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— **TUITION** —

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CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	ATOMIC STRUCTURE
PAPER TYPE:	QUESTION PAPER 5
TOTAL QUESTIONS	19
TOTAL MARKS	53

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Atomic structure

1. The first five successive ionization energies for element Z are shown.

Ionization number	1	2	3	4	5
Ionization energies(Kj/mol)	737.7	1450.7	7732.7	10542.5	13630

Based on this information, which element Y is most likely to be?

- A. Na
- B. Mg
- C. K
- D. Ca

[1]

2. Which of the following ions has an electron configuration similar to that of Argon?

- A. Na⁺ (sodium ion)
- B. Al³⁺ (aluminum ion)
- C. O²⁻ (oxygen ion)
- D. Cl⁻ (chloride ion)

[1]

3. Which atom has the smallest number of neutrons?

- A. ⁴He
- B. ³H
- C. ¹H
- D. ²H

[1]

4. An atom with only three unpaired electrons has which electron configuration?

- A. $1s^22s^22p^2$
- B. $1s^22s^22p^3$
- C. $1s^22s^22p^4$
- D. $1s^22s^22p^6$

[1]

5. Which atom exhibits the highest first ionisation energy?

- A. H
- B. Ne
- C. Ar
- D. Na

[1]

6. An unknown element X having two isotopes ^{35}X and ^{37}X in the ratio 3:1. Which of the following statements concerning the peaks in the X_2 mass spectrum is true?

- A. Peaks at $m/z = 70, 72$ and 74 in the ratio 9:6:1
- B. Peaks at $m/z = 70, 72$ and 74 in the ratio 9:3:1
- C. Peaks at $m/z = 70$ and 72 in the ratio 3:1
- D. Peaks at $m/z = 70$ and 74 in the ratio 3:1

[1]

7. The one with the highest initial ionisation energy is this.

- A. Na
- B. Mg
- C. Si
- D. Cl

[1]

8. Element X gives a sulfate with formula XSO_4

Which of these could represent an electronic representation of an X atom?

- A. $1s^2 2s^2 2p^6 3s^2$
- B. $1s^2 2s^2 2p^6 3s^2 3p^1$
- C. $1s^2 2s^2 2p^6 3s^2 3p^2$
- D. $1s^2 2s^2 2p^6 3s^1$

[1]

9. Electrospray ionisation is used to ionise molecule Y in a time-of-flight mass spectrometer.

What is the ionization equation?

- A. $Y_{(l)} + e^- \rightarrow Y^+_{(g)} + 2e^-$
- B. $Y^+_{(g)} + e^- \rightarrow Y^+_{(g)} + 2e^-$
- C. $Y_{(l)} + H^+ \rightarrow YH^+_{(g)}$
- D. $Y_{(g)} + H^+ \rightarrow YH^+_{(g)}$

[1]

10. What is the ground state electron configuration of Fe^{2+} ?

- A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$
- B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^1$
- C. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
- D. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

[1]

11. Which atom has three more protons and four more neutrons than the carbon atom?

- A. Ne (Neon)
- B. Si (Silicon)
- C. Cl (Chlorine)
- D. S (Sulfur)

[1]

12. Chlorine exists as two isotopes ^{35}Cl and ^{37}Cl , which are found in 3:1 abundance.

Which of the statements is correct?

- A. The first ionization energy of ^{35}Cl is less than first ionization energy of ^{37}Cl
- B. The atomic radius of ^{35}Cl is less than the atomic radius of ^{37}Cl
- C. The mass spectrum of $\text{C}_3\text{H}_7\text{Cl}$ has two molecular ion peaks at 35 and 37
- D. ^{35}Cl is more reactive than ^{37}Cl

[1]

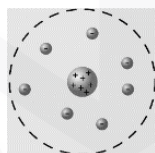
13. Which of the following options represents the electron configuration of an atom in a transition metal?

- A. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^0$
- B. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
- C. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$
- D. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$

[1]

14. Keeping in mind atomic structure, answer the following:

(a) According to Rutherford, the structure of an atom is given in a diagram.



Give two characteristics of the present model that the Rutherford model does not have.

[2]

(b) A time-of-flight mass spectrometer is used to evaluate a sample of neon. Electron impact causes the sample to get ionised, producing $1+$ ions.

The three peaks in this spectrum are described in the table below.

Percentage abundance	90.9	0.3	To be determined
m/z	20	21	22

Name the ion's symbol and mass number that hits the detector first.

[2]

(c) Determine neon's relative atomic mass.

[2]

15. The topic of this question is atomic structure.

(a) Define atomic number.

[1]

(b) Write the numbers of neutrons and electrons as.

	Number of protons	Number of electrons	Number of neutrons
^{56}Fe	26		
$^{56}\text{Fe}^{2+}$	26		

[1]

(c) A sample of nickel (Ni), contains four isotopes: ^{58}Ni , ^{60}Ni , ^{61}Ni , and ^{62}Ni .

This sample has a relative atomic mass of 58.7. In this sample, the ratio of abundance of isotopes ^{58}Ni , ^{60}Ni , and ^{62}Ni is 3:2:1.

What is the percentage abundance of ^{58}Ni in this nickel sample?

[2]

16. Regarding the time of flight (TOF) mass spectrometry, answer the following.

(a) What is relative atomic mass?

[1]

I am Sorry !!!!!

(b) Electron impact is used to ionise a neon sample. Three peaks can be seen in the mass spectrum of this neon sample.

Percentage abundance	90.9	0.3	8.8
m/z	20	21	22

Find the relative atomic mass (A_r) of this sample:

[2]

(c) A TOF mass spectrometer accelerates ions by

$$\text{K.E} = \frac{1}{2}mv^2$$

Where: KE = kinetic energy / J,

m = mass / kg ,

v = speed / m s⁻¹

Each ²⁰Ne⁺ ion is accelerated to a kinetic energy of 4.83×10^{-16} J, and the time of flight is 1.72×10^{-5} s.

Calculate the speed of the ²⁰Ne⁺ ion in meters per second.

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[4]

(d) Find the length of the TOF flight tube in metres.

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

[2]

17. This question is about the isotopes of an element X.

(a) Define term relative atomic mass.

[1]

(b) A sample of the isotopes ^{50}X , ^{52}X and ^{53}X has a relative atomic mass of 52.1. The sample contains 86.1% of the ^{52}X isotope.

Find the percentage abundance of each of the other two isotopes.

[2]

(c) Write **one** similarity and **one** difference between atoms of ^{50}X and ^{53}X

[2]

(d) Why it is necessary to ionise the isotopes write **two** reasons:

[2]

(e) A $^{53}\text{X}^+$ ion travels along a flight tube of length 1.25 m.

The ion has a constant kinetic energy (KE) of 1.102×10^{-13} J.

$$\text{K.E} = \frac{1}{2}mv^2$$

Where: KE = kinetic energy /J ,
 m = mass / kg, v = speed / m s^{-1}

Find the time, in s, for the $^{53}\text{X}^+$ ion to travel down the flight tube to fall on the detector.

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

[2]

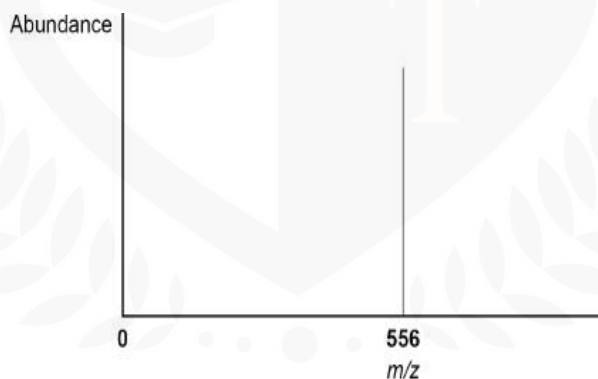
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18. As the atomic number rises, the first ionisation energies of the Period 3 elements vary.

Describe the trend in the elements' first ionisation energies from Sodium to Argon.

[4]

19. The diagram depicts the mass spectrum of biomolecule P after electrospray ionisation.



- (a) Explain the electrospray ionisation method.

Write an equation that describes how P is ionised throughout this process.

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[2]

(b) Which will be relative molecular mass of **P**?

- A. 555
- B. 556
- C. 557
- D. 540

[1]

(c) A molecule **X** is ionised in a TOF mass spectrometer.

The **X**⁺ ion has a kinetic energy of 2.09×10^{-15} J
This takes 1.23×10^{-5} s to reach the detector.

The length of the flight tube is 1.50 m

$$\text{K.E} = \frac{1}{2}mv^2$$

Where: KE = kinetic energy / J

m = mass / kg , v = speed / m s⁻¹

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

Calculate the relative molecular mass of **X**

[3]

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