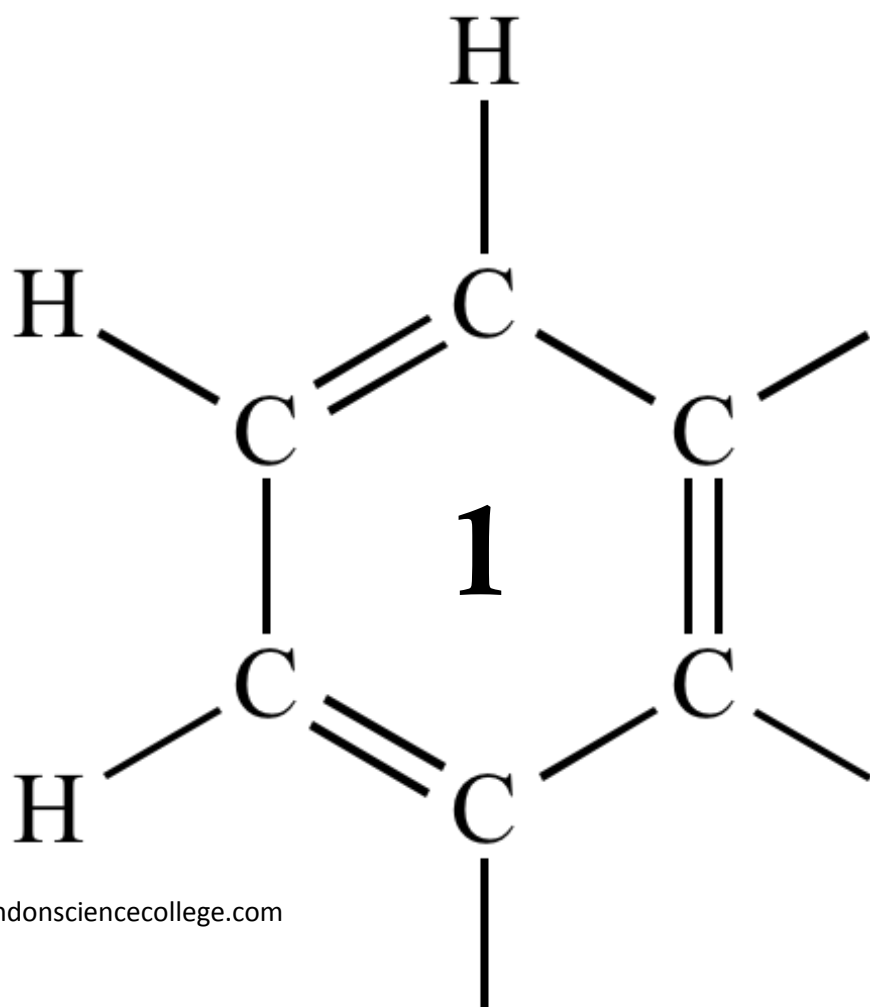


OCR AS CHEMISTRY

MODULE 2

AMOUNT OF SUBSTANCE
ATOMIC STRUCTURE



1

This question is about electron configuration.

- (a) Give the full electron configuration of an Al atom and of a Cr³⁺ ion.

Al atom.....

Cr³⁺ ion

(2)

- (b) Deduce the formula of the ion that has a charge of 2+ with the same electron configuration as krypton.

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(1)

- (c) Deduce the formula of the compound that contains 2+ ions and 3- ions that both have the same electron configuration as argon.

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(1)

(Total 4 marks)

2

Ions of two isotopes of iron are



Which statement is correct?

A The ions of both the isotopes have the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

B The ions of both the isotopes contains 26 neutrons

C $^{53}\text{Fe}^{2+}$ has fewer protons than $^{56}\text{Fe}^{2+}$

D After acceleration to the same kinetic energy $^{56}\text{Fe}^{2+}$ will move more slowly than $^{53}\text{Fe}^{2+}$

(Total 1 mark)

3

This question is about the periodicity of the Period 3 elements.

(a) State and explain the general trend in first ionisation energy across Period 3.

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(4)

(b) Give one example of an element which deviates from the general trend in first ionisation energy across Period 3.

Explain why this deviation occurs.

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(3)

(c) The table shows successive ionisation energies of an element Y in Period 3.

Ionisation number	1	2	3	4	5	6	7	8
Ionisation energy / kJ mol^{-1}	1000	2260	3390	4540	6990	8490	27 100	31 700

Identify element Y.

Explain your answer using data from the table.

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(2)

(d) Identify the Period 3 element that has the highest melting point.

Explain your answer by reference to structure and bonding.

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(4)

(Total 13 marks)

4

This question is about the elements in Group 2 and their compounds.

(a) Use the Periodic Table to deduce the full electron configuration of calcium.

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(1)

(b) Write an ionic equation, with state symbols, to show the reaction of calcium with an excess of water.

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(1)

(c) State the role of water in the reaction with calcium.

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(1)

(d) Write an equation to show the process that occurs when the first ionisation energy of calcium is measured.

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(1)

(e) State and explain the trend in the first ionisation energies of the elements in Group 2 from magnesium to barium.

Trend

Explanation

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(3)
(Total 7 marks)

5 Which of these atoms has the largest atomic radius?

A Ar

B Cl

C Mg

D Na

(Total 1 mark)

6 Which of these atoms has the smallest number of neutrons?

A ^3H

B ^4He

C ^5He

D ^4Li

(Total 1 mark)

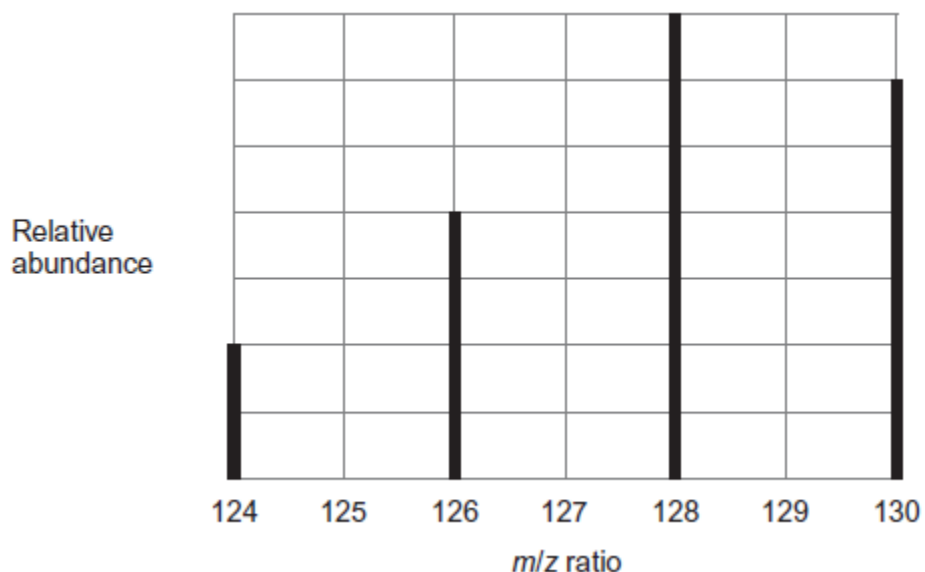
7 Tellurium is the element with atomic number of 52

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

[Kr]

(1)

(b) The mass spectrum of a sample of tellurium is shown in the graph.



(i) Use the graph to calculate the relative atomic mass of this sample of tellurium. Give your answer to one decimal place.

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(3)

(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.

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(1)

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

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(1)

- (d) State the m/z value of the ions that produce the biggest current at the detector when the spectrum in the graph is recorded.

Give a reason for your answer.

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.

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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.

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

Explanation

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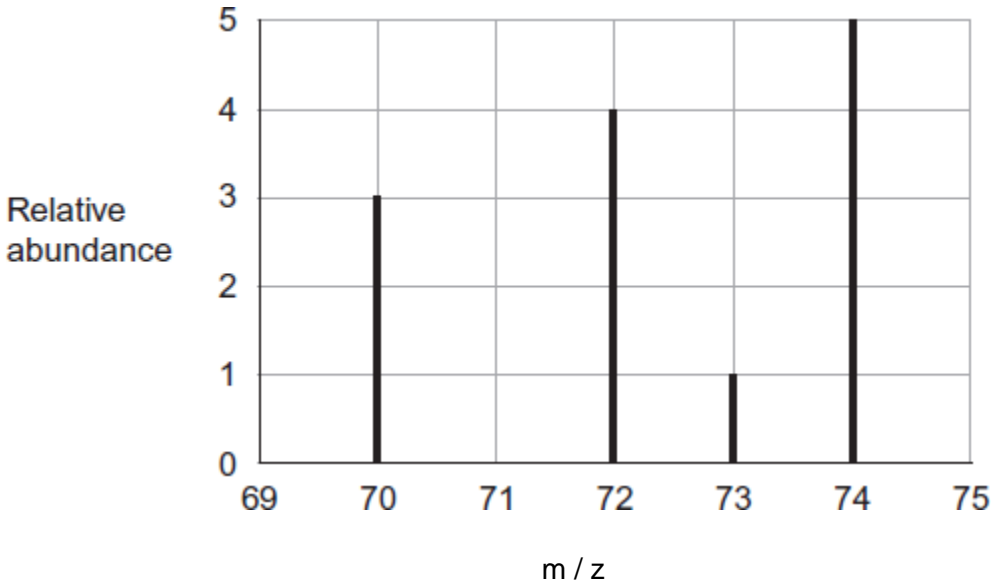
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(2)

(Total 12 marks)

8

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



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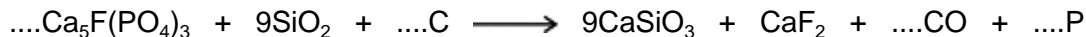
Explain why the chemical properties of ⁷⁰**X** and ⁷⁰**Zn** are different.

(1)

(Total 11 marks)

9 The manufacture of food grade phosphoric acid for use in cola drinks begins with the production of pure white phosphorus from the mineral fluoroapatite, Ca₅F(PO₄)₃

- (a) Complete the following equation for the manufacture of phosphorus.



(1)

- (b) As the phosphorus cools, it forms white phosphorus, P₄

Give the oxidation state of phosphorus in each of the following.

P₄

H₃PO₄

(2)

- (c) Fertiliser grade phosphoric acid is manufactured from sulfuric acid and calcium phosphate. Use the following precise relative atomic mass data to show how mass spectrometry can be used to distinguish between pure sulfuric acid (H_2SO_4) and pure phosphoric acid (H_3PO_4) which both have $M_r = 98$ to two significant figures.

Atom	Precise relative atomic mass
^1H	1.00794
^{16}O	15.99491
^{31}P	30.97376
^{32}S	32.06550

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(1)

- (d) Concentrated phosphoric acid is used as a catalyst in the hydration of propene to form the alcohol $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ as the main organic product. The industrial name for this alcohol is isopropyl alcohol.

- (i) State the meaning of the term *catalyst*.

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(Extra space)

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(1)

- (ii) State the meaning of the term *hydration*.

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(Extra space)

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(1)

- (iii) Write an equation for the hydration of propene to form isopropyl alcohol.
Give the IUPAC name for isopropyl alcohol.

Equation

IUPAC name

(2)
(Total 8 marks)

10

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

- (a) Nitrogen forms a nitride ion with the electron configuration $1s^2 2s^2 2p^6$
Write 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, Si_3N_4

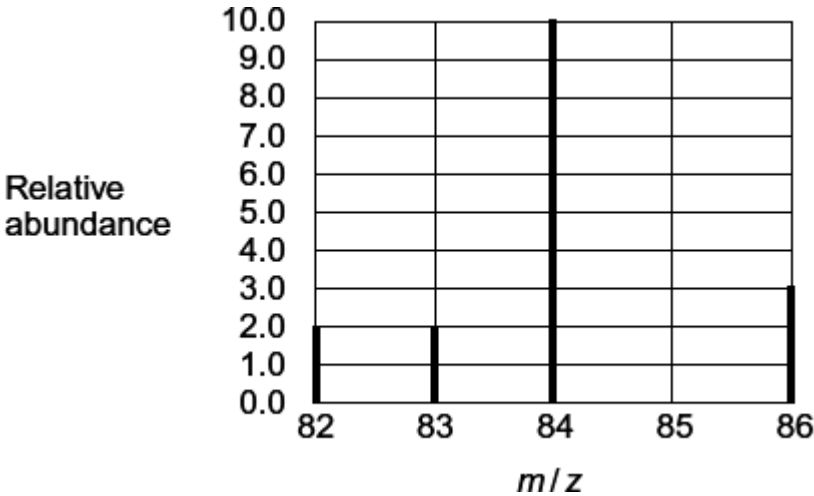
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(1)

(Total 7 marks)

11

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)

12

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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(Total 3 marks)

13

(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% ^{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)

- (b) In a mass spectrometer, under the same conditions, $^{14}\text{N}^+$ and $^{15}\text{N}^+$ 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)

- (c) 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)

(Total 8 marks)

14

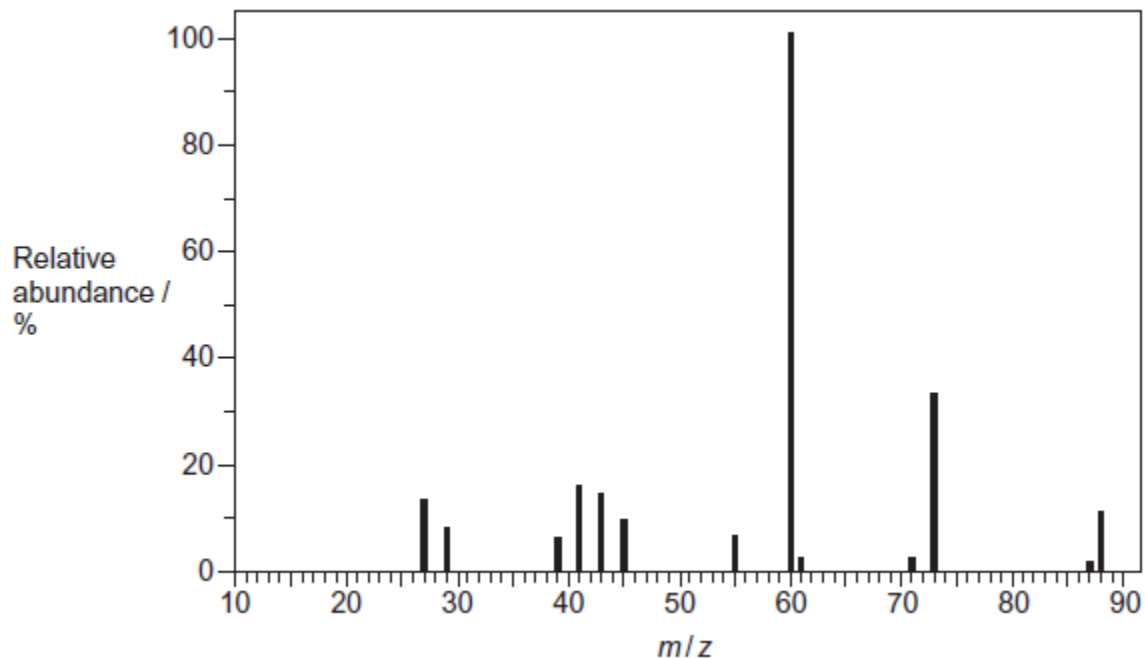
The manufacturer supplying concentrated ethanoic acid for the production of vinegar also supplied other acids. The label had come off a batch of one of these other acids. A sample of this unknown acid was analysed and found to contain 54.5% of carbon and 9.10% of hydrogen by mass, the remainder being oxygen.

- (a) Use these data to calculate the empirical formula of the unknown acid. Show your working.

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(3)

- (b) A sample of the unknown acid was analysed in a mass spectrometer. The mass spectrum obtained is shown below.



Use the mass spectrum to determine the M_r of the unknown acid.

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(1)

- (c) Use your answers from parts (a) and (b) to determine the molecular formula of the unknown acid.
(If you could not answer part (b), you should assume that the M_r of the acid is 132.0 but this is **not** the correct value.)
Show your working.

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(2)
(Total 6 marks)