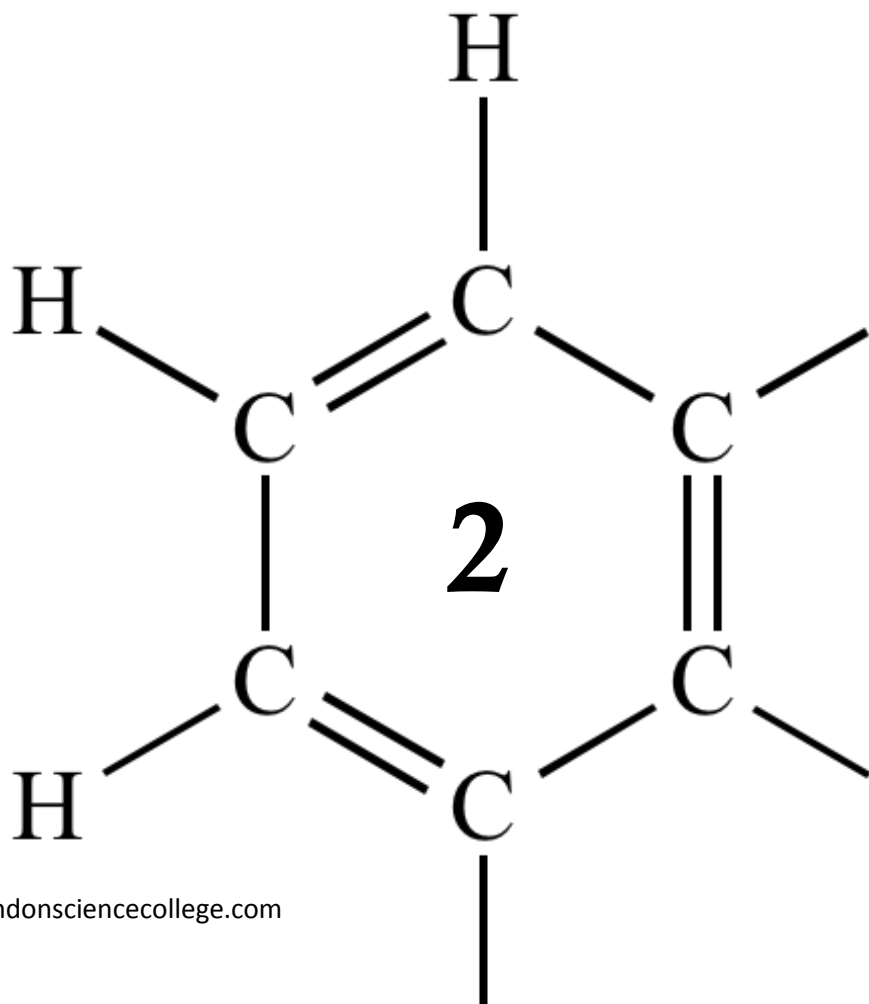


OCR AS CHEMISTRY

MODULE 2

AMOUNT OF SUBSTANCE
ATOMIC STRUCTURE



1

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

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

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(2)

(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

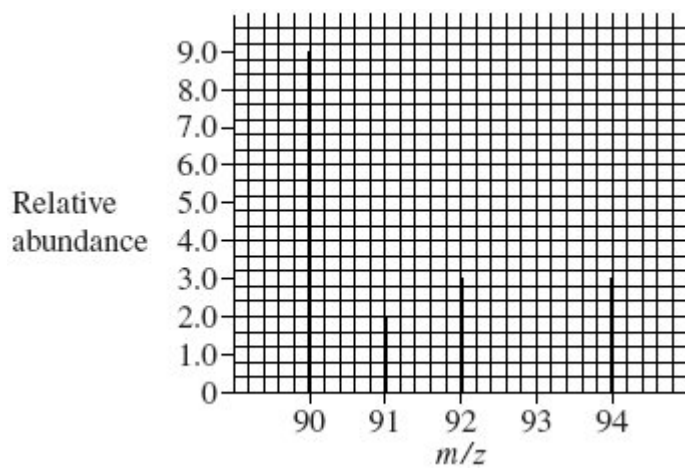
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(3)

(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)

(d) State how vaporised atoms of **Z** are converted into **Z⁺** ions in a mass spectrometer.

State and explain which of the **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)

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

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(2)

(Total 15 marks)

2

(a) Complete the electronic configuration for the sodium ion, Na⁺

1s²

(1)

(b) (i) Write an equation, including state symbols, to represent the process for which the energy change is the second ionisation energy of sodium.

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(2)

- (ii) Explain why the second ionisation energy of sodium is greater than the second ionisation energy of magnesium.

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(3)

- (iii) An element **X** in Period 3 of the Periodic Table has the following successive ionisation energies.

	First	Second	Third	Fourth
Ionisation energies / kJ mol ⁻¹	577	1820	2740	11600

Deduce the identity of element **X**.

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(1)

- (c) State and explain the trend in atomic radius of the Period 3 elements from sodium to chlorine.

Trend

Explanation

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(3)

- (d) Explain why sodium has a lower melting point than magnesium.

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(3)

- (e) Sodium reacts with ammonia to form the compound NaNH_2 which contains the NH_2^- ion.
 Draw the shape of the NH_2^- ion, including any lone pairs of electrons.
 Name the shape made by the three atoms in the NH_2^- ion.

Shape of NH_2^-

Name of shape

(2)

- (f) In terms of its electronic configuration, give **one** reason why neon does not form compounds with sodium.

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(1)

(Total 16 marks)

3

In 1913 Niels Bohr proposed a model of the atom with a central nucleus, made up of protons and neutrons, around which electrons moved in orbits. After further research, the model was refined when the existence of energy levels and sub-levels was recognised.

- (a) Complete the following table for the particles in the nucleus.

Particle	Relative charge	Relative mass
proton		
neutron		

(2)

- (b) State the block in the Periodic Table to which the element tungsten, W, belongs.

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(1)

(c) Isotopes of tungsten include ^{182}W and ^{186}W

(i) Deduce the number of protons in ^{182}W

.....

(1)

(ii) Deduce the number of neutrons in ^{186}W

.....

(1)

(d) In order to detect the isotopes of tungsten using a mass spectrometer, a sample containing the isotopes must be vaporised and then ionised.

(i) Give **two** reasons why the sample must be ionised.

1

2

(2)

(ii) State what can be adjusted in the mass spectrometer to enable ions formed by the different isotopes to be directed onto the detector.

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(1)

(e) State and explain the difference, if any, between the chemical properties of the isotopes ^{182}W and ^{186}W

Difference

Explanation

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(2)

- (f) The table below gives the relative abundance of each isotope in the mass spectrum of a sample of tungsten.

m/z	182	183	184	186
Relative abundance /%	26.4	14.3	30.7	28.6

Use the data above to calculate a value for the relative atomic mass of this sample of tungsten. Give your answer to 2 decimal places.

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(2)
(Total 12 marks)

4

In one model of atomic structure, the atom has a nucleus surrounded by electrons in levels and sub-levels.

- (a) Define the term *atomic number*.

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(1)

- (b) Explain why atoms of an element may have different mass numbers.

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(1)

- (c) The table below refers to a sample of krypton.

Relative m/z	82	83	84	86
Relative abundance / %	12	12	50	26

- (i) Name an instrument which is used to measure the relative abundance of isotopes.

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- (ii) Define the term *relative atomic mass*.

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(iii) Calculate the relative atomic mass of this sample of krypton.

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(5)

(d) Give the complete electronic configuration of krypton in terms of s, p and d sub-levels.

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(1)

(e) In 1963, krypton was found to react with fluorine. State why this discovery was unexpected.

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(1)

(f) Use a suitable model of atomic structure to explain the following experimental observations.

(i) The first ionisation energy of krypton is greater than that of bromine.

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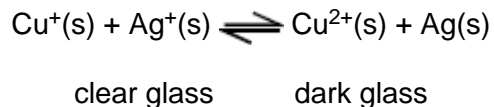
(ii) The first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

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(4)

(Total 13 marks)

- 5** Photochromic glass contains silver ions and copper ions. A simplified version of a redox equilibrium is shown below. In bright sunlight the high energy u.v. light causes silver atoms to form and the glass darkens. When the intensity of the light is reduced the reaction is reversed and the glass lightens.



Which one of the following is a correct electron arrangement?

- A Cu^+ is $[\text{Ar}]3\text{d}^94\text{s}^1$
- B Cu is $[\text{Ar}]3\text{d}^{10}4\text{s}^2$
- C Cu^{2+} is $[\text{Ar}]3\text{d}^84\text{s}^1$
- D Cu^+ is $[\text{Ar}]3\text{d}^{10}$

(Total 1 mark)

- 6** Chlorine has two isotopes, ^{35}Cl and ^{37}Cl . The number of molecular ion peaks in the mass spectrum of a sample of Cl_2 is

- A 2
- B 3
- C 4
- D 5

(Total 1 mark)

- 7** (a) Complete the following table.

	Relative mass	Relative charge
Proton		
Electron		

(2)

(b) An atom of element **Q** contains the same number of neutrons as are found in an atom of ^{27}Al . An atom of **Q** also contains 14 protons.

(i) Give the number of protons in an atom of ^{27}Al .

.....

(ii) Deduce the symbol, including mass number and atomic number, for this atom of element **Q**.

.....

(3)

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

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(2)

(d) The table below gives the relative abundance of each isotope in a mass spectrum of a sample of magnesium.

<i>m/z</i>	24	25	26
Relative abundance (%)	73.5	10.1	16.4

Use the data above to calculate the relative atomic mass of this sample of magnesium. Give your answer to one decimal place.

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(2)

(e) State how the relative molecular mass of a covalent compound is obtained from its mass spectrum.

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(1)
(Total 10 marks)

8

(a) One isotope of sodium has a relative mass of 23.

(i) Define, in terms of the fundamental particles present, the meaning of the term *isotopes*.

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(ii) Explain why isotopes of the same element have the same chemical properties.

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(iii) Calculate the mass, in grams, of a single atom of this isotope of sodium.
(The Avogadro constant, L , is $6.023 \times 10^{23} \text{ mol}^{-1}$)

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(5)

(b) Give the electronic configuration, showing all sub-levels, for a sodium atom.

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(1)

(c) Explain why chromium is placed in the d block in the Periodic Table.

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(1)

(d) An atom has half as many protons as an atom of ^{28}Si and also has six fewer neutrons than an atom of ^{28}Si . Give the symbol, including the mass number and the atomic number, of this atom.

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(2)

(Total 9 marks)

9

(a) Complete the following table.

Particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

(3)

(b) An atom of element **Z** has two more protons and two more neutrons than an atom of ${}^{34}_{16}\text{S}$. Give the symbol, including mass number and atomic number, for this atom of **Z**.

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(2)

(c) Complete the electronic configurations for the sulphur atom, S, and the sulphide ion, S²⁻.

S 1s²

S²⁻ 1s²

(2)

(d) State the block in the Periodic Table in which sulphur is placed and explain your answer.

Block

Explanation

(2)

(e) Sodium sulphide, Na₂S, is a high melting point solid which conducts electricity when molten. Carbon disulphide, CS₂, is a liquid which does not conduct electricity.

(i) Deduce the type of bonding present in Na₂S and that present in CS₂

Bonding in Na₂S

Bonding in CS₂.....

(ii) By reference to all the atoms involved explain, in terms of electrons, how Na₂S is formed from its atoms.

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(iii) Draw a diagram, including all the outer electrons, to represent the bonding present in CS_2

(iv) When heated with steam, CS_2 reacts to form hydrogen sulphide, H_2S , and carbon dioxide.

Write an equation for this reaction.

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(7)
(Total 16 marks)

10

Which one of the following is the electronic configuration of the strongest reducing agent?

A $1s^2 2s^2 2p^5$

B $1s^2 2s^2 2p^6 3s^2$

C $1s^2 2s^2 2p^6 3s^2 3p^5$

D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

(Total 1 mark)