Atomic Structure

8 (a) 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 ^{15}N

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(3 marks)

(Extra space) .....

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8 (b) 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% ^{14}N and 4.88% ^{15}N

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 marks)

(Extra space) .....

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8 (c) In a mass spectrometer, under the same conditions, $^{14}N^+$ and $^{15}N^+$ 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 marks)

Question 8 continues on the next page

8 (d) Organic fertilisers contain a higher proportion of ^{15}N 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 marks)

11

END OF QUESTIONS

SECTION A

Answer **all** questions in the spaces provided.

1 Ionisation energies provide evidence for the arrangement of electrons in atoms.

1 (a) Complete the electron configuration of the Mg^+ ion.

$1s^2$ .....

(1 mark)

1 (b) (i) State the meaning of the term *first ionisation energy*.

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(2 marks)

1 (b) (ii) Write an equation, including state symbols, to show the reaction that occurs when the **second** ionisation energy of magnesium is measured.

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(1 mark)

1 (b) (iii) Explain why the second ionisation energy of magnesium is greater than the first ionisation energy of magnesium.

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(1 mark)

1 (b) (iv) Use your understanding of electron arrangement to complete the table by suggesting a value for the third ionisation energy of magnesium.

	First	Second	Third	Fourth	Fifth
Ionisation energies of magnesium / kJ mol^{-1}	736	1450		10 500	13 629

(1 mark)

SECTION B

Answer **all** questions in the spaces provided.

5 A mass spectrometer can be used to investigate the isotopes in an element.

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

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(2 marks)

(Extra space) .....

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5 (b) Element **X** has a relative atomic mass of 47.9

Identify the block in the Periodic Table to which element **X** belongs and give the electron configuration of an atom of element **X**.

Calculate the number of neutrons in the isotope of **X** which has a mass number 49

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(3 marks)

(Extra space) .....

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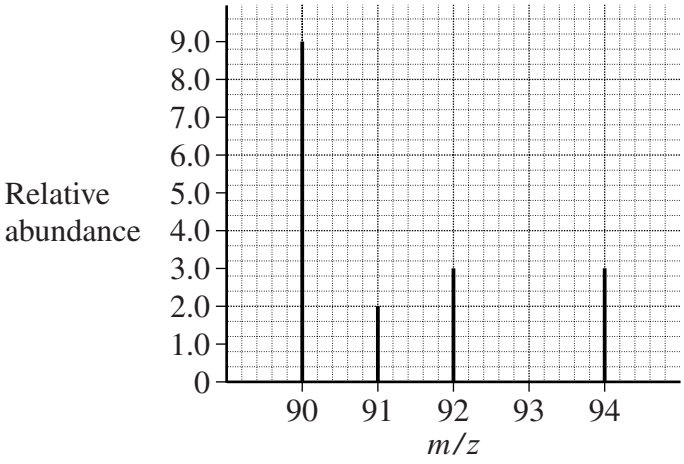
Question 5 continues on the next page

5 (c) The mass spectrum of element **Z** is shown below.

Use this spectrum to calculate the relative atomic mass of **Z**, giving your answer to one decimal place.

Identify element **Z**.



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(4 marks)

(Extra space) .....

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5 (d) State how vaporised atoms of **Z** are converted into $\mathbf{Z}^+$ ions in a mass spectrometer.

State and explain which of the $\mathbf{Z}^+$ ions formed from the isotopes of **Z** in part (c) will be deflected the most in a mass spectrometer.

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(4 marks)

(Extra space) .....

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5 (e) Explain briefly how the relative abundance of an ion is measured in a mass spectrometer.

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(2 marks)

(Extra space) .....

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15

Section A

Answer **all** questions in the spaces provided.

1 Mass spectrometry can be used to identify isotopes of elements.

1 (a) (i) In terms of fundamental particles, state the difference between isotopes of an element.

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(1 mark)

1 (a) (ii) State why isotopes of an element have the same chemical properties.

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(1 mark)

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

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(2 marks)

(Extra space).....

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1 (c) The mass spectrum of element **X** has four peaks. The table below gives the relative abundance of each isotope in a sample of element **X**.

m/*z*	64	66	67	68
Relative abundance	12	8	1	6

1 (c) (i) Calculate the relative atomic mass of element **X**.
Give your answer to one decimal place.

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(3 marks)

1 (c) (ii) Use the Periodic Table to identify the species responsible for the peak at *m*/*z* = 64

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(2 marks)

1 (d) Suggest **one** reason why particles with the same mass and velocity can be deflected by different amounts in the same magnetic field.

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(1 mark)

1 (e) Explain how the detector in a mass spectrometer enables the abundance of an isotope to be measured.

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(2 marks)

(Extra space) .....

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12

2 Indium is in Group 3 in the Periodic Table and exists as a mixture of the isotopes ^{113}In and ^{115}In.

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

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$ .....

(1 mark)

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

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

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(1 mark)

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

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(1 mark)

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

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(1 mark)

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

Reason 1 .....

Reason 2 .....

(2 marks)

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

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

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(2 marks)

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

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(2 marks)

(Extra space) .....

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

Difference in chemical properties.....

Explanation.....

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(2 marks)

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 marks)

15

Section A

Answer **all** questions in the spaces provided.

1 The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb

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

Number of protons .....

Number of neutrons .....

(2 marks)

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

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(2 marks)

1 (b) (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 mark)

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 mark)

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

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(1 mark)

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

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(1 mark)

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

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

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(3 marks)

1 (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 marks)

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

Atomic radius of ^{88}Sr compared to ^{87}Rb .....

Explanation .....

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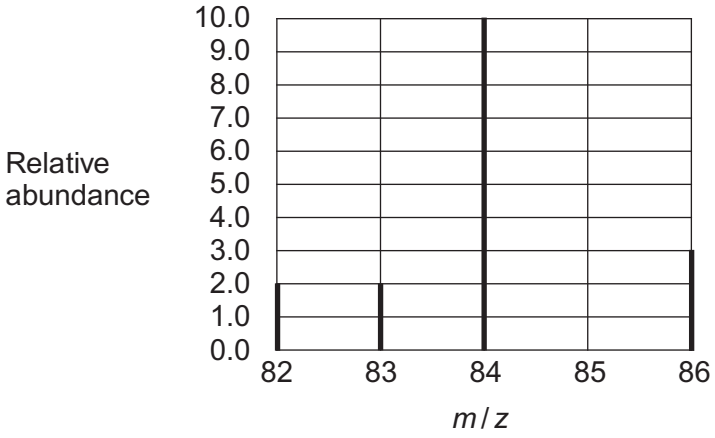
(3 marks)

16

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



7 (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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(4 marks)

(Extra space) .....

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7 (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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(5 marks)

(Extra space) .....

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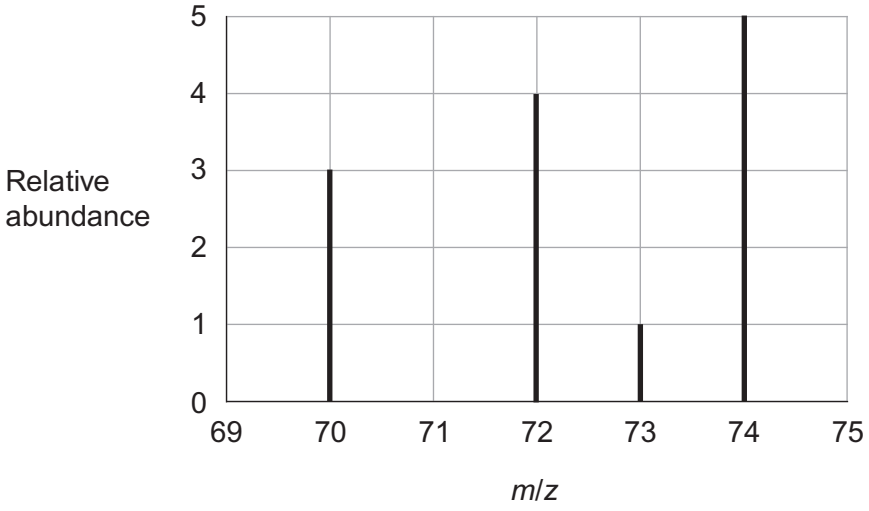
9

END OF QUESTIONS

Section A

Answer **all** questions in the spaces provided.

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



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

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(2 marks)

1 (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 marks)

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

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(1 mark)

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 marks)

1 (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 marks)

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

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

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(1 mark)

11

Section A

Answer **all** questions in the spaces provided.

1 (a) **Table 1** shows some data about fundamental particles in an atom.

Table 1

Particle	proton	neutron	electron
Mass / g	1.6725×10^{-24}	1.6748×10^{-24}	0.0009×10^{-24}

1 (a) (i) An atom of hydrogen can be represented as ^{1}H

Use data from **Table 1** to calculate the mass of this hydrogen atom.

[1 mark]

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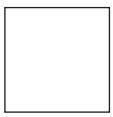
1 (a) (ii) Which **one** of the following is a fundamental particle that would **not** be deflected by an electric field?

A electron
B neutron
C proton

Write the correct letter, **A**, **B** or **C**, in the box.

[1 mark]



1 (b) A naturally occurring sample of the element boron has a relative atomic mass of 10.8 In this sample, boron exists as two isotopes, ^{10}B and ^{11}B

1 (b) (i) Calculate the percentage abundance of ^{10}B in this naturally occurring sample of boron.

[2 marks]

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1 (b) (ii) State, in terms of fundamental particles, why the isotopes ^{10}B and ^{11}B have similar chemical reactions.

[1 mark]

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1 (c) Complete **Table 2** by suggesting a value for the third ionisation energy of boron.

[1 mark]

Table 2

	First	**Second**	**Third**	**Fourth**	**Fifth**
Ionisation energy / kJ mol^{-1}	799	2420		25 000	32 800

1 (d) Write an equation to show the process that occurs when the **second** ionisation energy of boron is measured. Include state symbols in your equation.

[1 mark]

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1 (e) Explain why the second ionisation energy of boron is higher than the first ionisation energy of boron.

[1 mark]

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8

Turn over ▶

2 Tellurium is the element with atomic number of 52

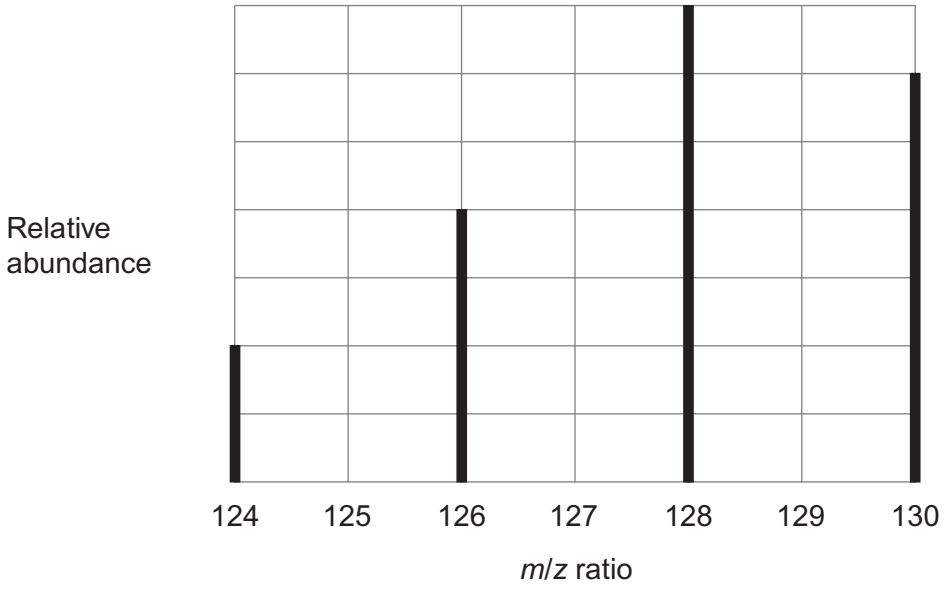
2 (a) Using information from the Periodic Table, complete the electron configuration of tellurium.

[1 mark]

[Kr] .....

2 (b) The mass spectrum of a sample of tellurium is shown in **Figure 1**.

Figure 1



2 (b) (i) Use **Figure 1** to calculate the relative atomic mass of this sample of tellurium. Give your answer to one decimal place.

[3 marks]

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2 (b) (ii) Suggest what might cause the relative atomic mass of this sample to be different from the relative atomic mass given in the Periodic Table.

[1 mark]

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2 (c) Write an equation for the reaction that occurs when a tellurium ion hits the detector.

[1 mark]

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2 (d) State the *m*/*z* value of the ions that produce the biggest current at the detector when the spectrum in **Figure 1** is recorded.
Give a reason for your answer.

[2 marks]

m/*z* value .....

Reason .....

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2 (e) The mass spectrum of tellurium also has a small peak at *m*/*z* = 64

Explain the existence of this peak.

[2 marks]

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2 (f) Predict whether the atomic radius of ^{124}Te is larger than, smaller than or the same as the atomic radius of ^{130}Te
Explain your answer.

[2 marks]

Atomic radius of ^{124}Te compared to ^{130}Te .....

Explanation .....

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12