**Q1.**          (a)     State the meaning of the term *electronegativity*.

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**(2)**

(b)     State and explain the trend in electronegativity values across Period 3 from sodium to chlorine.

*Trend* ...........................................................................................................

*Explanation* ..................................................................................................

**(3)**

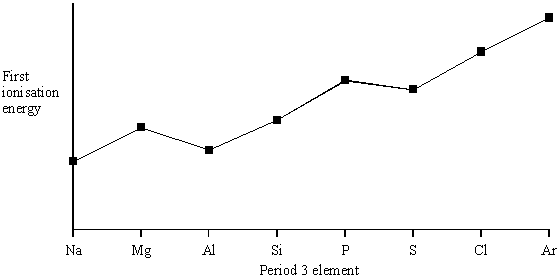
(c)     What is meant by the term *first ionisation energy*?

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**(2)**

(d)     The diagram below shows the variation in first ionisation energy across Period 3.



(i)      What is the maximum number of electrons that can be accommodated in an s sub-level?

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(ii)     What evidence from the diagram supports your answer to part (d)(i)?

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(iii)     What evidence from the diagram supports the fact that the 3p sub-level is higher in energy than the 3s?

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(iv)    What evidence from the diagram supports the fact that no more than three unpaired electrons can be accommodated in the 3p sub-level?

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**(5)**

**(Total 12 marks)**

**Q2.**          (a)     Define the term *atomic number* of an element.

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**(1)**

(b)     Give the symbol, including mass number and atomic number, for an atom of an element which contains 12 neutrons and 11 electrons.

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**(2)**

(c)     In terms of s and p sub-levels, give the electronic configuration of an aluminium atom.

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**(1)**

(d)     How many neutrons are there in one 27Al atom?

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**(1)**

(e)     Define the term *relative atomic mass* of an element.

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**(2)**

(f)      Parts (i) to (iv) below refer to the operation of a mass spectrometer.

(i)      Name the device used to ionise atoms in a mass spectrometer.

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(ii)     Why is it necessary to ionise atoms before acceleration?

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(iii)     What deflects the ions?

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(iv)    What is adjusted in order to direct ions of different mass to charge ratio onto the detector?

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**(4)**

(g)     A meteorite was found to contain three isotopes of element **X**.  
A mass spectrometer gave the following information about these isotopes.

|  |  |  |  |
| --- | --- | --- | --- |
| *m*/*z* | 24.0 | 25.0 | 26.0 |
| Relative abundance | 64.2 | 20.3 | 15.5 |

(i)      Calculate the relative atomic mass of **X**.

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(ii)     Using the Periodic Table, suggest the most likely identity of element **X**.

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(iii)     Suggest one reason why the relative atomic mass of **X**, given in the Periodic Table, differs from your answer to part (g)(i).

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**(5)**

**(Total 16 marks)**

**Q3.**          (a)     State the relative charge and relative mass of a proton, of a neutron and of an electron.  
In terms of particles, explain the relationship between two isotopes of the same element.  
Explain why these isotopes have identical chemical properties.

**(7)**

(b)     Define the term *relative atomic mass*. An element exists as a mixture of three isotopes.  
Explain, in detail, how the relative atomic mass of this element can be calculated from data obtained from the mass spectrum of the element.

**(7)**

**(Total 14 marks)**

**Q4.**          (a)     Ionisation is the first of the four main stages involved in obtaining the mass spectrum of a sample of gaseous titanium atoms. Explain how ionisation is achieved. Name the remaining three stages and, in each case, state how each stage is achieved. Explain why it would be difficult to distinguish between 48Ti2+ and 24Mg+ ions using a mass spectrometer.

**(10)**

(b)     State any differences and similarities in the atomic structure of the isotopes of an element. State the difference, if any, in the chemistry of these isotopes. Explain your answer.

**(4)**

(c)     The table below gives the percentage abundance of each isotope in the mass spectrum of a sample of titanium.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *m/z* | 46 | 47 | 48 | 49 | 50 |
| % abundance | 8.02 | 7.31 | 73.81 | 5.54 | 5.32 |

Define the term *relative atomic mass* of an element. Use the above data to calculate the value of the relative atomic mass of titanium in this sample. Give your answer to two decimal places.

**(4)**

**(Total 18 marks)**

**Q5.**          There is a general trend in the values of the first ionisation energies of the elements Na to Ar. The first ionisation energies of the elements Al and S deviate from this trend.

(a)     Write an equation, including state symbols, to represent the process for which the energy change is the first ionisation energy of Na.

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**(2)**

(b)     State and explain the general trend in the values of the first ionisation energies of the elements Na to Ar.

*Trend* ...........................................................................................................

*Explanation* ..................................................................................................

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**(3)**

(c)     State how, and explain why, the values of the first ionisation energies of the elements Al and S deviate from the general trend.

*How the values deviate from the trend* .........................................................

*Explanation for Al* .........................................................................................

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*Explanation for S* ..........................................................................................

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**(5)**

**(Total 10 marks)**

**Q6.**          (a)     Complete the following table.

|  |  |  |
| --- | --- | --- |
| Particle | Relative charge | Relative mass |
| Proton |  |  |
| Neutron |  |  |
| Electron |  |  |

**(3)**

(b)     An atom of element **Z** has two more protons and two more neutrons than an atom of . Give the symbol, including mass number and atomic number, for this atom of **Z.**

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**(2)**

(c)     Complete the electronic configurations for the sulphur atom, S, and the sulphide ion, S2–.

*S*       1s2 .......................................................................................................

*S2–*     1s2 .......................................................................................................

**(2)**

(d)     State the block in the Periodic Table in which sulphur is placed and explain your answer.

*Block* ...........................................................................................................

*Explanation* ..................................................................................................

**(2)**

(e)     Sodium sulphide, Na2S, is a high melting point solid which conducts electricity when molten. Carbon disulphide, CS2, is a liquid which does not conduct electricity.

(i)      Deduce the type of bonding present in Na2S and that present in CS2

*Bonding in Na2S* ..................................................................................

*Bonding in CS2*.....................................................................................

(ii)     By reference to all the atoms involved explain, in terms of electrons, how Na2S is formed from its atoms.

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(iii)     Draw a diagram, including all the outer electrons, to represent the bonding present in CS2

(iv)    When heated with steam, CS2 reacts to form hydrogen sulphide, H2S, and carbon dioxide.  
Write an equation for this reaction.

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**(7)**

**(Total 16 narks)**

**Q7.**          (a)     Give the relative charge and relative mass of an electron.

*Relative charge ..*.........................................................................................

*Relative mass* ..............................................................................................

**(2)**

(b)     Isotopes of chromium include 54Cr and 52Cr

(i)      Give the number of protons present in an atom of 54Cr

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(ii)     Deduce the number of neutrons present in an atom of 52Cr

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(iii)     Apart from the relative mass of each isotope, what else would need to be known for the relative atomic mass of chromium to be calculated?

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**(3)**

(c)     In order to obtain a mass spectrum of a gaseous sample of chromium, the sample must first be ionised.

(i)      Give **two** reasons why it is necessary to ionise the chromium atoms in the sample.

*Reason 1 .*..........................................................................................

*Reason 2* ............................................................................................

(ii)     State what is adjusted so that each of the isotopes of chromium can be detected in turn.

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(iii)     Explain how the adjustment given in part (c)(ii) enables the isotopes of chromium to be separated.

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**(4)**

(d)     (i)      State what is meant by the term *empirical formula*.

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(ii)     A chromium compound contains 28.4% of sodium and 32.1% of chromium by mass, the remainder being oxygen.  
Calculate the empirical formula of this compound.

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**(4)**

**(Total 13 marks)**

**Q8.**          (a)     (i)      Complete the electronic configuration of aluminium.

1s2 .......................................................................................................

(ii)     State the block in the Periodic Table to which aluminium belongs.

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**(2)**

(b)     Describe the bonding in metals.

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**(2)**

(c)     Explain why the melting point of magnesium is higher than that of sodium.

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**(3)**

(d)     Explain how metals conduct electricity.

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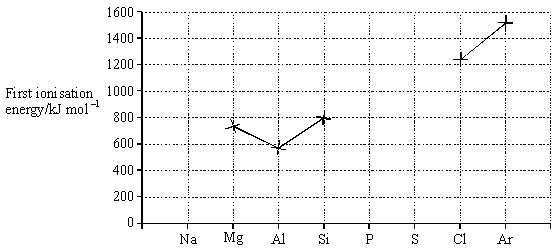
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**(2)**

**(Total 9 marks)**

**Q9.**          The diagram below shows the values of the first ionisation energies of some of the elements in Period 3.



(a)     On the above diagram, use crosses to mark the approximate positions of the values of the first ionisation energies for the elements Na, P and S. Complete the diagram by joining the crosses.

**(3)**

(b)     Explain the general increase in the values of the first ionisation energies of the elements Na–Ar.

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**(3)**

(c)     In terms of the electron sub-levels involved, explain the position of aluminium and the position of sulphur in the diagram.

*Explanation for aluminium* ............................................................................

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*Explanation for sulphur .*................................................................................

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**(4)**

**(Total 10 marks)**

**Q10.**          A gaseous sample of chromium can be analysed in a mass spectrometer. Before deflection, the chromium atoms are ionised and then accelerated.

(a)     Describe briefly how positive ions are formed from gaseous chromium atoms in a mass spectrometer.

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**(2)**

(b)     What is used in a mass spectrometer to accelerate the positive ions?

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**(1)**

(c)     What is used in a mass spectrometer to deflect the positive ions?

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**(1)**

(d)     The mass spectrum of a sample of chromium shows four peaks. Use the data below to calculate the relative atomic mass of chromium in the sample. Give your answer to two decimal places.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *m/z* | 50 | 52 | 53 | 54 |
| Relative abundance / % | 4.3 | 83.8 | 9.5 | 2.4 |

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**(2)**

**(Total 6 marks)**

**Q11.**          (a)     One isotope of sodium has a relative mass of 23.

(i)      Define, in terms of the fundamental particles present, the meaning of the term *isotopes*.

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(ii)     Explain why isotopes of the same element have the same chemical properties.

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(iii)     Calculate the mass, in grams, of a single atom of this isotope of sodium.  
(The Avogadro constant, *L*, is 6.023 × 1023 mol–1)

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**(5)**

(b)     Give the electronic configuration, showing all sub-levels, for a sodium atom.

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**(1)**

(c)     Explain why chromium is placed in the d block in the Periodic Table.

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**(1)**

(d)     An atom has half as many protons as an atom of 28Si and also has six fewer neutrons than an atom of 28Si. Give the symbol, including the mass number and the atomic number, of this atom.

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**(2)**

**(Total 9 marks)**

**Q12.**          Lithium hydride, LiH, is an ionic compound containing the hydride ion, H–The reaction between LiH and aluminium chloride, AlCl3, produces the ionic compound LiAlH4

(a)     Balance the equation below which represents the reaction between LiH and AlCl3

LiH +    AlCl3  →      LiAlH4   +     LiCl

**(1)**

(b)     Give the electronic configuration of the hydride ion, H–

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**(1)**

(c)     Predict the shape of the  ion. Explain why it has this shape.

*Shape* ..........................................................................................................

*Explanation* ..................................................................................................

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**(3)**

(d)     A bond in  can be represented by H → Al

Name this type of bond and explain how it is formed.

*Type of bond* ................................................................................................

*Explanation* ..................................................................................................

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......................................................................................................................

**(3)**

**(Total 8 marks)**

**Q13.**          The values of the first ionisation energies of neon, sodium and magnesium are 2080, 494 and 736 kJ mol–1, respectively.

(a)     Explain the meaning of the term *first ionisation* of an atom.

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**(2)**

(b)     Write an equation to illustrate the process occurring when the **second** ionisation energy of magnesium is measured.

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**(2)**

(c)     Explain why the value of the first ionisation energy of magnesium is higher than that of sodium.

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**(2)**

(d)     Explain why the value of the first ionisation energy of neon is higher than that of sodium.

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**(2)**

**(Total 8 marks)**

**Q14.**          (a)     Complete the following table.

|  |  |  |
| --- | --- | --- |
|  | Relative mass | Relative charge |
| Proton |  |  |
| Electron |  |  |

**(2)**

(b)     An atom of element **Q** contains the same number of neutrons as are found in an atom of 27A1. An atom of **Q** also contains 14 protons.

(i)      Give the number of protons in an atom of 27A1.

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(ii)     Deduce the symbol, including mass number and atomic number, for this atom of element **Q**.

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**(3)**

(c)     Define the term *relative atomic mass* of an element.

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**(2)**

(d)     The table below gives the relative abundance of each isotope in a mass spectrum of a sample of magnesium.

|  |  |  |  |
| --- | --- | --- | --- |
| *m*/*z* | 24 | 25 | 26 |
| Relative abundance (%) | 73.5 | 10.1 | 16.4 |

Use the data above to calculate the relative atomic mass of this sample of magnesium.  
Give your answer to one decimal place.

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**(2)**

(e)     State how the relative molecular mass of a covalent compound is obtained from its mass spectrum.

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**(1)**

**(Total 10 marks)**

**Q15.**          (a)     Define the terms

(i)      *mass number* of an atom,

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(ii)     *relative molecular mass*.

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**(3)**

(b)     (i)      Complete the electron arrangement for a copper atom.

*1s*2 .......................................................................................................

(ii)     Identify the block in the Periodic Table to which copper belongs.

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(iii)     Deduce the number of neutrons in one atom of 65Cu

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**(3)**

(c)     A sample of copper contains the two isotopes 63Cu and 65Cu only. It has a relative atomic mass, *A*r, less than 64. The mass spectrum of this sample shows major peaks with *m/z* values of 63 and 65, respectively.

(i)      Explain why the *A*r of this sample is less than 64.

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(ii)     Explain how Cu atoms are converted into Cu+ ions in a mass spectrometer.

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(iii)     In addition to the major peaks at *m/z* = 63 and 65, much smaller peaks at *m/z* = 31.5 and 32.5 are also present in the mass spectrum. Identify the ion responsible for the peak at *m/z* = 31.5 in the mass spectrum. Explain why your chosen ion has this *m/z* value and suggest **one** reason why this peak is very small.

*Identity of the ion*

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*Explanation for m/z value* ....................................................................

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*Reason why this peak is very small* ....................................................

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**(6)**

**(Total 12 marks)**

**Q16.**          A sample of iron from a meteorite was found to contain the isotopes 54Fe, 56Fe and 57Fe.

(a)     The relative abundances of these isotopes can be determined using a mass spectrometer. In the mass spectrometer, the sample is first vaporised and then ionised.

(i)      State what is meant by the term *isotopes*.

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(ii)     Explain how, in a mass spectrometer, ions are detected and how their abundance is measured.

How ions are detected.........................................................................

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*How abundance is measured*...............................................................

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**(5)**

(b)     (i)      Define the term *relative atomic mass* of an element.

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(ii)     The relative abundances of the isotopes in this sample of iron were found to be as follows.

|  |  |  |  |
| --- | --- | --- | --- |
| *m/z* | 54 | 56 | 57 |
| Relative abundance (%) | 5.8 | 91.6 | 2.6 |

Use the data above to calculate the relative atomic mass of iron in this sample. Give your answer to one decimal place.

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**(4)**

(c)     (i)      Give the electron arrangement of an Fe2+ ion.

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(ii)     State why iron is placed in the d block of the Periodic Table.

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(iii)     State the difference, if any, in the chemical properties of isotopes of the same element. Explain your answer.

*Difference .*..........................................................................................

*Explanation* .........................................................................................

.............................................................................................................

**(4)**

**(Total 13 marks)**

**Q17.**          A sample of element **Q** was extracted from a meteorite. The table below shows the relative abundance of each isotope in a mass spectrum of this sample of **Q**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *m/z* | 64 | 66 | 67 | 68 |
| Relative abundance (%) | 38.9 | 27.8 | 14.7 | 18.6 |

(a)     Define the term *relative atomic mass* of an element.

**(2)**

(b)     Use the data above to calculate the relative atomic mass of this sample of **Q**. Give your answer to one decimal place. Suggest the identity of **Q**.

**(3)**

(c)     In order to obtain a mass spectrum of **Q**, a gaseous sample is first ionised. Describe how ionisation is achieved in a mass spectrometer. Give **three** reasons why ionisation is necessary.

**(5)**

**(Total 10 marks)**

**Q18.**          (a)     State the meaning of the term *first ionisation energy* of an atom.

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**(2)**

(b)     Complete the electron arrangement for the Mg2+ ion.

*1s2 ..*..............................................................................................................

**(1)**

(c)     Identify the block in the Periodic Table to which magnesium belongs.

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**(1)**

(d)     Write an equation to illustrate the process occurring when the **second** ionisation energy of magnesium is measured.

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**(1)**

(e)     The Ne atom and the Mg2+ ion have the same number of electrons. Give **two** reasons why the first ionisation energy of neon is lower than the third ionisation energy of magnesium.

*Reason 1* .....................................................................................................

*Reason 2* .....................................................................................................

**(2)**

(f)      There is a general trend in the first ionisation energies of the Period 3 elements, Na – Ar

(i)      State and explain this general trend.

*Trend ………..*.....................................................................................

*Explanation .*........................................................................................

.............................................................................................................

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(ii)     Explain why the first ionisation energy of sulphur is lower than would be predicted from the general trend.

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**(5)**

**(Total 12 marks)**

**Q19.**          (a)     Complete the following table.

|  |  |  |
| --- | --- | --- |
|  | Relative mass | Relative charge |
| Neutron |  |  |
| Electron |  |  |

**(2)**

(b)     An atom has twice as many protons as, and four more neutrons than, an atom of 9Be. Deduce the symbol, including the mass number, of this atom.

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**(2)**

(c)     Draw the shape of a molecule of BeCl2 and the shape of a molecule of Cl2O. Show any lone pairs of electrons on the central atom. Name the shape of each molecule.

*BeCl2 Cl2O*

*Name of shape* ................................ *Name of shape* ..................................

**(4)**

(d)     The equation for the reaction between magnesium hydroxide and hydrochloric acid is shown below.

Mg(OH)2(s) + 2HCl(aq) → MgCl2(aq) + 2H2O(l)

Calculate the volume, in cm3, of 1.00 mol dm–3 hydrochloric acid required to react completely with 1.00 g of magnesium hydroxide.

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**(4)**

**(Total 12 marks)**

**Q20.**          (a)     State, in terms of the fundamental particles present, the meaning of the term *isotopes*.

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**(1)**

(b)     An atom contains one more proton than, but the same number of neutrons as, an atom of 36S. Deduce the symbol, including the mass number and the atomic number, of this atom.

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**(2)**

(c)     The table below gives the relative abundance of each isotope in a mass spectrum of a sample of germanium, Ge.

|  |  |  |  |
| --- | --- | --- | --- |
| m/z | 70 | 72 | 74 |
| Relative abundance (%) | 24.4 | 32.4 | 43.2 |

(i)      Complete the electron arrangement of a Ge atom.

*1s2* .......................................................................................................

(ii)     Use the data above to calculate the relative atomic mass of this sample of germanium. Give your answer to one decimal place.

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(iii)     State what is adjusted in a mass spectrometer in order to direct ions with different *m/z* values onto the detector. Explain your answer.

*Adjustment* ..........................................................................................

*Explanation* .........................................................................................

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(iv)    One of the isotopes of Ge, given in the table in part (c), has an ion that forms a small peak in the mass spectrum which is indistinguishable from a peak produced by  
36S+ ions. Identify this Ge ion and explain your answer.

*Ion* .......................................................................................................

*Explanation .*........................................................................................

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**(8)**

**(Total 11 marks)**

**Q21.**          In one model of atomic structure, the atom has a nucleus surrounded by electrons in levels and sub-levels.

(a)     Define the term *atomic number*.

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**(1)**

(b)     Explain why atoms of an element may have different mass numbers.

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**(1)**

(c)     The table below refers to a sample of krypton.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Relative *m/z* | 82 | 83 | 84 | 86 |
| Relative abundance / % | 12 | 12 | 50 | 26 |

(i)      Name an instrument which is used to measure the relative abundance of isotopes.

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(ii)     Define the term *relative atomic mass*.

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(iii)     Calculate the relative atomic mass of this sample of krypton.

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**(5)**

(d)     Give the complete electronic configuration of krypton in terms of s, p and d sub-levels.

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**(1)**

(e)     In 1963, krypton was found to react with fluorine. State why this discovery was unexpected.

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**(1)**

(f)      Use a suitable model of atomic structure to explain the following experimental observations.

(i)      The first ionisation energy of krypton is greater than that of bromine.

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(ii)     The first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

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**(4)**

**(Total 13 marks)**

**Q22.**         In 1913 Niels Bohr proposed a model of the atom with a central nucleus, made up of protons and neutrons, around which electrons moved in orbits. After further research, the model was refined when the existence of energy levels and sub-levels was recognised.

(a)     Complete the following table for the particles in the nucleus.

|  |  |  |
| --- | --- | --- |
| Particle | Relative charge | Relative mass |
| proton |  |  |
| neutron |  |  |

**(2)**

(b)     State the block in the Periodic Table to which the element tungsten, W, belongs.

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**(1)**

(c)     Isotopes of tungsten include 182W and 186W

(i)      Deduce the number of protons in 182W

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**(1)**

(ii)     Deduce the number of neutrons in 186W

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**(1)**

(d)     In order to detect the isotopes of tungsten using a mass spectrometer, a sample containing the isotopes must be vaporised and then ionised.

(i)      Give **two** reasons why the sample must be ionised.

1 ..........................................................................................................

2 ..........................................................................................................

**(2)**

(ii)     State what can be adjusted in the mass spectrometer to enable ions formed by the different isotopes to be directed onto the detector.

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**(1)**

(e)     State and explain the difference, if any, between the chemical properties of the isotopes 182W and 186W

Difference ....................................................................................................

Explanation ..................................................................................................

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**(2)**

(f)      The table below gives the relative abundance of each isotope in the mass spectrum of a sample of tungsten.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *m/z* | 182 | 183 | 184 | 186 |
| Relative abundance /% | 26.4 | 14.3 | 30.7 | 28.6 |

Use the data above to calculate a value for the relative atomic mass of this sample of tungsten. Give your answer to 2 decimal places.

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**(2)**

**(Total 12 marks)**

**Q23.**          (a)     (i)      Define the term *relative atomic mass* (*A*r) of an element.

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**(2)**

(ii)     A sample of the metal silver has the relative atomic mass of 107.9 and exists as two isotopes. In this sample, 54.0% of the silver atoms are one isotope with a relative mass of 107.1

Calculate the relative mass of the other silver isotope.

State why the isotopes of silver have identical chemical properties.

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**(4)**

(b)     The isotopes of silver, when vaporised, can be separated in a mass spectrometer.

Name the **three** processes that occur in a mass spectrometer before the vaporised isotopes can be detected.

State how each process is achieved.

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**(6)**

(c)     State the type of bonding involved in silver.

Draw a diagram to show how the particles are arranged in a silver lattice and show the charges on the particles.

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**(3)**

(d)     Silver reacts with fluorine to form silver fluoride (AgF).

Silver fluoride has a high melting point and has a structure similar to that of sodium chloride.

State the type of bonding involved in silver fluoride.

Draw a diagram to show how the particles are arranged in a silver fluoride lattice and show the charges on the particles.

Explain why the melting point of silver fluoride is high.

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**(5)**

**(Total 20 marks)**

**Q24.**          (a)     Complete the electronic configuration for the sodium ion, Na+

ls2 .................................................................................................................

**(1)**

(b)     (i)      Write an equation, including state symbols, to represent the process for which the energy change is the second ionisation energy of sodium.

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**(2)**

(ii)     Explain why the second ionisation energy of sodium is greater than the second ionisation energy of magnesium.

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**(3)**

(iii)     An element **X** in Period 3 of the Periodic Table has the following successive ionisation energies.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | First | Second | Third | Fourth |
| Ionisation energies / kJ mol–1 | 577 | 1820 | 2740 | 11600 |
|  |  |  |  |  |

Deduce the identity of element **X**.

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**(1)**

(c)     State and explain the trend in atomic radius of the Period 3 elements from sodium to chlorine.

Trend ...........................................................................................................

Explanation ..................................................................................................

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**(3)**

(d)     Explain why sodium has a lower melting point than magnesium.

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**(3)**

(e)     Sodium reacts with ammonia to form the compound NaNH2 which contains the NH2– ion. Draw the shape of the NH2– ion, including any lone pairs of electrons.  
Name the shape made by the three atoms in the NH2– ion.

Shape of NH2–

Name of shape ............................................................................................

**(2)**

(f)      In terms of its electronic configuration, give **one** reason why neon does not form compounds with sodium.

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**(1)**

**(Total 16 marks)**

**Q25.**          (a)     Define the term *relative atomic mass*.

An organic fertiliser was analysed using a mass spectrometer. The spectrum showed that the nitrogen in the fertiliser was made up of 95.12% 14N and 4.88% 15N

Calculate the relative atomic mass of the nitrogen found in this organic fertiliser.  
Give your answer to two decimal places.

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**(4)**

(b)     In a mass spectrometer, under the same conditions, 14N+ and 15N+ ions follow different paths. State the property of these ions that causes them to follow different paths.

State **one** change in the operation of the mass spectrometer that will change the path of an ion.

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**(2)**

(c)     Organic fertilisers contain a higher proportion of 15N atoms than are found in synthetic fertilisers.

State and explain whether or not you would expect the chemical reactions of the nitrogen compounds in the synthetic fertiliser to be different from those in the organic fertiliser. Assume that the nitrogen compounds in each fertiliser are the same.

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**(2)**

**(Total 8 marks)**

**Q26.**          Define the term *mass number* of an atom.

The mass number of an isotope of nitrogen is 15. Deduce the number of each of the fundamental particles in an atom of 15N

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**(Total 3 marks)**

**Q27.**          Indium is in Group 3 in the Periodic Table and exists as a mixture of the isotopes 113In and 115In.

(a)     Use your understanding of the Periodic Table to complete the electron configuration of indium.

1s2 2s2 2p6 3s2 3p6 4s2 3d10 4p6 ........................................................................

**(1)**

(b)     A sample of indium must be ionised before it can be analysed in a mass spectrometer.

(i)      State what is used to ionise a sample of indium in a mass spectrometer.

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**(1)**

(ii)     Write an equation, including state symbols, for the ionisation of indium that requires the minimum energy.

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**(1)**

(iii)     State why more than the minimum energy is **not** used to ionise the sample of indium.

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**(1)**

(iv)    Give two reasons why the sample of indium must be ionised.

Reason 1 ............................................................................................

Reason 2 ............................................................................................

**(2)**

(c)     A mass spectrum of a sample of indium showed two peaks at *m/z* = 113 and *m/z*= 115. The relative atomic mass of this sample of indium is 114.5

(i)      Give the meaning of the term *relative atomic mass*.

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**(2)**

(ii)     Use these data to calculate the ratio of the relative abundances of the two isotopes.

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**(2)**

(d)     State and explain the difference, if any, between the chemical properties of the isotopes 113In and 115In

Difference in chemical properties ................................................................

Explanation ..................................................................................................

**(2)**

(e)     Indium forms a compound **X** with hydrogen and oxygen. Compound **X** contains 69.2% indium and 1.8% hydrogen by mass.  
Calculate the empirical formula of compound **X**.

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**(3)**

**(Total 15 marks)**

**Q28.**          This question is about the first ionisation energies of some elements in the Periodic Table.

(a)     Write an equation, including state symbols, to show the reaction that occurs when the first ionisation energy of lithium is measured.

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**(1)**

(b)     State and explain the general trend in first ionisation energies for the Period 3 elements aluminium to argon.

Trend ..........................................................................................................

Explanation .................................................................................................

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*(Extra space)*...............................................................................................

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**(3)**

(c)     There is a similar general trend in first ionisation energies for the Period 4 elements gallium to krypton.

State how selenium deviates from this general trend and explain your answer.

How selenium deviates from this trend ......................................................

Explanation .................................................................................................

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*(Extra space)*................................................................................................

**(3)**

(d)     Suggest why the first ionisation energy of krypton is lower than the first ionisation energy of argon.

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**(1)**

(e)     The table below gives the successive ionisation energies of an element.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | First | Second | Third | Fourth | Fifth |
| Ionisation energy / kJ mol–1 | 590 | 1150 | 4940 | 6480 | 8120 |
|  |  |  |  |  |  |

Deduce the group in the Periodic Table that contains this element.

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**(1)**

(f)      Identify the element that has a 5+ ion with an electron configuration of  
1s2 2s2 2p6 3s2 3p6 3d10

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**(1)**

**(Total 10 marks)**

**Q29.**          There are several types of crystal structure and bonding shown by elements and compounds.

(a)     (i)      Name the type of bonding in the element sodium.

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**(1)**

(ii)     Use your knowledge of structure and bonding to draw a diagram that shows how the particles are arranged in a crystal of sodium.  
You should identify the particles and show a minimum of six particles in a two-dimensional diagram.

**(2)**

(b)     Sodium reacts with chlorine to form sodium chloride.

(i)      Name the type of bonding in sodium chloride.

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**(1)**

(ii)     Explain why the melting point of sodium chloride is high.

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*(Extra space)* .......................................................................................

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**(2)**

(c)     The table below shows the melting points of some sodium halides.

|  |  |  |  |
| --- | --- | --- | --- |
|  | NaCl | NaBr | NaI |
| Melting point /K | 1074 | 1020 | 920 |
|  |  |  |  |

Suggest why the melting point of sodium iodide is lower than the melting point of sodium bromide.

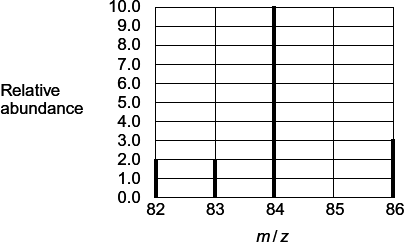
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**(1)**

**(Total 7 marks)**

**Q30.**The mass spectrum of a sample of krypton taken from a meteorite is shown below.



(a)     Use this spectrum to calculate the relative atomic mass of this sample of krypton.  
Give your answer to one decimal place.

Explain why the value you have calculated is slightly different from the relative atomic mass given in the Periodic Table.

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*(Extra space)* .................................................................................................

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**(4)**

(b)     State how krypton is ionised in the mass spectrometer.

Write an equation, including state symbols, to show the reaction that occurs when the **first** ionisation energy of Kr is measured.

Sometimes the mass spectrum of Kr has a very small peak with an *m/z* value of 42.  
Explain the occurrence of this peak.

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*(Extra space)* .................................................................................................

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**(5)**

**(Total 9 marks)**

**Q31.**The element nitrogen forms compounds with metals and non-metals.

(a)     Nitrogen forms a nitride ion with the electron configuration 1s2 2s2 2p6Write the formula of the nitride ion.

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**(1)**

(b)     An element forms an ion **Q** with a single negative charge that has the same electron configuration as the nitride ion.  
Identify the ion **Q**.

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**(1)**

(c)     Use the Periodic Table and your knowledge of electron arrangement to write the formula of lithium nitride.

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**(1)**

(d)     Calcium nitride contains 81.1% by mass of the metal.  
Calculate the empirical formula of calcium nitride.  
Show your working.

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**(3)**

(e)     Write an equation for the reaction between silicon and nitrogen to form silicon nitride, Si3N4

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**(1)**

**(Total 7 marks)**

**Q32.**The element rubidium exists as the isotopes 85Rb and 87Rb

(a)     State the number of protons and the number of neutrons in an atom of the isotope 85Rb

Number of protons .........................................................................................

Number of neutrons .......................................................................................

**(2)**

(b)     (i)      Explain how the gaseous atoms of rubidium are ionised in a mass spectrometer

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**(2)**

(ii)     Write an equation, including state symbols, to show the process that occurs when the **first** ionisation energy of rubidium is measured.

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**(1)**

(c)     The table shows the first ionisation energies of rubidium and some other elements in the same group.

|  |  |  |  |
| --- | --- | --- | --- |
| **Element** | sodium | potassium | rubidium |
| **First ionisation energy / kJ mol–1** | 494 | 418 | 402 |

State **one** reason why the first ionisation energy of rubidium is lower than the first ionisation energy of sodium.

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**(1)**

(d)     (i)      State the block of elements in the Periodic Table that contains rubidium.

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**(1)**

(ii)     Deduce the full electron configuration of a rubidium atom.

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**(1)**

(e)     A sample of rubidium contains the isotopes 85Rb and 87Rb only.  
The isotope 85Rb has an abundance 2.5 times greater than that of 87Rb

Calculate the relative atomic mass of rubidium in this sample.  
Give your answer to one decimal place.

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**(3)**

(f)      By reference to the relevant part of the mass spectrometer, explain how the abundance of an isotope in a sample of rubidium is determined.

Name of relevant part ....................................................................................

Explanation ....................................................................................................

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**(2)**

(g)     Predict whether an atom of 88Sr will have an atomic radius that is larger than, smaller than or the same as the atomic radius of 87Rb. Explain your answer.

Atomic radius of 88Sr compared to 87Rb .........................................................

Explanation ....................................................................................................

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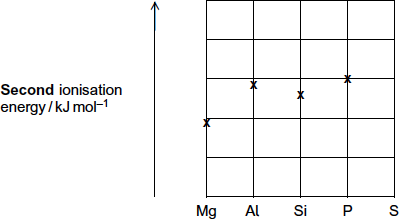
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**(3)**

**(Total 16 marks)**

**Q33.**(a)     Use your knowledge of electron configuration and ionisation energies to answer this question. The following diagram shows the **second** ionisation energies of some Period 3 elements.



(i)      Draw an ‘**X**’ on the diagram to show the **second** ionisation energy of sulfur.

**(1)**

(ii)     Write the full electron configuration of the Al2+ ion.

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**(1)**

(iii)    Write an equation to show the process that occurs when the **second** ionisation energy of aluminium is measured.

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**(1)**

(iv)    Give **one** reason why the **second** ionisation energy of silicon is lower than the **second** ionisation energy of aluminium.

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**(1)**

(b)     Predict the element in Period 3 that has the highest **second** ionisation energy.  
Give a reason for your answer.

Element ........................................................................................................

Reason .........................................................................................................

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**(2)**

(c)     The following table gives the successive ionisation energies of an element in Period 3.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | First | Second | Third | Fourth | Fifth | Sixth |
|  | Ionisation energy / kJ mol−1 | 786 | 1580 | 3230 | 4360 | 16100 | 19800 |

Identify this element.

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**(1)**

(d)     Explain why the ionisation energy of every element is endothermic.

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*(Extra space)* .................................................................................................

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**(1)**

**(Total 8 marks)**

**Q34.**(a)    State the meaning of the term *mass number* of an isotope.

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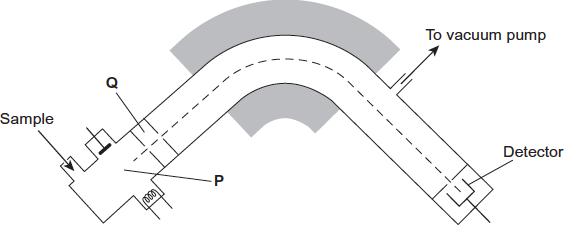
**(1)**

(b)     Give the symbol of the element that has an isotope with a mass number of 68 and has 38 neutrons in its nucleus.

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**(1)**

(c)     The following shows a simplified diagram of a mass spectrometer.



(i)      State what happens to the sample in the parts labelled **P** and **Q**.

**P** ..........................................................................................................

**Q** ..........................................................................................................

**(2)**

(ii)     In a mass spectrometer, the isotopes of an element are separated.  
Two measurements for each isotope are recorded on the mass spectrum.

State the **two** measurements that are recorded for each isotope.

Measurement 1 ....................................................................................

Measurement 2 ....................................................................................

**(2)**

(d)     A sample of element **R** contains isotopes with mass numbers of 206, 207 and 208 in a 1:1:2 ratio of abundance.

(i)      Calculate the relative atomic mass of **R**. Give your answer to one decimal place.

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**(3)**

(ii)     Identify **R**.

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**(1)**

(iii)    All the isotopes of **R** react in the same way with concentrated nitric acid.

State why isotopes of an element have the same chemical properties.

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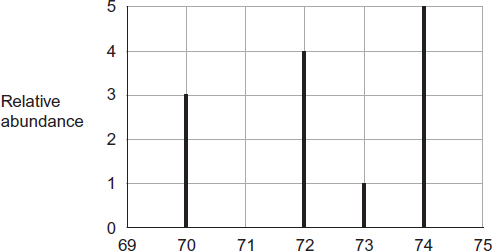
*(Extra space)* ........................................................................................

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**(1)**

**(Total 11 marks)**

**Q35.**The mass spectrum of the isotopes of element **X** is shown in the diagram.



m / z

(a)     Define the term *relative atomic mass*.

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**(2)**

(b)     Use data from the diagram to calculate the relative atomic mass of **X**.

Give your answer to one decimal place.

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**(3)**

(c)     Identify the ion responsible for the peak at 72

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**(1)**

(d)     Identify which one of the isotopes of **X** is deflected the most in the magnetic field of a mass spectrometer. Give a reason for your answer.

Isotope ..........................................................................................................

Reason ..........................................................................................................

**(2)**

(e)     In a mass spectrometer, the relative abundance of each isotope is proportional to the current generated by that isotope at the detector.

Explain how this current is generated.

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**(2)**

(f)     **X** and **Zn** are different elements.

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Explain why the chemical properties of 70**X** and 70**Zn** are different.

**(1)**

**(Total 11 marks)**

**M1.**          (a)     Ability (or power) of an atom to attract electron density  
(or electrons or ‑ve charge) **(1)**in a covalent bond **(1)**

*or shared pair  
If remove an electron lose first mark*

**2**

(b)     *Trend:* increases **(1)***Explanation:* nuclear charge (number of protons) increases **(1)**electrons in same shell **(1)**

*OR similar shielding  
OR atoms similar size or smaller  
OR 1 mol of e-*

**3**

(c)     Heat / enthalpy / energy for removal of one electron **(1)**from a gaseous atom **(1)**can score in an equation

*must have first mark to score the second*

**2**

(d)     (i)      2 **(1)**

(ii)     Two elements (or Na / Mg) before the drop (in energy) to Al **(1)**

(iii)     ionisation energy of Al < that for Mg **(1)**

(iv)    fall in energy from P to S **(1)**

*or discontinuity in trend*

From Al to P there are 3 additional electrons **(1)**

*or three elements*

*For second mark idea of block of 3 elements*

**5**

**[12]**

**M2.**          (a)     number of protons in one atom or nucleus **(1)**

*Allow protons & electrons*

*do not allow protons + electrons or electrons*

**1**

(b)     **(1)** Na **(1)**

*OR Na or Na (1) + unambiguous statement of mass no. and atomic no.*

**2**

(c)     1s2 2s2 2p6 3s2 3p1 **(1)**

*Allow Ne 3s2 3p1*

**1**

(d)     14 **(1)**

**1**

(e)     **(1)** × 12 **(1)**

*Reference to mass number not mass C.E. = 0  
OR stated in moles*

*OR compared with 1/12 of a 12C atom or relative  
to 12C when taken as 12*

**2**

(f)      (i)      electron gun **(1)**

(ii)     (particles must be charged) (ions) before attraction to  
a charged plate (or electric field) **(1)**

(or only ions can be attracted or accelerated by an  
electric field)

*or converse; if not charged not attracted to electric field*

(iii)     magnetic field (or magnet) **(1)**

(iv)    magnetic field **(1)** or (accelerating potential or strength of magnet)

*allow magnet*

**4**

(g)     (i)       **(1)**

(1) mark for any m/z × relative abundance

*If numerator is correct but 100 has A.E. conseq A.E. -1*

*If A.E. on 100 allow conseq correct answer provided numerator is correct*

= 24.5 **(1)**

*Allow 24.5 to 24.52*

*ignore units*

(ii)     magnesium **(1)** (or Mg) (allow conseq on wrong Ar)

(iii)     abundance of isotopes is different **(1) (or different isotopes)**

**5**

**[16]**

**M3.**         (a)     Proton: mass 1, charge + 1 **(1)**Neutron: mass 1, charge 0 **(1)**Electron mass 1/1840, charge -1 **(1)**

*Allow mass = 0, or negligible, or 1/1800 to 1/2000*

          Isotopes have the same number of protons **(1)**

*OR atomic number*

          different number of neutrons **(1)**

          Isotopes have the same electronic configuration **(1)**

*OR same number of electrons*

          Chemical properties depend on electrons **(1)**

**7**

(b)      ×12 **(1)**

*OR  × 12 or in words*

          Spectrum gives (relative) abundance **(1)**

*OR % or amount*

And *m/z* **(1)**Multiply *m/z* by relative abundance for each isotope **(1)**

*Allow instead of m/z mass no, Ar or actual value from example*

Sum these values **(1)**Divide by the sum of the relative abundances **(1)**

*only award this mark if previous 2 given*

*Max 2 if e.g. has only 2 isotopes*

**7**

**[14]**

**M4.**          (a)     Ionisation **(1)**High speed **or** high energy electrons **or** electron gun **(1)**

*NOT bombard  
NOT beam or stream of electrons*

          Knocks out (outer) electron **(1)**

          Forming positive ion ‑ could be from Ti → Ti+ + e– **(1)**

*Accept + ion later in question to clarify charge of ion  
Ti + e– → Ti+ + 2 e– worth 2 marks  
Ignore state symbols*

          Acceleration **(1)**

          By electric field **or** attraction to negative plate **or** electrostatic attraction **(1)**

*NOT repelled by + plate  
Allow passed through positive & negative plates / oppositely  
charged plates  
Not just charged plates*

          Deflection **(1)**

          By magnetic field or magnet **or** electromagnet **(1)**

          Detection **(1)**

          Idea that ions collected at detector and generate current **(1)**

          Both ions have the same m / z value (of 24) **or** valid arguments  
in terms of the doubled charge on 48Ti2+ exactly counteracting its  
doubled mass **(1)**

          Deflected equally (so detected together) **or** deflection dependent  
on m / z value **(1)**

*Can’t get this from previous section*

**10**

(b)     Differ in mass number **or** number of neutrons **(1)**Same proton / atomic number **(1)**

*Ignore reference to electrons here*

          Isotopes have the same chemical properties **(1)**

because all have the same electron configuration **or** number of electrons  
**or** same number of valence electrons (so no chemical difference) **(1)**

*This mark is tied to the above mark or near miss [similar etc] in M3*

**4**

(c)     Mean mass of an atom or (isotope) **(1)** [NOT mass of average atom]

          Relative to 1/12 mass of 12C atom atc. **Or** to 12C taken as 12.000 or  
exactly 12 **(1)**

*Isotope can be accepted*

*OR  (1) × 12 (1)*

*OR  (1) × 12 (1)*

*A*r = (46 × .0802) + (47 × .0731) + (48 × .7381) + (49 × .0554)

+ (50 × .0532) **(1)**

= 47.93 answer to 2 d.p **(1)**

*47.92 is acceptable  
Must be 5 sets of values  
Ignore transcription errors BUT DON’T ignore missing 100 C.E.*

*If missing isotope C.E.*

**4**

**[18]**

**M5.**          (a)     Na(g) → Na+(g) + e–OR Na(g) + e– → Na+(g) + 2e–

*(‑) on electron not essential  
equation (1)  
state symbols (1)  
Ignore state symbols on electrons*

**2**

(b)     *Trend* : Increases **(1)**

*Explanation* : Increased nuclear charge or proton number **(1)**Stronger attraction (between nucleus and (outer) e–) **(1)**

*Trend wrong*

*Allow M2 only if M3 correct (con)*

**3**

(c)     *How values deviate from trend*: (both values) too low **(1)***Explanation for Al*: e– removed from (3) p **(1)**e– or orbital is higher in energy or better  
                               shielded than (3)**s  
                             or** p electron is shielded by 3s electrons **(1)**

*Allow e– is further away*

Mark independently

*Explanation for S*: e– removed from (3)p electron pair **(1)**                   repulsion between paired e– (reduces energy required) **(1)**

*Mark separately  
If deviation wrong allow M2 and M4  
If M3 and / or M5 right (con)  
If used ‘d’ rather than ‘p’ orbital - lose M2 + M4 but may get M3, M5 (explanation marks)*

**5**

**[10]**

**M6.**         (a)

|  |  |  |  |
| --- | --- | --- | --- |
| Particle | Relative charge | Relative mass |  |
| Proton | +1 **or** 1+ | 1 | **(1)** |
| Neutron | 0 **or** no charge/neutral/zero | 1 (not – 1) | **(1)** |
| Electron | –1 or 1– | 1/1800 to 1/2000 | **(1)** |

**or** negligible  
**or** zero  
**or** 5.0 × 10– 4 to 5.6 × 10– 4

*if ‘g’ in mass column - wrong  
penalise once*

**3**

(b)      **(1)(1)**

*Allow numbers before or after Ar*

**2**

(c)     *S*: 1s2 2s2 2p6 3s2 3p4 **(1)**

*Allow upper case letters*

*S2–:* 1s2 2s2 2p6 3s2 3p6 **(1)**

*If use subscript penalise once*

**2**

(d)     *Block*: p **(1)***Explanation*: Highest energy or outer orbital is (3) p

*OR outer electron, valency electron in (3) p  
NOT 2p etc.*

**2**

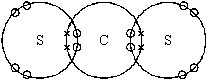
(e)     (i)      *Bonding in Na2S*: ionic **(1)***Bonding in CS2*:  covalent **(1)**

*ignore other words such as dative / polar / co-ordinate*

(ii)     Clear indication of electron transfer from Na to S **(1)**1 e– from each (of 2) Na atoms or 2 e– from 2 Na atoms **(1)**

*QoL correct English*

(iii)



Correct covalent bonds **(1)**All correct including lone pairs **(1)**

*Allow all •s or all ×s*

*M2 tied to M1*

*NOT separate e–s in S•- 2 l p*

(iv)    CS2 + 2H2O → CO2 + 2H2S **(1)**

*Ignore state symbols even if wrong*

**7**

**[16]**

**M7.**          (a)     Relative charge –1 **(1)**

          Relative mass  1/1800 or  5.55 × 10–4 **(1)**

*Accept zero / negligible*

**2**

(b)     (i)      Protons = 24 **(1)**

(ii)     Neutrons = 28 **(1)**

(iii)     Need (relative) abundance or peak height or intensity  
/ amount / number / % / fraction of each element **(1)**

*Not: ‘ratio of each isotope’*

**3**

(c)     (i)      *Reason 1:* To allow particles to be accelerated / deflected /  
detected **or** to count

*Reason 2:* Charged particles **or** to generate a current in the detector  
*Any 2* **(2)**

*Not: ‘to allow m/z to be measured’*

(ii)     Magnetic field or electric field or electromagnet **(1)**

(iii)     Deflection depends on mass or m/z **(1)**

**4**

(d)     (i)      (simplest) ratio of atoms of each element in compound **(1)**

(ii)     % oxygen = 39.5% **(1)**

         Na 28.4/23             Cr 32.1/52                O 39.5/16 **(1)**= 1.23                     = 0.617                     = 2.47  
(2:1:4) so empirical formula = Na2CrO4 **(1)**

*If % oxygen not calculated, only M2 available; if Ar values wrong, only M1 available*

**4**

**[13]**

**M8.**          (a)     (i)      *1s2* 2s2 2p6 3s2 3p1 **(1)**

*Allow subscripted electron numbers*

(ii)     p (block) **(1)**

*Allow upper or lower case ‘s’ and ‘p’ in (a)(i) and (a)(ii)*

**2**

(b)     Lattice of metal / +ve ions/ cations / atoms **(1)**

*Not +ve nuclei/centres*

*Accept regular array/close packed/tightly packed/uniformly arranged*

          (Surrounded by) delocalised electrons **(1)**

*Note: Description as a ‘giant ionic lattice’ = CE*

**2**

(c)     Greater nuclear or ionic charge or more protons **(1)**

          Smaller atoms / ions **(1)**

*Accept greater charge density for either M1 or M2*

          More delocalised electrons / e– in sea of e– / free e– **(1)**

          Stronger attraction between ions and delocalised / free electrons etc. **(1)**

*Max 3*

*Note: ‘intermolecular attraction/ forces’ or covalent molecules = CE*

*Accept stronger ‘electrostatic attraction’ if phrase prescribed elsewhere  
Ignore references to m/z values  
If Mg or Na compared to Al, rather than to each other, then:* ***Max 2****Treat description that is effectively one for Ionisation Energy as a ‘****contradiction****’*

**3**

(d)     (Delocalised) electrons **(1)**

          Move / flow in a given direction (idea of moving non-randomly)  
**or** under the influence applied pd   *QoL mark*   **(1)**

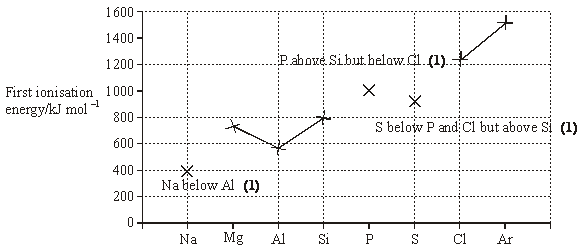
*Allow ‘flow through metal’*

*Not: ‘Carry the charge’; ‘along the layers’; ‘move through the metal’*

**2**

**[9]**

**M9.**          (a)



**1**

(b)     Increased nuclear charge / proton number **(1)**

*NOT increased atomic number*

Electrons enter same shell / energy level OR atoms get smaller  
OR same shielding **(1)**

          Stronger attraction between nucleus and (outer) electrons **(1)**

*Q of L*

**3**

(c)     *Explanation for aluminium*: (third) electron in (3)p sub-shell **(1)**Sub-shell further away from nucleus OR of higher energy **(1)**OR extra shielding from (3)s

*Explanation for sulphur*: Pair of electrons in (3)p orbital **(1)**Repulsion between electrons **(1)**

*tied to reference to e– pair in M3*

*Penalise ‘2p’ once only*

**4**

**[10]**

**M10.**          (a)     High speed electrons OR electrons from an electron gun **(1)**

Knocks out an (outer-shell) electron (on the chromium atom) **(1)**

*Accept Cr(g) + e– → Cr+(g) + 2e–*

*NOT e– gun alone / beam of e– / bombardment with e–*

**2**

(b)     Electric field OR (attraction to) -ve plate OR electrostatic attraction **(1)**OR (repelled by) +ve plate OR charged plate

*NOT high p.d. / electromagnetic field / electric plates*

**1**

(c)     Magnet OR magnetic field OR electromagnet**(1)**

**1**

(d)     *A*r = (50 × 0.043) + (52 × 0.838) + (53 × 0.095) + (54 × 0.024) **(1)**

52.06 OR 52.05 **(1)**

*Mark consequentially on transcription, or addition of %, error*

**2**

**[6]**

**M11.**          (a)     (i)      Atoms with the same number of protons / proton number **(1)**

*NOT same atomic number*

with different numbers of neutrons **(1)**

***NOT*** *different mass number / fewer neutrons*

(ii)     Chemical properties depend on the number or amount of  
(outer) electrons **(1)** OR, isotopes have the same electron  
configuration / same number of e–

(iii)     23/6.023 × 1023 **(1)**

*CE = 0 if inverted or multiplied*

         tied to M1 3.8(2) × 10–23      [2-5 sig figs] **(1)**

**5**

(b)     1s2 2s2 2p6 3s1 **(1)**

*accept subscripted figures*

**1**

(c)     Highest energy e– / outer e–s / last e– in (3)d sub-shell **(1)**

*OR d sub-shell being filled / is incomplete  
OR highest energy sub-shell is (3)d  
NOT transition element / e– configuration ends at 3d*

*Q of L*

**1**

(d)                      N correct symbol **(1)**

*allow *

Mass number = 15 AND atomic number = 7 **(1)**

**2**

**[9]**

**M12.**          (a)     **4**LiH + AlCl3 → LiAlH4 + **3**LiCl

**1**

(b)     H – = 1s2 **or** 1s2

**1**

(c)     Tetrahedral    or diagram

*(Not distorted tetrahedral)*

**1**

(Equal) repulsion

**1**

between four bonding pairs / bonds

*(Not repulsion between H atoms loses M2 and M3)*

*(Not ‘separate as far as possible’)*

*(‘4’ may be inferred from a correct diagram)*

**1**

(d)     Dative (covalent) or coordinate

**1**

Lone pair **or** non-bonding pair of electron **or** both e–

**1**

**QoL**  Donated from H– to Al **or** shared between H and Al

*(tied to M2)*

*(Not ‘from H atom’) (Not ‘to Al ion’) (Not ‘e–s transferred’)*

**1**

**[8]**

**M13.**          (a)     Enthalpy change/required when an electron is removed/knocked  
out/displaced (Ignore ‘minimum’ energy)

**1**

          From a gaseous atom

*(could get this mark from equation)*

**1**

(b)     Mg+(g) → Mg2+(g) + e–                       Equation

**1**

**Or** Mg+(g) + e– → Mg2+(g) + 2e–      State symbols (*Tied to M1*)

**1**

(c)     Increased/stronger nuclear charge **or** more protons

**1**

Smaller atom **or** electrons enter the same shell **or**same/similar shielding

**1**

(d)     Electron removed from a shell of lower energy **or** smaller  
atom **or** e– nearer

**1**

nucleus **or** e– removed from 2p rather than from 3s  
Less shielding

*(Do not accept ‘e– from inner shell’)*

**1**

**[8]**

**M14.**         (a)     Proton        mass = 1                                             charge = +1  
Electron     mass  1/1800 Or  5.6 × 10–4            charge = –1

*(Do not accept +1 for proton mass or ‘g’ units)*

**2**

(b)     (i)      13

**1**

(ii)     Si

**1**

Mass number = 28 **and** atomic number = 14

*(Do not accept 28.1 or 28.0 or ‘Silicon’)*

**5**

(c)     Mean (average) mass of an atom / all the isotopes  
1/12th mass of atom of 12C   
OrMass of 1 mole of atoms of an element**(1)**       1/12th mass of 1 mole of 12C**(1)**OrAverage mass of an atom / all the isotopes**(1)**       relative to the mass of a 12C atom taken as exactly 12 / 12.000**(1)**

*(Penalise ‘weight’ once only) (Ignore ‘average’ mass of 12C)*

*(Do not allow ‘mass of average atom’)*

**2**

(d)     Ar = (24 × 0.735) + (25 × 0.101) + (26 × 0.164) 1 = 24.4 1

*(mark M2 conseq on transcription error or incorrect addition of %)*

(e)     Mr = highest m/z value 1

*(NOT ‘highest/largest/right-hand’ peak)*

**3**

**[10]**

**M15.**          (a)     (i)      p + n / number of nucleons

*(accept protons and neutrons)*

*(Incorrect reference to electrons = contradiction)*

**1**

(ii)     Mean /average mass of a molecule/entity/formula

**1**

1/12th mass of atom of 12C

*[Not 1/12th mass of molecule of 12C]*

*(mark independently)*

**1**

**OR**    Mass of 1 mole of molecules/entities (1)  
1/12thmass of 1 mole of 12C (1)

**OR**    Average mass of a molecule/entity (1)  
Relative to the mass of a 12C atom taken as 12 / 12.000 (1)

*(Mean/average = stated or explained)*

*(mass = stated or explained)*

*(Penalise ‘weight’ once only)*

*(Ignore ‘average ‘ mass of 12C)*

*(Do not allow ‘mass of average molecule)*

(b)     (i)      2s22p63s23p64s13d10

*(accept 3d 94s2)*

*(accept subscripts or caps)*

*[Penalise missing shell numbers]*

**1**

(ii)     d / D [NOT 3d/ ‘transition element]

**1**

(iii)     36 [NOT 36.0]

**1**

(c)     (i)      More 63Cu atoms than 65Cu atoms

*(idea of more abundant 63Cu isotope - NOT just reference to peak heights)*

**1**

(ii)     Electron from electron gun / high speed electron / high  
energy electron

*(accept electron gun fired at)  
[NOT ‘bombarded with electrons]*

**1**

knock electron off (Cu atom) / idea of loss of e- / appropriate  
equation

*(Mark independently)*

**1**

(iii)     63Cu2+or equivalent [NOT 63.0 - penalise this error once only]

**1**

*m/z* = 63/2 (=31.5) or equivalent

**1**

More energy needed to remove second electron **OR**63Cu2+ statistically less likely to remove second electron  
(Idea that not many 63Cu2+ ions formed **OR** explains why few are  
formed e.g. more energy needed)

*If ‘63Cu’ not given, can only award M2 & M3*

**1**

Notes on [If 65 used, lose M1 **and** M2]

(c)     (iii)     [If mass number missing from identity but appears in explanation,   
penalise Ml but allow M2 if earned]

**[12]**

**M16.**          (a)     (i)      (atoms with the) same number of protons / same atomic number /  
atoms of the same element;

**1**

*(molecules = contradiction)*But different number of neutrons / different mass number;  
*(not different atomic mass or A*r*)*

**1**

(ii)     detected by: +ve ions collide with / are directed or deflected to /  
are collected at the detector;

**1**

causing current to flow / detected electrically /  
idea of electricity or voltage generated;

**1**

*(not ‘charge produced’ or ‘detected electronically’)*abundance measured: idea that current depends on  
abundance/number of ions hitting detector;

**1**

(b)     (i)      mean /average mass of an atom / all the isotopes;  
1/12th mass of atom of 12C ;

*(mark independently)*

OR

mass of 1 mole of atoms (of an element);  
1/12thmass of 1 mole of 12C;

OR

average mass of a molecule/entity;  
relative to the mass of a 12C atom taken as 12 / 12.000;

**2**

*(penalise ‘weight’ once only)  
(ignore ‘average’ mass of 12C)  
(do not allow ‘mass of average atom )*

(ii)     ;

**1**

= 55.9;

**1**

(c)     (i)      1s2 2s22p63s23p6;

*(accept subscripts or caps; ignore 4s°) (penalise missing shell numbers)*

**1**

(ii)     highest energy level / last sub-shell to be filled / is (3)d;

OR

outermost electrons in the d sub-shell/orbital;

*(not incomplete d sub-shell)  
(not valance electron in d sub-shell)*

**1**

(iii)     no difference;  
same e– arrangement / same number of e– / same valence e–.

**2**

OR

same chemical properties;

OR

chemical properties determined by electrons;

*(M2 tied to correct answer for M1)*

**1**

**[13]**

**M17.**          (a)     **Mean (average) mass of an atom / all the isotopes or**

**1**

**1/12th mass of atom of 12C**

**1**

Mass of 1mole of atoms of an element or  
1/12th mass of 1mole of 12C

average mass of an atom / all the isotopes  
**relative to the mass of a 12C atom taken as exactly 12 / 12.000**

*(penalise ‘weight’ once only)*

*(ignore ‘average’ mass of 12C)*

*(not ‘mass of average atom’)*

(b)     A r = (64 × 0.389) + (66 × 0.278) + (67 × 0.147) + (68 × 0.186)

**1**

 = 65.7

*(mark M2 conseq on transcription error or incorrect addition of %)*

**1**

identity: zinc / Zn

*(Conseq on Ar but only if their Ar is within range of Periodic Table)*

**1**

(c)     electron gun (fires) electrons or high speed/energy electrons

*(not just ‘bombarded by electrons’ or ‘bombarded by electron gun’)*

**1**

knocks off e– from **Q**

*(may be earned from a real or generic equation)*

**1**

Reasons: to allow ions to be: accelerated (by an electric field)

**1**

deflected (by a magnet/magnetic field)

**1**

detected / description of current formed at the detector/sensor

*(accept in any order)*

*(allow clear descriptions of ‘accelerated’,  
‘deflected’, ‘detected’)*

**1**

**[10]**

**M18.**          (a)     enthalpy/energy change/required when an electron is removed/  
knocked out / displaced/ to form a uni-positive ion

*(ignore ‘minimum’ energy)*

**1**

from a gaseous atom

*(could get M2 from a correct equation here)  
(accept ‘Enthalpy/energy change for the process...’  
followed by an appropriate equation, for both marks)  
(accept molar definitions)*

**1**

(b)     *1s2* 2s22p6

*(accept capitals and subscripts)*

**1**

(c)     ‘s’ block

*(not a specific ‘s’ orbital – e.g. 2s)*

**1**

(d)     Mg+(g) → Mg2+(g) + e– or

Mg+(g) + e– → Mg2+(g) + 2e– or

Mg+(g) – e– → Mg2+(g)

**1**

(e)     Mg2+ ion smaller than Ne atom / Mg2+ e– closer to nucleus

*(Not ‘atomic’ radius fo Mg2+)*

**1**

Mg2+ has more protons than Ne / higher nuclear charge or   
e– is removed from a charged Mg2+ion / neutral neon atom

*(accept converse arguments)*

*(If used ‘It’ or Mg/magnesium/Mg3+ etc. & 2 correct reasons, allow* ***(1)****)*

**1**

(f)      (i)      trend: increases

*(if ‘decreases’, CE = 0/3)*

**1**

Expln: more protons / increased proton number /  
increased nuclear charge

*(NOT increased atomic number)*

**1**

same shell / same shielding / smaller size

**1**

(ii)     QoL reference to the e– pair in the 3p sub-level

*(penalise if wrong shell, e.g. ‘2p’, quoted)*

**1**

repulsion between the e–in this e–pair

*(if not stated, ‘e– pair’ must be clearly implied)*

*(mark M4 and M5 separately)*

**1**

**[12]**

**M19.**          *(penalty for sig fig error =1 mark per question)*

(a)     neutron:          relative mass = 1          relative charge = 0

*(not ‘neutral’)*

**1**

electron:          relative mass = 1/1800 → 0/negligible *or*

5.56 × 10–4 → 0 relative charge = –1

**1**

(b)     17O/O17 mass number               (*Do not accept 17.0*)

**1**

          oxygen symbol ‘O’

*(if ‘oxygen’ + — ‘mass number = 17’(1))*

*(if ‘oxygen’+ — ‘mass number = 17’(0))*

*(if at N 0 given but ≠ 8, treat as ‘con’ for M2)*

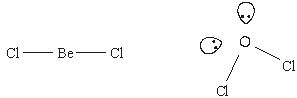
*(if lp on Be, diagram = 0)*

*(ignore bond angles)*

*(not dot and cross diagrams)*

**1**

(c)



**2**

          QoL Linear **(1)**                        bent / V-shaped / angular **(1)**

*(mark name and shape independently)*

*(accept (distorted) tetrahedral)*

*(if balls instead of symbols, lose M1 – can award M2)*

*(penalise missing ‘Cl’ once only)*

*(not ‘non-linear’)*

**2**

(d)     *M*r (Mg(NO3)2 = 58(.3) *(if At N 0 used, lose M1 and M2)*

**1**

          moles Mg(OH)2 = 0.0172 (conseq on wrong M2) (answer to 3+ s.f.)

**1**

          moles HCl = 2 × 0.0172 = 0.0344 *or* 0.0343 (mol) *(process mark)*

**1**

          vol HCl = = 34.3 – 34.5 (cm3) *(unless wrong unit)*

*(if candidate* ***used*** *0.017 or 0.0171 lose M2)*

*(just answer with no working, if in range = (4).  
if, say, 34 then =(2))*

*(if not 2:1 ratio, lose M3 and M4)*

*(if work on HCl, CE = 0/4)*

**1**

**[12]**

**M20.**          (a)     Atoms/isotopes/particles/species with the same (number of) protons  
and different (number of) neutrons

*[Not atomic number/mass number/molecules/same element/diff electrons]*

**1**

(b)                                                                      Mass number

**1**

17 & Cl

**1**

*[Not 37.0] [Mark independently] [ignore charges]*

(c)     (i)      2s22p63s23p63d104s24p2

*[allow reversed 4s2 3d10]  
[allow capitals/subscripts]*

**1**

(ii)     Ar = 

*[Wrong approach or not dividing by 100 = CE = 0]*

**1**

         = 72.4

*[Answer to 1 d.p.] [Mark conseq on transcription error]*

**1**

(iii)     Magnet/electromagnet/magnetic field / electric field/charge on   
negative/accelerator plate

**1**

Correct link between deflection and *m/z*

**1**

Correct link between deflection and field

*[Penalise ‘reflected’/’diffracted’ once only]*

*[Ignore references to molecules/atoms/particles]*

*[Consolation mark: allow correct link between mass and deflection for 1 mark out of the 2]*

**1**

(iv)    Geonly

**1**

*Same m/z as 36S+*

*[Mark independently]*

**1**

**[11]**

**M21.**          (a)     Number of protons in the nucleus

**1**

(b)     They may have different numbers of neutrons

**1**

(c)     (i)      Mass spectrometer

**1**

(ii)      × 12

**2**

(iii)     *A*r = 

**1**

= (82 × 12 + 83 × 12 + 84 × 50 + 86 × 26)/100 = 84.16

**1**

(d)     1s2 2s2 2p6 3s2 3p6 4s2 3d10 4p6

**1**

(e)     Krypton was thought to be an inert gas  
(or has 8 electrons in outer shell)

**1**

(f)      (i)      Krypton has more protons than bromine

**1**

But its outer electrons are in the same shell  
(or have similar shielding)

**1**

(ii)     Al electron is in a 3p orbital, magnesium in 3s

**1**

         Energy of 3p is greater than 3s

**1**

**[13]**

**M22.**          (a)

|  |  |  |  |
| --- | --- | --- | --- |
| Particle | Relative Charge | Relative mass |  |
| Proton | +1 | 1 | **1** |
| Neutron | 0 | 1 | **1** |

*Need +1 for proton*

(b)     d block/ D block;

*Or D or d*

**1**

(c)     (i)      74;

*Not 74.0*

**1**

(ii)     112;

*Not 112.0*

**1**

(d)     (i)      To accelerate/ make go faster;

**1**

         To deflect/ to bend the beam;

*Any order  
Not just attract to negative plate*

**1**

(ii)     Electromagnet / magnet / electric field /accelerating potential or  
voltage;

*Not electric current  
Not electronic field*

**1**

(e)     None/ nothing;

*If blank mark on.  
If incorrect CE = 0*

**1**

Same number of electrons (in outer orbital/shell)/ both have 74  
electrons/same electron configuration;

*Not just electrons determine chemical properties  
Ignore protons and neutrons unless wrong statement.*

**1**

(f)      ;

*If transcription error then  
M1 = AE = –1 and mark  
M2 consequentially*

**1**

= 183.90; allow range from 183.90 – 184.00;

**1**

**[12]**

**M23.**          (a)     (i)      Average/mean mass of 1 atom (of an element);

*Average mass of 1 atom × 12.*

**1**

         Mass 1/12 atom of 12C;

*Mass 1 atom of 12C.  
QWC.*

**1**

(ii)     Other isotope = 46.0%;

**1**

         107.9 = ;

*M2 whole expression.*

**1**

         108.8;

*Answer 108.8 (3 marks).  
Answer min 1 d.p..*

**1**

Same electronic configuration/ same number of electrons (in  
outer shell)/ both have 47 electrons;

*Ignore protons and neutrons unless incorrect.  
Not just electrons determine chemical properties.*

**1**

(b)     Ionisation;

**1**

          high energy electrons fired at sample;

*Allow electron gun /blasted with electrons.*

**1**

          Acceleration;

**1**

          With electric field/accelerating potential/potential difference;

*Allow by negative plate.*

**1**

          Deflection;

**1**

          With electromagnet/ magnet/ magnetic field;

*M2 dependent on M1.  
M4 dependent on M3.  
M6 dependent on M5.*

**1**

(c)     (Silver) metallic (bonding);

*Vdw/molecules CE=0.*

**1**

          Regular arrangement of same sized particles;

**1**

          + charge in each ion;

*Ignore multiple positive charges.  
Candidates do not need to show delocalised electrons.*

**1**

(d)     Ionic (bonds);

**1**

          Minimum 4 ions shown in 2D square arrangement placed Correctly;

*Do not allow multiple charges on ions.*

**1**

          Further 3 ions shown correctly in a cubic lattice;

**1**

          Strong (electrostatic) forces/bonds;

*If vdw/molecules/covalent mentioned CE = 0 for M4 and M5.*

**1**

          Between + and – ions;

*Accept between oppositely charged ions.*

**1**

**[20]**

**M24.**          (a)     2s2 2p6;

*If ignored the 1s2 given and written 1s22s22p6 mark as correct  
Allow capitals and subscripts*

**1**

(b)     (i)      Na+(g) → Na2+ (g) + e(–);

*One mark for equation and one mark for state symbols*

         Na+(g) + e(–) → Na2+ (g) + 2e(–);

*M2 dependent on M1  
Allow Na+(g) – e(–) → Na(g)  
Allow X+(g) → X2+ (g) + e = 1 mark*

**2**

(ii)     Na(2+) requires loss of e– from a 2(p) orbital or 2nd energy level or  
2nd shell and Mg(2+) requires loss of e– from a 3(s) orbital or 3rdenergy level or 3rd shell / Na(2+) loses e from a lower (energy)  
orbital/ or vice versa;

*Not from 3p*

**1**

         Less shielding (in Na);

*Or vice versa for Mg*

**1**

         e(–) closer to nucleus/ more attraction (of electron to nucleus) (in Na);

*M3 needs to be comparative*

**1**

(iii)     Aluminium /Al;

**1**

(c)     Decreases;

*If not decreases CE = 0  
If blank, mark on*

**1**

          Increasing nuclear charge/ increasing number of protons;

**1**

          Electrons in same shell or level/ same shielding/ similar shielding;

**1**

(d)     Answer refers to Na;

*Allow converse answers relating to Mg.*

          Na fewer protons/smaller nuclear charge/ fewer delocalised electrons;

*Allow Mg is 2+ and Na is +.  
If vdw CE = 0.*

**1**

          Na is a bigger ion/ atom;

**1**

          Smaller attraction between nucleus and delocalised electrons;

*If mentioned that charge density of Mg2+ is greater then allow first 2 marks.  
(ie charge / size / attraction).  
M3 allow weaker metallic bonding.*

**1**

(e)     (Bent) shape showing 2 lone pairs + 2N−H bond pairs;

*Atoms must be labelled.  
Lone pairs can be with or without lobes.*

**1**

          Bent / v shape/ triangular;

*Not tetrahedral.  
Allow non-linear.  
Bent-linear = contradiction.*

**1**

(f)      Ne has full sub-levels/ can’t get any more electrons in the sub-levels/  
Ne has full shells;

*Not 2s2 2p6 alone.  
Not stable electron configuration.*

**1**

**[16]**

**M25.**          (a)     Average/mean mass of (1) atom(s) (of an element)

**1**

1/12 mass of one atom of 12C

*Accept answer in words  
Can have top line × 12 instead of bottom line ÷ 12*

**1**

***OR***

(Average) mass of one mole of atoms  
1/12 mass of one mole of 12C

***OR***

(Weighted) average mass of all the isotopes  
1/12 mass of one atom of 12C

***OR***

Average mass of an atom/isotope compared to C-12  
on a scale in which an atom of C-12 has a mass of 12



*Allow 95.12 + 4.88 instead of 100*

**1**

= 14.05

*If not to 2 d.p. then lose last mark  
Not 14.04*

**1**

(b)     15N is heavier/15N has a bigger m/z/different m/z values

*Not different no’s of neutrons  
Not ionisation potential*

**1**

Electromagnet/electric field/magnet/accelerating  
potential or voltage/electric current

**1**

(c)     No difference

**1**

Same no of electrons (in outer orbital/shell/sub shell)/same  
electron configuration

*M2 dependent on M1  
Not just electrons determine chemical properties  
Ignore protons*

**1**

**[8]**

**M26.**          Mass number = number of protons + neutrons (in the nucleus/atom)

*Not in a substance or compound or element*

**1**

7 protons and 7 electrons

**1**

8 neutrons

**1**

**[3]**

**M27.**          (a)     4d10 5s2 5p1 in any order

*Allow subscripts for numbers*

*Allow capitals*

**1**

(b)     (i)      Using an electron gun/(beam of) high energy/fast  
moving electrons

*Ignore ‘knocks out an electron’*

**1**

(ii)     In(g) + e– → In+(g) + 2e–

***OR***

In(g) → In+(g) + e–

In(g) – e– → In+(g)

*The state symbols need not be present for the electron - but if they are they must be (g)*

*No need to show charge on electron*

*If I CE = 0*

*Ignore any equations using M*

**1**

(iii)     So no more than 1 electron is knocked out/so only one electron  
is knocked out/prevent further ionisation

*Allow stop 2+ and 3+/other ions being formed*

*Not to get wrong m/z*

**1**

(iv)    Any two processes from

•        Accelerate (owtte)

•        Deflect (owtte)

•        Detect (owtte)

*Ignore wrong causes of process*

**2 max**

(c)     (i)      Average/mean mass of (1) atom(s) (of an element)

**1**

1/12 mass of one atom of 12C

**1**

***OR***

(Average) mass of one mole of atoms

1/12 mass of one mole of 12C

***OR***

(Weighted) average mass of all the isotopes

1/12 mass of one atom of 12C

***OR***

Average mass of an atom/isotope compared to C-12 on a  
scale in which an atom of C-12 has a mass of 12

*Not average mass of 1 molecule*

*Allow the wording Average mass of 1 atom of an element compared to 1/12 mass atom of 12C (or mass 1/12 atom of 12C)*

*Allow if moles of atoms on both lines*

*Accept answer in words*

*Can have top line × 12 instead of bottom line ÷12*

*If atoms/moles mixed, max = 1*

(ii)     

*Allow idea that there are 4 × 0.5 divisions between 113 and 115*

**1**

ratio (113:115) = 1:3 **OR** 25:75 **OR** 0.5:1.5 etc

*Correct answer scores M1 and M2*

*If 1:3 for In(115):In(113), max = 1*

**1**

(d)     None

**1**

Same no of electrons (in the outer shell)/same electron configuration)

*Ignore electrons determine chemical properties/ignore protons*

*M2 dependent on M1 being correct*

**1**

(e)     29.0%/29% O

*If no O calculated, allow M2 if In and H divided by the correct Ar*

**1**

****

**1**

or

0.603      1.8      1.81

   1            3          3

EF = In H3O3

*Allow In(OH)3*

*Do not allow last mark just for ratio 1:3:3*

*If InO3H3 given with no working then allow 3 marks*

*If I not In, lose M3*

**1**

**[15]**

**M28.**          (a)     Li(g) → Li+(g) + e-(g)

Li(g) - e-(g) → Li+(g)

Li(g) + e-(g) → Li+(g) + 2e-

*One mark for balanced equation with state symbols*

*Charge and state on electron need not be shown*

**1**

(b)     Increases

*If trend wrong then CE = 0/3 for (b). If blank mark on.*

**1**

Increasing nuclear charge / increasing no of protons

*Ignore effective with regard to nuclear charge*

**1**

Same or similar shielding / same no of shells / electron  
(taken) from same (sub)shell / electron closer to the  
nucleus / smaller atomic radius

**1**

(c)     Lower

*If not lower then CE = 0/3*

**1**

Paired electrons in a (4) p orbital

*If incorrect p orbital then M2 = 0*

**1**

(Paired electrons) repel

*If shared pair of electrons M2 + M3 = 0*

**1**

(d)     Kr is a bigger atom / has more shells / more shielding  
in Kr / electron removed further from nucleus/ electron  
removed from a higher (principal or main) energy level

*CE if molecule mentioned*

*Must be comparative answer*

*QWC*

**1**

(e)     2 / two / II

**1**

(f)      Arsenic / As

**1**

**[10]**

**M29.**          (a)     (i)      Metallic

*Allow body centred cubic*

**1**

(ii)



*One mark for regular arrangement of particles. Can have a space between them*

*Do not allow hexagonal arrangement*

**1**

OR



Na+ Na+ Na+

Na+ Na+ Na+

*One mark for + in each*

*Ignore electrons*

*If it looks like ionic bonding then CE = 0/2*

**1**

(b)     (i)      Ionic

*CE = 0 for (b)(i) and (b)(ii) if not ionic*

**1**

(ii)     Strong (electrostatic) attraction

*Any mention of IMF or molecules / metallic / covalent in (b)(ii) then CE 0/2*

**1**

Between oppositely charged ions / particles

*Or + and – ions*

**1**

(c)     Iodide / I– bigger (ion) (so less attraction to the Na+ ion)

*Need comparison*

*Do not allow iodine is a bigger atom*

*Ignore I- has one more c– shell*

*CE = 0 if IMF / covalent / metallic mentioned*

**1**

**[7]**

**M30.**(a)              

*M1 for the top line*

*M2 is for division by 17*

**1**

**1**

= 84.0

*Not 84*

*No consequential marking from M1 or M2*

*Ignore units*

**1**

The *A*r in the Periodic table takes account of the other isotopes /different amounts of isotopes (or words to that effect regarding isotopes)

*Award independently*

*Comparison implied*

*Isotope(s) alone, M4 = 0*

**1**

(b)     (Beam of electrons from) an electron gun / high speed / high energy electrons

**1**

Knocks out electron(s) (to form a positive ion)

**1**

Kr(g) + e– → Kr+(g) + 2e(–)

*State symbols must clearly be (g)*

**1**

***OR***

Kr(g) → Kr+(g) + e(–) / Kr(g) – e(–) → Kr+(g)

The 84Kr isotope

*One mark for identifying the 84 isotope*

**1**

Has 2 electrons knocked out / gets a 2+ charge

*One mark for the idea of losing 2 electrons (from this isotope)*

**1**

**[9]**

**M31.**(a)    N3- / N–3

**1**

(b)     F–/ fluoride

*Ignore fluorine/F*

*Penalise Fl*

**1**

(c)     Li3N / NLi3

**1**

(d)               

*M1 for correct fractions*

**1**

(=2.02       = 1.35)

1.5           1       or       3 : 2

*M2 for correct ratio*

**1**

Ca3N2

*If Ca3N2 shown and with no working award 3 marks*

*If Ca3N2 obtained by using atomic numbers then lose M1*

**1**

(e)     3 Si + 2 N2 → Si3N4

*Accept multiples*

**1**

**[7]**

**M32.**          (a)    37

*These answers only.*

*Allow answers in words.*

**1**

48

*Ignore any sum(s) shown to work out the answers.*

**1**

(b)     (i)     Electron gun / high speed/high energy electrons

*Not just electrons.*

*Not highly charged electrons.*

**1**

Knock out electron(s)

*Remove an electron.*

**1**

(ii)     Rb(g) → Rb+(g) + e(–)***OR***Rb(g) + e(–) → Rb+(g) + 2e(–)***OR***Rb(g) - e(–) → Rb+(g)

*Ignore state symbols for electron.*

**1**

(c)     Rb is a bigger (atom) / e further from nucleus / electron lost from a higher  
energy level/ More shielding in Rb / less attraction of nucleus in Rb for outer  
electron / more shells

*Answer should refer to Rb not Rb molecule*

*If converse stated it must be obvious it refers to Na*

*Answer should be comparative.*

**1**

(d)     (i)     s / block s / group s

*Only*

**1**

(ii)     1s2 2s2 2p6 3s2 3p6 4s2 3d10 4p6 5s1

*Allow 3d10 before 4s2*

*Allow in any order.*

**1**

(e)     (85 × 2.5) + 87 ×1            3.5

*M1 is for top line*

**1**

**1**

= 85.6

*Only*

**1**

***OR***

(58 × 5) + 87 ×2            7

*M185Rb 71.4% and 87Rb 28.6%*

*M2 divide by 100*

**1**

**1**

85.6

*M3 = 85.6*

**1**

(f)     Detector

*Mark independently*

*Allow detection (plate).*

**1**

Current / digital pulses / electrical signal related to abundance

*Not electrical charge.*

**1**

(g)     Smaller

*Chemical error if not smaller, CE = 0/3*

*If blank mark on.*

**1**

Bigger nuclear charge / more protons in Sr

*Not bigger nucleus.*

**1**

Similar/same shielding

*QWC*

*(Outer) electron entering same shell/sub shell/orbital/same number of shells.*

*Do not allow incorrect orbital.*

**1**

**[16]**

**M33.**(a)     (i)      Higher than P

**1**

(ii)     1s2 2s2 2p6 3s1

*Allow any order*

**1**

(iii)    Al+(g) + e (−)   Al2+(g) + 2e(−)

***OR***Al+(g)   Al2+(g) + e(−)

***OR***Al+(g) − e(−)   Al2+(g)

**1**

(iv)    Electron in Si (removed from) (3)p orbital / electron (removed) from higher energy orbital or sub-shell / electron in silicon is more shielded

*Accept converse arguments relating to Al  
Penalise incorrect p-orbital*

**1**

(b)     Sodium / Na

*Allow Na+*

**1**

Electron (removed) from the 2nd shell / 2p (orbital)

*M2 is dependent on M1  
Allow electron from shell nearer the nucleus (so more attraction)*

**1**

(c)     Silicon / Si

*Not SI*

**1**

(d)     Heat or energy needed to overcome the attraction between the (negative) electron and the (positive) nucleus or protons

*Not breaking bonds*

*QoL*

Or words to that effect eg electron promoted to higher energy level (infinity) so energy must be supplied

**1**

**[8]**

**M34.**(a)    (Total number of) protons and neutrons (in nucleus of atom)

*(number of) nucleons*

**1**

(b)     Zn

*Do not allow Zn−1 or Zn+1 or ZN  
Ignore numbers*

**1**

(c)    (i)      P = ionise (sample)

*Allow removing an electron / forms (+) ions*

**1**

Q = accelerate (sample)

*Allow speeds (ions) up  
Penalise molecules / atoms*

**1**

(ii)     m / z

*Allow mass / charge*

**1**

(relative) abundance / (relative) intensity

*QoL  
Allow M1 + M2 in any order*

**1**

(d)    (i)       

*M1 = topline*

**1**

*M2 = ÷ 4*

**1**

= 207.3

*Only  
207.3 = 3 marks*

**1**

(ii)     Lead / Pb

*Not PB*

**1**

(iii)    Same number of electrons (in outer shell) / same electronic configuration

*Ignore electrons determine chemical properties  
Ignore reference to p and n if correct  
Penalise if incorrect*

**1**

**[11]**

**M35.**(a)    Average / mean mass of 1 atom (of an element)  
1/12 mass of one atom of 12C

*If moles and atoms mixed, max = 1*

**1**

*Mark top and bottom line independently.  
All key terms must be present for each mark.*

**1**

***OR***

Average / mean mass of atoms of an element  
1/12 mass of one atom of 12C

***OR***

Average / mean mass of atoms of an element ×12  
mass of one atom of 12C

***OR***

(Average) mass of one mole of atoms  
1/12 mass of one mole of 12C

***OR***

(Weighted) average mass of all the isotopes  
1/12 mass of one atom of 12C

***OR***

Average mass of an atom / isotope (compared to C−12) on a scale in which an atom of C−12 has a mass of 12

*This expression = 2 marks.*

(b)      

**1**

**1**

= 72.4

*72.4 only*

**1**

(c)     (72)Ge+ or germanium+

*Must show ‘+’ sign.*

*Penalise wrong mass number*

**1**

(d)     70

*If M1 incorrect or blank CE = 0/2*

*Ignore symbols and charge even if wrong.*

**1**

Lowest mass / lowest m/z

*Accept lightest.*

*Accept fewest neutrons.*

**1**

(e)     Electron(s) transferred / flow (at the detector)

*M1 must refer to electron flow at the detector.*

*If M1 incorrect CE = 0/2*

**1**

(From detector / plate) to the (+) ion

*Do not allow from a charged plate.*

**1**

(f)     They do not have the same electron configuration / they have different number of electrons (in the outer shell)

*Ignore electrons determine the properties of an atom.*

*Ignore they are different elements or different number of protons.*

**1**

**[11]**