 1 mark)

Q9.

This question is about energy changes involved in the formation of ionic compounds.

(a) What is the order of increasing first ionisation energy for the elements beryllium, helium and lithium?

(1)

☐ **A** lithium < helium < beryllium

☐ **B** beryllium < lithium < helium

☐ **C** helium < beryllium < lithium

☐ **D** lithium < beryllium < helium

(b) The **second** ionisation energy of calcium has a magnitude of 1150 kJ mol^{-1}.

Which of the following represents the **second** ionisation energy of calcium?

(1)

☐ **A** $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$ $\Delta H^{\ominus} = +1150$ kJ mol^{-1}

☐ **B** $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$ $\Delta H^{\ominus} = +1150$ kJ mol^{-1}

☐ **C** $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$ $\Delta H^{\ominus} = -1150$ kJ mol^{-1}

☒ **D** $Ca^{+}(g) \rightarrow Ca^{2+}(g) + e^{-}$ $\Delta H^{\ominus} = -1150 \text{ kJ mol}^{-1}$

(c) The formation of potassium ions can be represented by the equation

$$K(s) \rightarrow K^{+}(g) + e^{-}$$

Which statement corresponds to the energy change for this process?

(1)

☒ **A** the first electron affinity of potassium

☒ **B** the first ionisation energy of potassium

☒ **C** the sum of the enthalpy change of atomisation of potassium and the first electron affinity of potassium

☒ **D** the sum of the enthalpy change of atomisation of potassium and the first ionisation energy of potassium

Q10.

Ionisation energies provide information about the number of electrons and the arrangement of the electrons in an atom of an element.

Estimate a value for the first ionisation energy of oxygen given the data in the table.

(1)

Element	First ionisation energy / kJ mol^{-1}
carbon	1086
nitrogen	1402
oxygen	.....

(Total for question = 1 mark)

Q11.

Magnesium bromide, $MgBr_2$, is an ionic compound.

(i) The first ionisation energy of sodium is 496 kJ mol^{-1}.

Explain why the first ionisation energy of magnesium is higher than that of sodium.

(3)

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(ii) Write the equation, including state symbols, to show the **third** ionisation energy of magnesium.

(1)

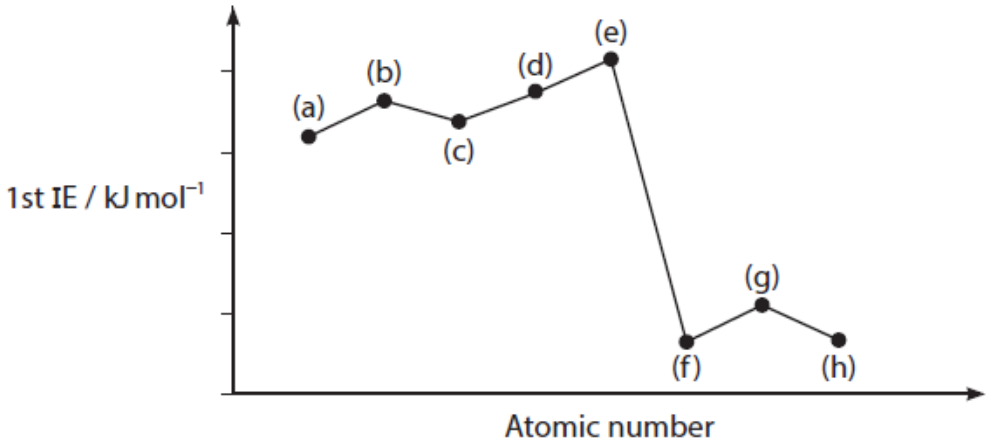
(Total for question = 4 marks)

Q12.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The graph shows the first ionisation energies (IE) of eight successive elements from the first 20 elements in the Periodic Table.

Which letter represents the first ionisation energy of oxygen?



(1)

☒ **A** (a)

☒ **B** (b)

☒ **C** (c)

☒ **D** (h)

(Total for question = 1 mark)

Q13.

Ionisation energies provide information about the number of electrons and the arrangement of the electrons in an atom of an element.

A sodium atom has 11 protons whereas a potassium atom has 19 protons.

Explain why the first ionisation energy of sodium is greater than that of potassium.

(3)

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(Total for question = 3 marks)

Q14.

This question is about ions and ionic compounds.

The first three ionisation energies of calcium are shown in the table.

	First ionisation	Second ionisation	Third ionisation
Ionisation energy / $kJ\,mol^{-1}$	590	1145	4912
Orbital			

(i) Complete the table by identifying the specific orbital from which each electron is removed.

(2)

(ii) Write the equation for the **third** ionisation energy of calcium.

Include state symbols.

(1)

(iii) Explain why the difference between the second and third ionisation energies of calcium is much larger than the difference between the first and second ionisation energies.

(2)

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(Total for question = 5 marks)

Q15.

Give the formula of a stable **ion** that is isoelectronic with the magnesium ion, Mg^{2+}.

(1)

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(Total for question = 1 mark)

Q16.

A phosphorus atom has mass number 31.

Phosphorus has one naturally occurring isotope with mass number 31.
Chlorine exists as two isotopes with mass numbers 35 and 37.

Give the formulae and mass/charge ratio of the ions responsible for the molecular ion peaks in the mass spectrum of phosphorus(III) chloride, PCl_3.

(2)

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(Total for question = 2 marks)

Q17.

This question is about atoms, molecules and ions.

The mass spectrum of a diatomic molecule, X_2, has peaks at the following *m* / *z* values for the X_2^+ ion:

32, 33, 34, 35, 36

Deduce the formulae of all the species responsible for **each** of the peaks in the mass spectrum of X_2, identifying element X and showing clearly the isotopes present.

(3)

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(Total for question = 3 marks)

Q18.

Cinnamon is a spice that is extracted from the bark of the cinnamon tree.

It is extracted by crushing the soft bark with water, and then steam distilling the mixture to produce cinnamon oil.

(b) Compound **Q** is the main component of cinnamon oil. Some chemical tests are carried out to try to find the structure of **Q**.

The results of each test are given in parts (i) to (iii).

Deduce from the results of each test what functional group may be present in **Q**.

(i) **Q** decolourises both bromine water and acidified potassium manganate(VII).

(1)

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(ii) **Q** gives a yellow precipitate with 2,4-dinitrophenylhydrazine.

(1)

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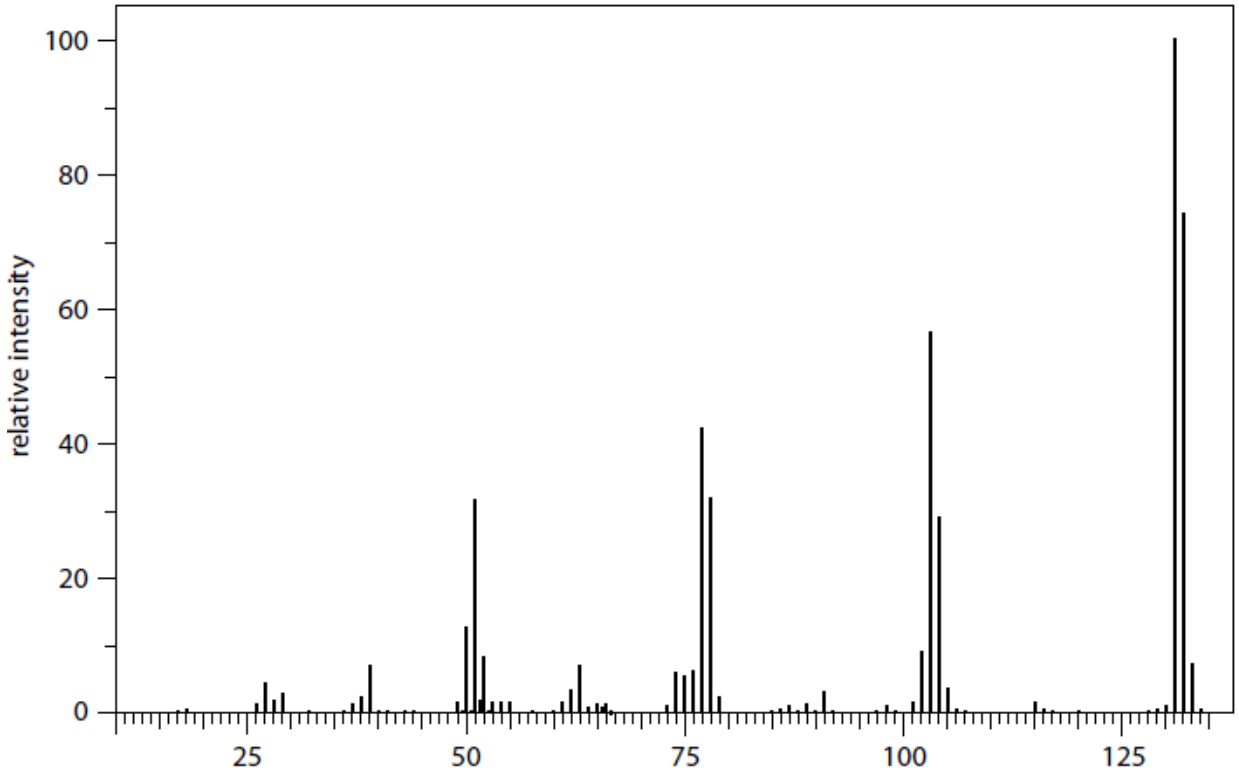
(iii) **Q** forms a red precipitate when boiled with either Benedict's or Fehling's solution.

(1)

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(c) **Q** has the empirical formula C_9H_8O and its mass spectrum is shown.



(i) Predict the identity of the fragment ions causing the peaks at 77 and 103.

(2)

m/z	formula of fragment ion
77	
103	

(ii) Deduce **two** possible displayed formulae for **Q**.

(2)

(iii) The peak at m/z = 132 in the mass spectrum of **Q** is the molecular ion peak. The mass spectrum also shows a peak at m/z = 133.

Give a reason why the peak at m/z = 133 occurs.

(1)

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Q19.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which element in this table is in Group 2?

	Ionisation energy / kJ mol^{-1}			
Element	First	Second	Third	Fourth
W	1086	2353	4621	6223
X	653	1592	2987	4740
Y	590	1145	4912	6474
Z	496	4563	6913	9544

(1)

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

(Total for question = 1 mark)

Q20.

Ionisation energies provide information about the number of electrons and the arrangement of the electrons in an atom of an element.

Write an equation for the **second** ionisation energy of oxygen.
Include state symbols.

(2)

(Total for question = 2 marks)

Q21.

Ionisation energies provide information about the number of electrons and the arrangement of the electrons in an atom of an element.

The successive ionisation energies for magnesium are given in the table.

Electron number removed	1	2	3	4	5	6	7	8	9	10	11	12
Ionisation energy / kJ mol^{-1}	738	1451	7733	10541	13629	17995	21704	25657	31644	35463	169996	189371
Log (ionisation energy)	2.87	3.16	3.89	4.02	4.13		4.34	4.41	4.50	4.55	5.23	

(i) Complete the table.

(1)

(ii) Give a reason why the logarithm of the ionisation energy, rather than just the ionisation energy, is used to plot a graph.

(1)

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(iii) Give a reason why the successive ionisation energies increase.

(1)

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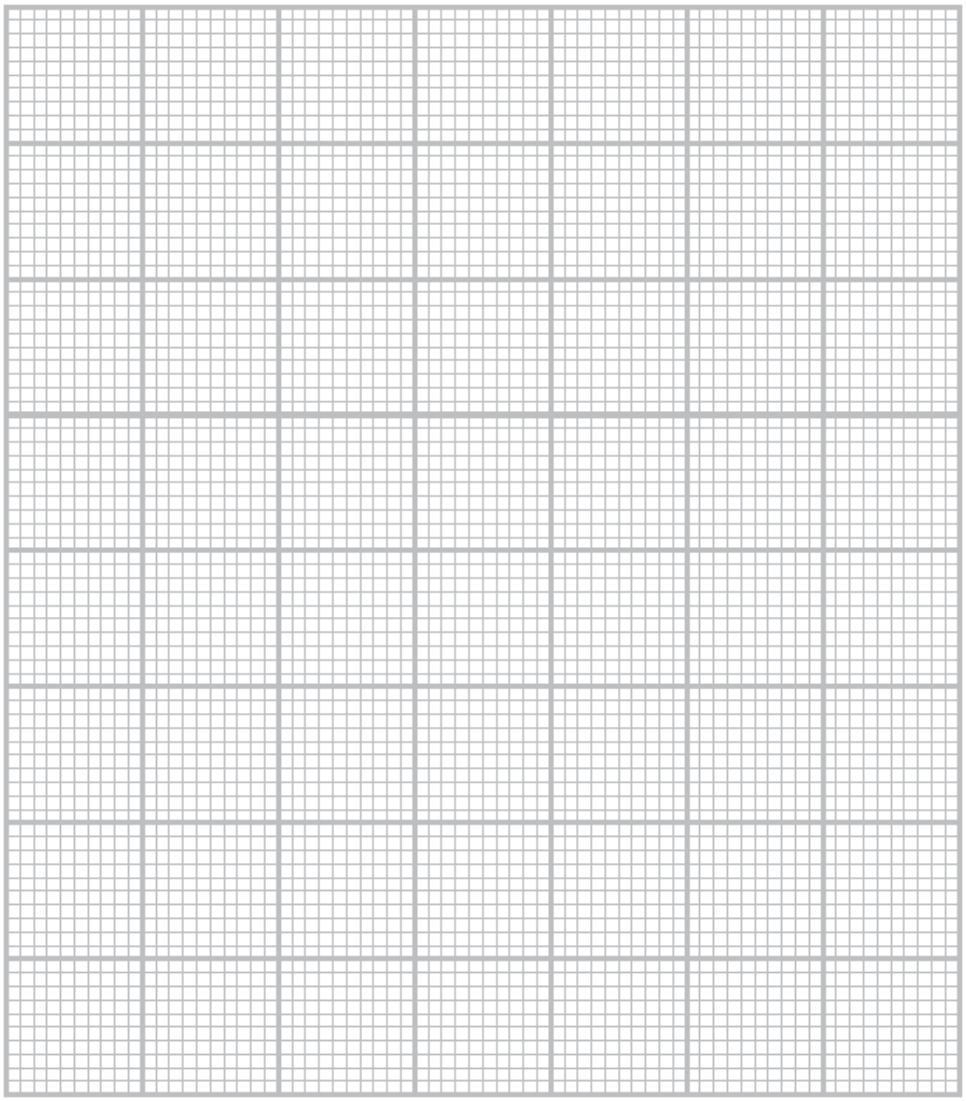
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(iv) Plot the graph of log(ionisation energy) against electron number removed.

Join the individual points using straight lines.

(3)



(v) Identify on the graph, using a circle, the points that represent the removal of the electrons in the **outermost** energy level of magnesium.

(1)

(Total for question = 7 marks)

Q22.

This question is about chlorine.

Chlorine has two isotopes with mass numbers 35 and 37.

(i) Complete the table to show the numbers of subatomic particles in a ^{35}Cl atom and a $^{37}Cl^-$ ion.

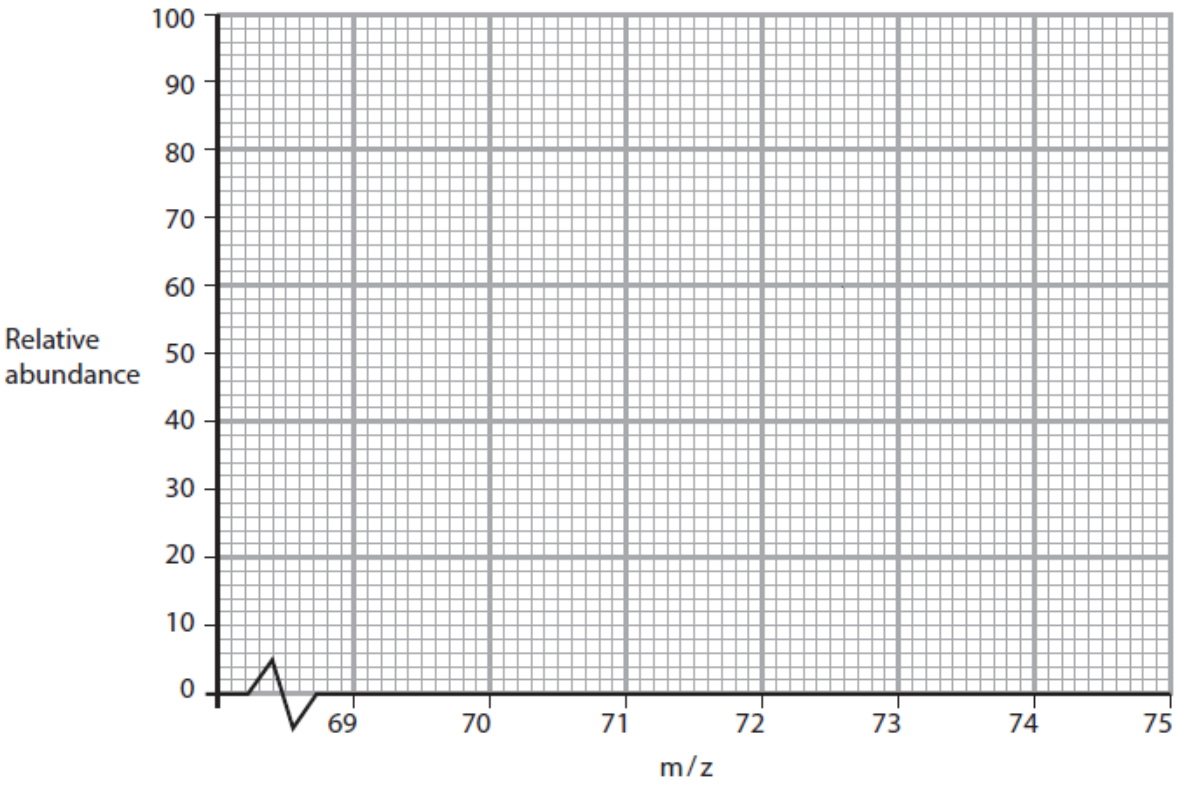
(2)

Particle	Protons	Neutrons	Electrons
^{35}Cl atom			
$^{37}Cl^-$ ion			

(ii) A sample of chlorine contained 75 % of ^{35}Cl and 25 % of ^{37}Cl.

Complete the mass spectrum to show the peaks you would expect for the molecular ion Cl_2^+ from this sample of chlorine gas.

(2)



(Total for question = 4 marks)

Q23.

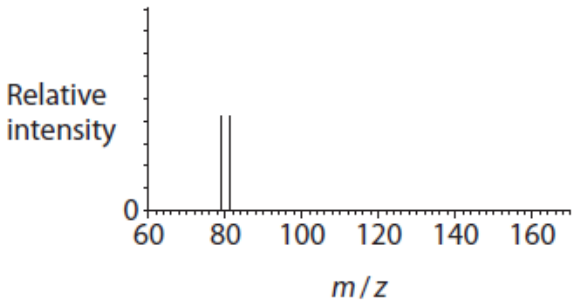
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about atoms, molecules and ions.

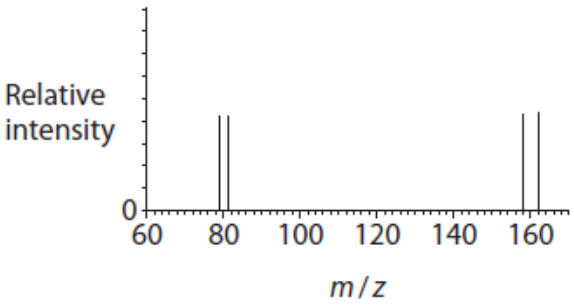
The mass spectrum of a sample of bromine **molecules** with approximately equal proportions of the ^{79}Br and ^{81}Br isotopes is

(1)

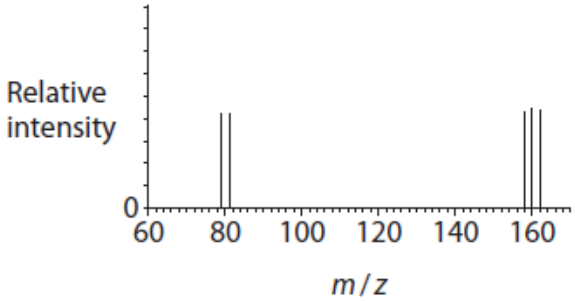
☐ **A**



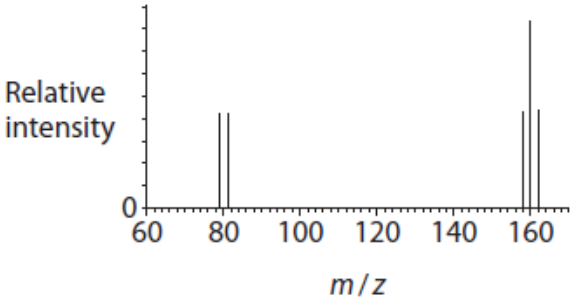
☐ **B**



☐ **C**



☐ **D**



(Total for question = 1 mark)

Q24.

This question is about atoms, molecules and ions.

Complete the table to show the maximum number of electrons which can fill each region of an atom.

(3)

Region	Maximum number of electrons
the 1s orbital	
the 2p subshell	
the third quantum shell	

(Total for question = 3 marks)

Q25.

This question is about atoms, molecules and ions.

Lithium exists as two isotopes.

Complete the table to show the numbers of subatomic particles in a ^{6}Li **atom** and a $^{7}Li^{+}$ **ion**.

(2)

Particle	Protons	Neutrons	Electrons
^{6}Li			
$^{7}Li^{+}$			

(Total for question = 2 marks)

Q26.

A phosphorus atom has mass number 31.

How many of each sub-atomic particle are present in the phosphide ion, P^{3-}?

(1)

	Number of protons	Number of neutrons	Number of electrons
☐ A	15	16	12
☐ B	15	16	18
☐ C	16	15	12
☐ D	16	15	18

(Total for question = 1 mark)

Q27.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about atoms, molecules and ions.

The numbers of subatomic particles in an ^{18}O atom are

(1)

☐ **A** 8 protons, 10 neutrons and 8 electrons

☐ **B** 9 protons, 9 neutrons and 9 electrons

☐ **C** 10 protons, 8 neutrons and 10 electrons

☐ **D** 18 protons, 18 neutrons and 18 electrons

(Total for question = 1 mark)

Q28.

Magnesium and strontium are elements in Group 2 of the Periodic Table. The first three ionisation energies of magnesium and strontium are shown in the table.

Element	Ionisation energy / kJ mol^{-1}		
	First	Second	Third
magnesium	738	1451	7733
strontium	550	1064	4210

(a) (i) Explain why the first ionisation energy of magnesium is larger than that of strontium.

(2)

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(ii) Explain why the second ionisation energy of magnesium is larger than its first ionisation energy.

(2)

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(iii) Explain why the third ionisation energy of magnesium is **significantly** larger than its second ionisation energy.

(2)

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Q29.

Answer the question with a cross in the box you think is correct ☒. If you change your