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CHEMISTRY

Physical Chemistry

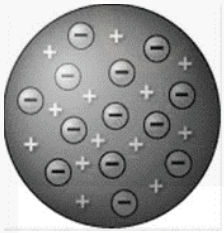
Level & Board	AQA (A-LEVEL)
TOPIC:	ATOMIC STRUCTURE
PAPER TYPE:	QUESTION PAPER 4
TOTAL QUESTIONS	8
TOTAL MARKS	59

Atomic structure

1. J Thomson made the discovery of electrons in the nineteenth century.

Using the analogy of "plums in a pudding of positive charge," he claimed that negative electrons might be found throughout an atom.

The 'plum pudding' concept is used to depict an atom of the element X in the diagram.



Nine electrons are found in one atom of X.

(a) Identify two contrasts between the 'plum pudding' model and the current atomic structure model.

[2]

(b) Determine the electron configuration of X atom.

[2]

(c) Determine X's identity and calculate the formula of the molecule that results from X reacting with the Group 7 non-metal.

[2]

2. This question relates to atomic structure.

(a) For Cr and Cr^{2+}, write down the whole electron configuration.

[2]

(b) Describe the process that takes place when the third ionization energy of Fe is measured using an equation using state symbols.

[2]

(c) Identify which element, out of Sodium and Aluminium, has the lower initial ionization energy. Explain.

[2]

(d) With the help of a time of flight (TOF) mass spectrometer, a sample of neon was examined. Electron impact ionisation was used to ionise the material. The resulting spectrum displayed three peaks with the abundances listed in the table.

Percentage abundance	90.9	0.3	8.8
m/z	20	21	22

Give the symbol and mass number of the ion in the sample that would hit the detector first.

[2]

(e) Determine the sample's relative neon's atomic mass**.**

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[2]

3. A sample of X element was ionised by electron impact in a time of flight(TOF) mass spectrometer. Information from the mass spectrum about the isotopes of X in the sample is

m/z	46	47	48	49
Abundance %	9.1	7.8	74.6	8.6

(a) Calculate the relative atomic mass of X.

[2]

(b) To demonstrate how an atom of X is ionised by electron impact,

Write an equation with state symbols and include the m/z value of the ion that would fall at the detector first.

[2]

(c) Find the mass, in kg, of one atom of ^{49}X

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

[2]

(d) In a TOF mass spectrometer, the time t, of an ion is given by the equation

$$t = d\sqrt{\frac{m}{2K.E}}$$

d is the length of the flight tube
m is the mass, in kg, of an ion
K.E is the kinetic energy of the ions.

The kinetic energy is 1.013×10^{-13}J
The time of flight of a $^{49}X^{+}$ ion is 9.816×10^{-7} s

Calculate the time of flight of the $^{47}X^{+}$ ion

[3]

4. An element Y exists as three isotopes:

^{24}Y
^{25}Y
^{26}Y

(a) Write the difference between the three isotopes of Y in terms of sub atomic particles.

[2]

(b) Describe any differences in the chemical nature of these isotopes, if any.

[2]

(c) 10.0% of the mass of a sample of Y is composed of ^{25}Y atoms.
Ar = 24.3

Calculate the percentages of the other two Y isotopes in the sample using this knowledge.

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[2]

(d) In a TOF mass spectrometer, each $^{25}Y^{+}$ ion is accelerated to a kinetic energy of 4.52×10^{-16} J
time of flight is 1.44×10^{-5} s.
Find the distance travelled, in metres.

[3]

5. The time of flight (TOF) mass spectrometry is the subject of this question. The table's m/z values correspond to peaks in element Z's mass spectrum.

m/z	82	83	84	86
Abundance	5	3	26	7

(a) Find relative atomic mass of Z.

[2]

(b) The Avogadro constant L = 6.022×10^{23} mol^{-1}
The time of flight of a $^{82}Z^{+}$ ion is 1.243×10^{-5} s.

Find the time of flight of the $^{86}Z^{+}$ ion.

[3]

6. The Group 1 elements and their compounds are the subject of this question.

(a) Determine potassium's complete electron configuration using the Periodic Table.

[2]

(b) Make an ionic equation using state symbols to illustrate how sodium reacts with water.

[2]

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

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[2]

(d) When the first ionization energy of sodium is detected, create an equation to illustrate the process that takes place.

[2]

(e) Explain the trend in the first ionization energies of Group 1 elements from sodium to cesium.

[2]

7. The relative atomic mass of a sample of three isotopes of oxygen is 15.999.

The relative abundance of two of these isotopes is provided in the table below.

Mass number of isotope	16	17
Relative abundance / %	69.759	13.5

(a) Apply this knowledge to calculate the third isotope's mass number and relative abundance.

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[2]

(b) Give an explanation of the formation of ions in a time of flight (TOF) mass spectrometer.

[2]

(c) The relative molecular mass of molecules can be calculated using a TOF mass spectrometer.

Describe the necessity of ionising molecules in order to measure their mass with a TOF mass spectrometer.

[2]

8. An excess of an unidentified alcohol was used to treat a sample of ethane dioic acid in the presence of an acids powerful catalyst. A time of flight (TOF) mass spectrometer was used to isolate and study the reaction's byproducts. There were two peaks seen at m/z = 104 and 118.

(a) Determine the species responsible that caused the two peaks.

[3]

(b) Describe how the TOF mass spectrometer can distinguish between these two substances to produce two peaks.

[2]

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