

Atomic structure

11 questions · 71 marks

Answer all questions. The marks available are shown against each part. Every question is taken unaltered from a past paper; the source is noted beneath it. In Section A, choose the best answer and write its letter in the box.

Section A · Multiple choice

6 questions · 6 marks

1. Which row shows the number of each fundamental particle in one $^{25}\text{Mg}^{2+}$ ion? 1 mark
[1 mark]

	protons	neutrons	electrons	
A	12	12	10	☐
B	14	11	12	☐
C	12	13	10	☐
D	12	13	12	☐

Answer

AQA 7405/3 Chemistry · June 2023 · Paper 3, Question 7

2. Which has the electron configuration of a noble gas? 1 mark
[1 mark]

- A** H^+ ☐
- B** O^- ☐
- C** Se^{2-} ☐
- D** Zn^{2+} ☐

Answer

AQA 7405/3 Chemistry · 2021 · Paper 3, Question 10

3. Which row contains two species with different numbers of electrons?

[1 mark]

1 mark

A NH_3 and HF ☐

B CO_3^{2-} and NO_3^- ☐

C H_3O^+ and HF_2^+ ☐

D CH_4 and NH_2^- ☐

Answer

— AQA 7405/3 Chemistry · June 2024 · Paper 3, Question 6

4. Which element has the highest third ionisation energy?

[1 mark]

1 mark

A Li ☐

B Be ☐

C K ☐

D Ca ☐

Answer

— AQA 7405/3 Chemistry · June 2024 · Paper 3, Question 7

5. Which atom has the greatest first ionisation energy?

[1 mark]

1 mark

A H ☐

B He ☐

C Li ☐

D Ne ☐

Answer

— AQA 7405/3 Chemistry · June 2019 · Paper 3, Question 14

6. Which shows the electron configuration of an atom of a transition metal? 1 mark

[1 mark]

A $[\text{Ar}] 4s^2 3d^0$

☐

B $[\text{Ar}] 4s^2 3d^8$

☐

C $[\text{Ar}] 4s^2 3d^{10}$

☐

D $[\text{Ar}] 4s^2 3d^{10} 4p^1$

☐

Answer

AQA 7405/3 Chemistry · June 2020 · Paper 3, Question 17

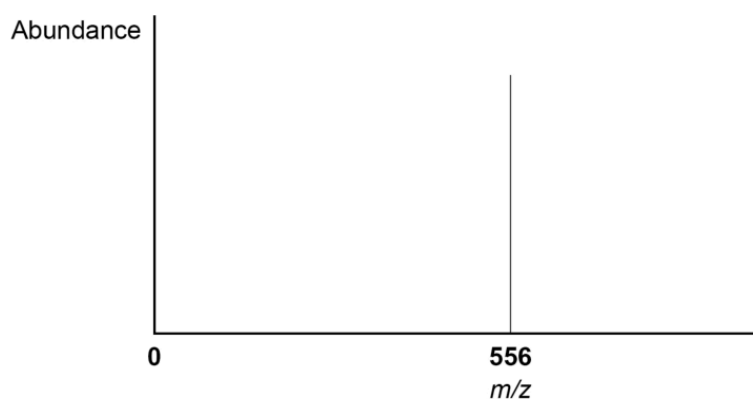
Section B · Structured questions

5 questions · 65 marks

7. Time of flight (TOF) mass spectrometry can be used to analyse large molecules such as the pentapeptide, leucine enkephalin (**P**). 10 marks

P is ionised by electrospray ionisation and its mass spectrum is shown in **Figure 2**.

Figure 2



1

Describe the process of electrospray ionisation.

Give an equation to represent the ionisation of **P** in this process.

[4 marks]

Description

Equation

2

What is the relative molecular mass of **P**?

Tick (✓) **one** box.

[1 mark]

555

☐

556

☐

557

☐

3

A molecule **Q** is ionised by electron impact in a TOF mass spectrometer.

The **Q**⁺ ion has a kinetic energy of $2.09 \times 10^{-15} \text{ J}$

This ion takes $1.23 \times 10^{-5} \text{ s}$ to reach the detector.

The length of the flight tube is 1.50 m

Calculate the relative molecular mass of **Q**.

$$KE = \frac{1}{2}mv^2 \quad \text{where } m = \text{mass (kg) and } v = \text{speed (m s}^{-1}\text{)}$$

The Avogadro constant, $L = 6.022 \times 10^{23} \text{ mol}^{-1}$

[5 marks]

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Relative molecular mass

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— AQA 7405/1 Chemistry · June 2019 · Paper 1, Question 2

8.

This is a question about time of flight (TOF) mass spectrometry.

12 marks

1

Give the equation, including state symbols, for the formation of Sr^+ ions from Sr atoms by electron impact.

[1 mark]

.....

.....

.....

2

A sample of strontium is analysed by TOF mass spectrometry.
The sample is ionised using electron impact.

The ions are accelerated to have a kinetic energy (KE) of $7.02 \times 10^{-20} \text{ J}$
An ion takes $9.47 \times 10^{-4} \text{ s}$ to travel along a 95.0 cm flight tube.

$$KE = \frac{1}{2} mv^2$$

where m = mass (kg) and v = speed (m s^{-1})

Use the information given to deduce the mass number of this ion.

The Avogadro constant, $L = 6.022 \times 10^{23} \text{ mol}^{-1}$

[5 marks]

Mass number

3

Explain how the ions are detected in the TOF mass spectrometer.

State how the relative abundance of the ions is determined.

[2 marks]

How ions are detected

How relative abundance is determined

4

A sample of strontium contains three isotopes, ^{86}Sr , ^{87}Sr and ^{88}Sr
 82% of the sample is ^{88}Sr
 The other isotopes are in a 1:2 ratio of $^{86}\text{Sr} : ^{87}\text{Sr}$

Calculate the percentage abundance of ^{87}Sr in this sample.

Use your answer to deduce the relative atomic mass (A_r) of the sample.
 Give your answer to 1 decimal place.

[3 marks]

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Abundance of ^{87}Sr %

A_r

5

Electrospray ionisation is used instead of electron impact for the ionisation of a protein in a mass spectrometry experiment.

Suggest why.

[1 mark]

— AQA 7405/1 Chemistry · June 2023 · Paper 1, Question 9

9.

Rhenium has an atomic number of 75

12 marks

1

Define the term relative atomic mass.

[2 marks]

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S

[2 marks]

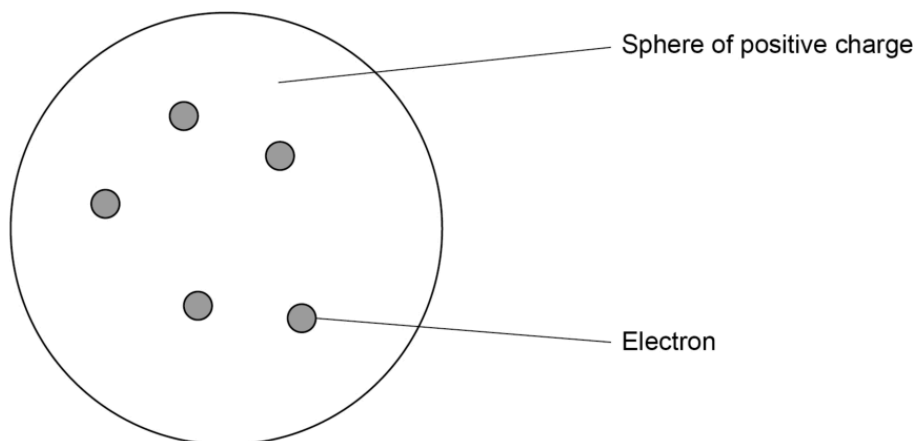
[illegible]

10.

13 marks

Figure 1 represents an atom using Thomson's model.

Page 9



Suggest the identity of this atom.

Give **two** differences between the modern model of an atom and the Thomson model of an atom.

[3 marks]

Identity _____

Difference 1

Difference 2

2

Tellurium has a relative atomic mass of 127.6

Iodine has a relative atomic mass of 126.9

Define relative atomic mass.

Suggest **one** property of tellurium that justifies its position before iodine in the modern Periodic Table.

[3 marks]

Definition

Justification

3

A sample of tellurium is analysed in a time of flight (TOF) mass spectrometer using electron impact ionisation.

Give an equation, including state symbols, for this ionisation.

[1 mark]

4

In the TOF mass spectrometer an ion of an isotope of tellurium, with mass number y , travels along a 1.25 m flight tube with a kinetic energy of 1.88×10^{-12} J

The ion takes 3.00×10^{-7} s to reach the detector.

$$KE = \frac{1}{2} mv^2$$

KE = kinetic energy / J

m = mass / kg

v = speed / m s^{-1}

Calculate the mass, in g, of 1 mole of these tellurium ions.

Use your answer to suggest the mass number y of the tellurium isotope.

The Avogadro constant, $L = 6.022 \times 10^{23} \text{ mol}^{-1}$

[5 marks]

Mass _____ g

Mass number y

5

Tellurium has several other isotopes.

Two of these isotopes are ^{126}Te and ^{124}Te

A different sample of tellurium is analysed using a TOF mass spectrometer.

Which statement about kinetic energy (KE) is correct?

[1 mark]

Tick (✓) **one** box.

The KE of $^{126}\text{Te}^+$ is greater than the KE of $^{124}\text{Te}^+$

☐

The KE of $^{126}\text{Te}^+$ is the same as the KE of $^{124}\text{Te}^+$

☐

The KE of $^{126}\text{Te}^+$ is less than the KE of $^{124}\text{Te}^+$

☐

— AQA 7405/1 Chemistry · June 2024 · Paper 1, Question 1

11. This question is about s-block metals. 18 marks

1

Give the full electron configuration for the calcium ion, Ca^{2+}

[1 mark]

2

Explain why the second ionisation energy of calcium is lower than the second ionisation energy of potassium.

[2 marks]

3

Identify the s-block metal that has the highest first ionisation energy.

[1 mark]

4

Give the formula of the hydroxide of the element in Group 2, from Mg to Ba, that is least soluble in water.

[1 mark]

A student added 6 cm^3 of 0.25 mol dm^{-3} barium chloride solution to 8 cm^3 of 0.15 mol dm^{-3} sodium sulfate solution.

The student filtered off the precipitate and collected the filtrate.

Give an ionic equation for the formation of the precipitate.

Show by calculation which reagent is in excess.

Calculate the total volume of the other reagent which should be used by the student so that the filtrate contains only one solute.

[3 marks]

Ionic equation

Reagent in excess

Total volume of other reagent

6

A sample of strontium has a relative atomic mass of 87.7 and consists of three isotopes, ^{86}Sr , ^{87}Sr and ^{88}Sr

In this sample, the ratio of abundances of the isotopes ^{86}Sr : ^{87}Sr is 1:1

State why the isotopes of strontium have identical chemical properties.

Calculate the percentage abundance of the ^{88}Sr isotope in this sample.

[4 marks]

Why isotopes of strontium have identical chemical properties

[illegible]

Percentage abundance of ^{88}Sr _____ %

7

A time of flight (TOF) mass spectrum was obtained for a sample of barium that contains the isotopes ^{136}Ba , ^{137}Ba and ^{138}Ba .
The sample of barium was ionised by electron impact.

Identify the ion with the longest time of flight.

[1 mark]

8

A $^{137}\text{Ba}^+$ ion travels through the flight tube of a TOF mass spectrometer with a kinetic energy of $3.65 \times 10^{-16} \text{ J}$.
This ion takes $2.71 \times 10^{-5} \text{ s}$ to reach the detector.

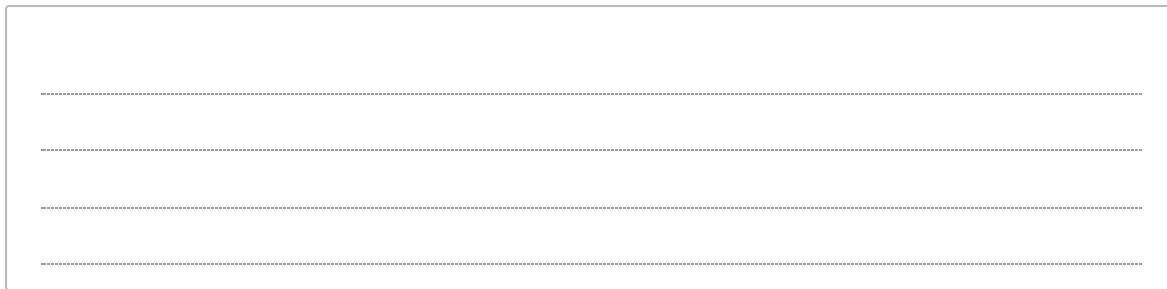
$$KE = \frac{1}{2}mv^2 \quad \text{where } m = \text{mass (kg) and } v = \text{speed (m s}^{-1}\text{)}$$

The Avogadro constant, $L = 6.022 \times 10^{23} \text{ mol}^{-1}$

Calculate the length of the flight tube in metres.
Give your answer to the appropriate number of significant figures.

[5 marks]

Length of flight tube m



— AQA 7405/1 Chemistry · June 2018 · Paper 1, Question 4