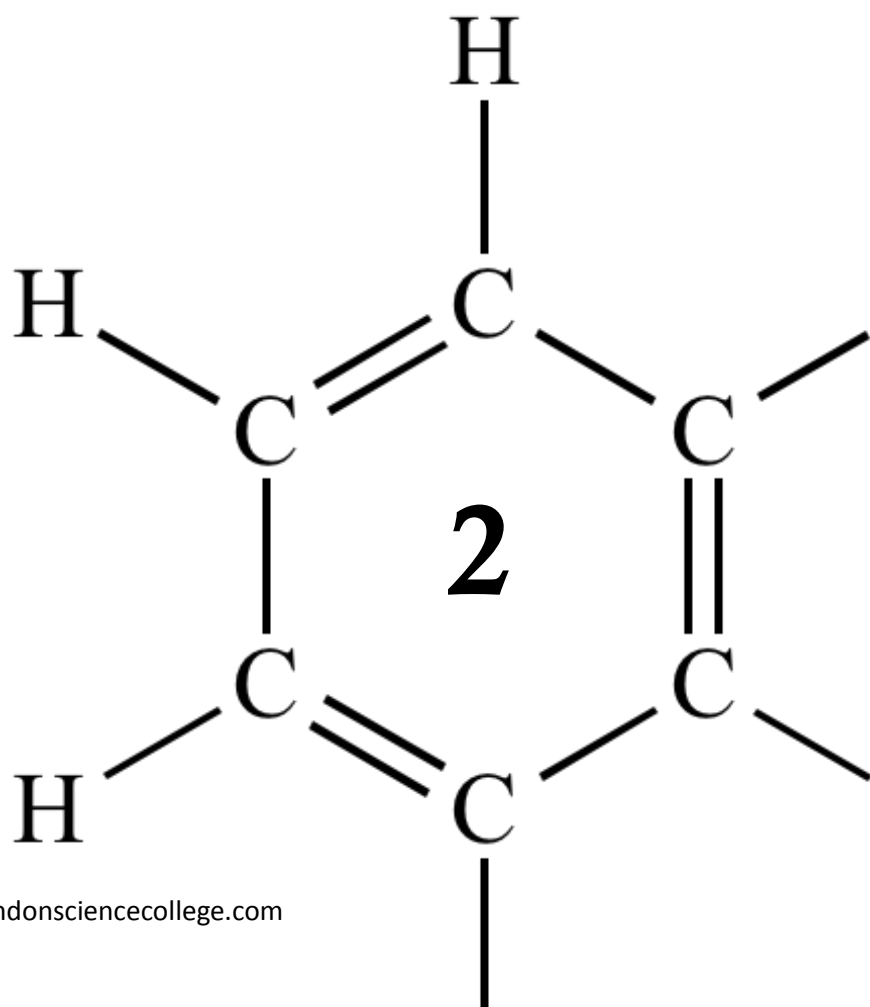


AQA AS CHEMISTRY

ATOMIC STRUCTURE



1

A sample of ethanedioic acid was treated with an excess of an unknown alcohol in the presence of a strong acid catalyst. The products of the reaction were separated and analysed in a time of flight (TOF) mass spectrometer. Two peaks were observed at $m/z = 104$ and 118 .

(a) Identify the species responsible for the two peaks.

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(2)

(b) Outline how the TOF mass spectrometer is able to separate these two species to give two peaks.

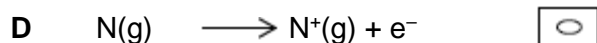
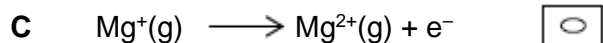
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(4)

(Total 6 marks)

2

Which change requires the largest amount of energy?



(Total 1 mark)

3

This question is about the elements in Period 3 of the Periodic Table.

- (a) State the element in Period 3 that has the highest melting point.
Explain your answer.

Element

Explanation

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.....

(3)

- (b) State the element in Period 3 that has the highest first ionisation energy.
Explain your answer.

Element

Explanation

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(3)

- (c) Suggest the element in Period 3 that has the highest electronegativity value.

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(1)

- (d) Chlorine is a Period 3 element.
Chlorine forms the molecules ClF_3 and CCl_2

- (i) Use your understanding of electron pair repulsion to draw the shape of ClF_3 and the shape of CCl_2
Include any lone pairs of electrons that influence the shape.

Shape of ClF_3

Shape of CCl_2

(2)

- (ii) Name the shape of CCl_2

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(1)

(iii) Write an equation to show the formation of one mole of ClF_3 from its elements.

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(1)
(Total 11 marks)

4

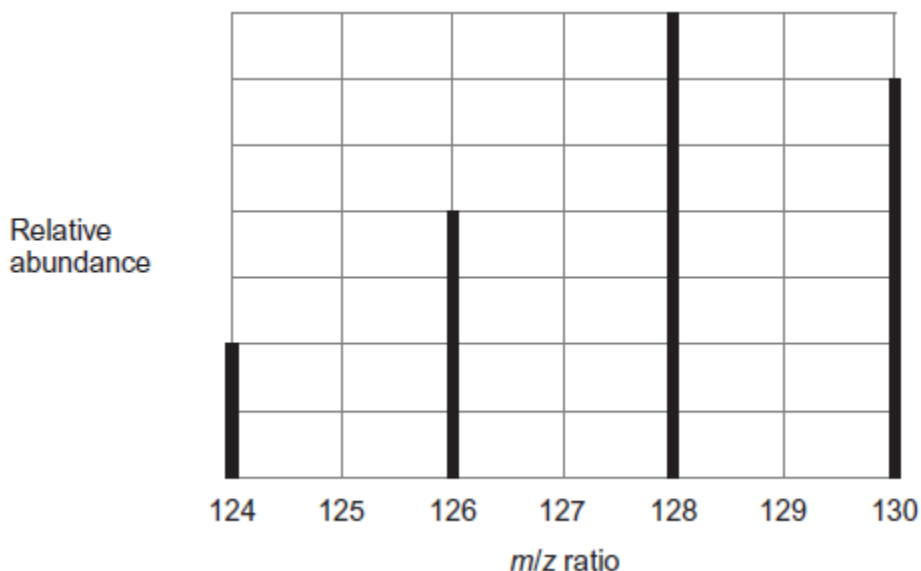
Tellurium is the element with atomic number of 52

(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

.....

.....

(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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(2)
(Total 12 marks)

5

(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}

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

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

.....

(1)

(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)

(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, ${}^{10}\text{B}$ and ${}^{11}\text{B}$

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

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(2)

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

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(1)

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

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.

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(1)

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

.....

(1)

(Total 8 marks)

6

- (a) Nickel is a metal with a high melting point.

- (i) State the block in the Periodic Table that contains nickel.

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(1)

- (ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

.....

(2)

(iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel. In your answer, include at least six particles of each type.

(2)

(iv) Explain why nickel is ductile (can be stretched into wires).

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(1)

(b) Nickel forms the compound nickel(II) chloride (NiCl₂).

(i) Give the full electron configuration of the Ni²⁺ ion.

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(1)

(ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using SOCl₂. Identify **one** substance that could react with both gaseous products.



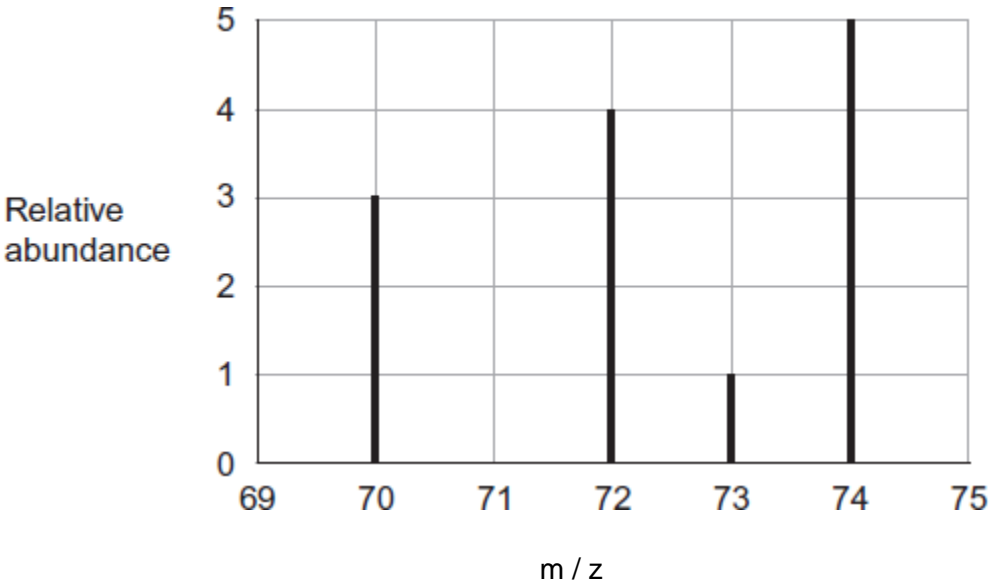
Substance

(2)

(Total 9 marks)

7

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)

8

Aluminium and thallium are elements in Group 3 of the Periodic Table. Both elements form compounds and ions containing chlorine and bromine.

- (a) Write an equation for the formation of aluminium chloride from its elements.

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(1)

- (b) An aluminium chloride molecule reacts with a chloride ion to form the AlCl_4^- ion.

Name the type of bond formed in this reaction. Explain how this type of bond is formed in the AlCl_4^- ion.

Type of bond

Explanation

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(2)

(c) Aluminium chloride has a relative molecular mass of 267 in the gas phase.

Deduce the formula of the aluminium compound that has a relative molecular mass of 267

.....

(1)

(d) Deduce the name or formula of a compound that has the same number of atoms, the same number of electrons and the same shape as the AlCl_4^- ion.

.....

(1)

(e) Draw and name the shape of the TlBr_5^{2-} ion.

Shape of the TlBr_5^{2-} ion.

Name of shape

(2)

(f) (i) Draw the shape of the TlCl_2^+ ion.

(1)

(ii) Explain why the TlCl_2^+ ion has the shape that you have drawn in part (f)(i).

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(1)

- (g) Which **one** of the first, second or third ionisations of thallium produces an ion with the electron configuration $[\text{Xe}] 5d^{10}6s^1$?

Tick (✓) one box.

First

Second

Third

(1)
(Total 10 marks)

9

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

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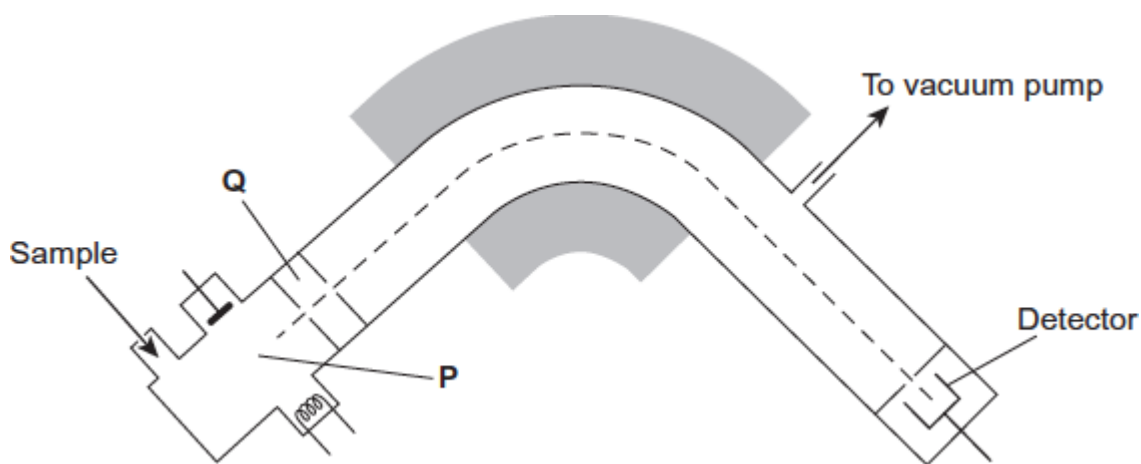
(1)

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

.....

(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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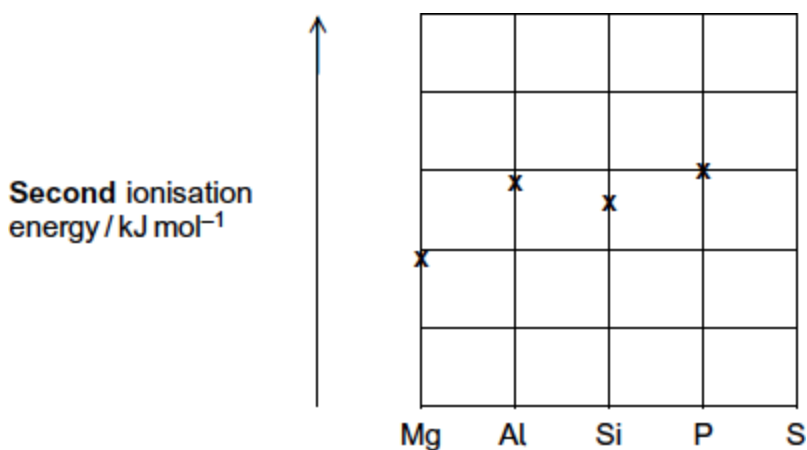
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(1)
(Total 11 marks)

10

(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 Al^{2+} ion.

.....

(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.

.....

.....

.....

(1)

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

Element

Reason

.....

.....

(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)