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Physical Chemistry

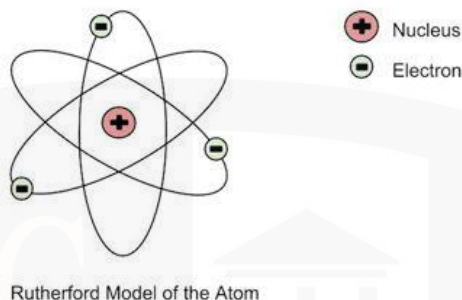
Level & Board	AQA (A-LEVEL)
TOPIC:	ATOMIC STRUCTURE
PAPER TYPE:	QUESTION PAPER -2
TOTAL QUESTIONS	11
TOTAL MARKS	40

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Atomic Structure - 2

1.

- (a) The model Rutherford proposed below illustrates an atom's structure.



State two features of the current model that differ from the Rutherford model.

(2)

- (b) In a time-of-flight mass spectrometer, an analysis was performed on a sample of Fe.

The sample was ionized using electron impact to create 1+ ions. The table below displays information about the four peaks in the spectrum, including their respective m/z values and percentage abundance:

m/z	Percentage Abundance
54	5.8%
56	91.8%
57	2.1%
58	To be determined

Your task is to provide the symbol, including the mass number, of the ion that reaches the detector first.

Calculate the relative atomic mass of Fe in this sample.

Give your answer to 1 decimal place.

(4)

2. In a time-of-flight mass spectrometer, molecule X is ionized using electrospray ionization. What is the equation for this ionization process?

- A. $X(l) + e^- \rightarrow X^+(g) + 2e^-$
 B. $X(g) + e^- \rightarrow X^+(g) + 2e^-$
 C. $X(l) + H^+ \rightarrow XH^+(g)$
 D. $X(g) + H^+ \rightarrow XH^+(g)$

(1)

3. Indicate which of the following options represents the correct electron configuration of V^{2+} in its ground state:

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

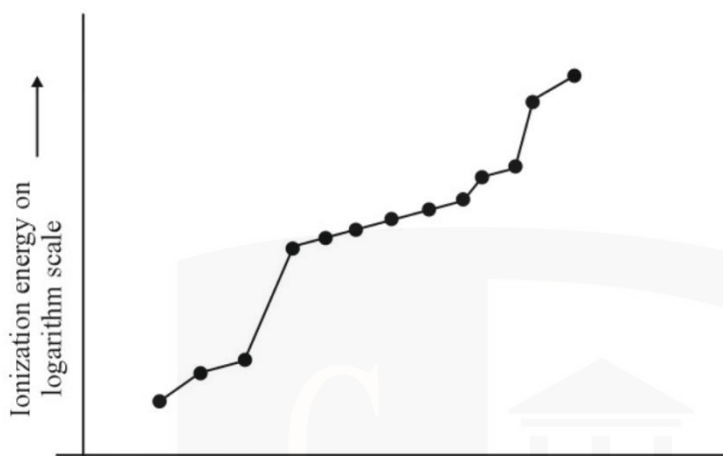
(1)

4. Which element has one additional proton and two extra neutrons compared to phosphorus?

- A. ${}_{16}^{33}P$
 B. ${}_{16}^{34}P$
 C. ${}_{16}^{33}S$
 D. ${}_{16}^{34}S$

(1)

5. The first seven successive ionization energies for element Z are displayed. What is the identity of element Z?



- A. Carbon
- B. Boron
- C. Silicon
- D. Aluminum

(1)

6. This question pertains to atomic structure.

(a) Please define the mass number of an atom.

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(2)

(b) Additionally, complete the information below to show the numbers of neutrons and electrons in the given species.

I am Sorry !!!!!

Isotope	Protons	Neutrons	Electrons
^{50}Cr	24		
$^{54}\text{Cr}^{2+}$	24		

A sample of Chromium contains five isotopes

^{56}Ni , ^{57}Ni , ^{58}Ni , ^{59}Ni , and ^{61}Ni

The relative atomic mass of this sample is 58.1.

The abundance ratio of isotopes ^{57}Ni , ^{58}Ni , ^{59}Ni , and ^{61}Ni is 2:2:1:2 respectively.

Can you calculate the percentage abundance of ^{56}Ni in this sample?

(3)

7. Which of the following ions has the electron configuration of a noble gas?

- A. H^+
- B. O^-
- C. S^{2-}
- D. Cr^{2+}

(1)

8. This question pertains to time of flight (TOF) mass spectrometry.

(a) Please define the term "relative atomic mass".

(1)

(b) A sample of Iron (Fe) was ionized using electron impact, resulting in a mass spectrum of Iron with four peaks.

The table below displays the data obtained from this spectrum:

Mass/charge ratio	Relative intensity
54	4
56	2
57	14
58	6

Your task is to calculate the relative atomic mass (A_r) of this sample of Iron.

Please provide your answer rounded to 1 decimal place.

(2)

(c) In a Time-of-Flight (TOF) mass spectrometer, all ions are accelerated to the same kinetic energy (KE) regardless of their mass.

The KE of an ion is calculated using the equation:

$KE = \frac{1}{2}mv^2$ (where m is the mass of the ion, v is its velocity, and KE is measured in joules).

In a TOF mass spectrometer, each $^{58}\text{Fe}^+$ ion is accelerated to a KE of 3.63×10^{-14} J, and the time it takes for the ion to travel to the detector is 1.20×10^{-3} s.

Calculate the length, in metres, of the TOF flight tube.

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

(4)

9. What is the atom with the smallest number of neutrons?

- A. ${}^3\text{H}$
- B. ${}^{11}\text{N}$
- C. ${}^{14}\text{N}$
- D. ${}^4\text{Li}$

(1)

10. What is the electron configuration of an atom with one unpaired electron?

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

(1)

11. This question is about the isotopes of Scandium.

(a) Give the meaning of the term relative atomic mass.

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(2)

(b) A sample of scandium containing the isotopes ${}^{43}\text{Sc}$, ${}^{45}\text{Sc}$, and ${}^{46}\text{Sc}$ has a relative atomic mass of 44.90.

The sample is composed of 76.1% ${}^{45}\text{Sc}$ isotope.

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

(4)

(c) In atoms of ^{43}Sc and ^{46}Sc state one similarity and one difference in terms of fundamental particles.

(2)

(d) The Scandium sample undergoes analysis using a time-of-flight (TOF) mass spectrometer.

Before being analyzed in a TOF mass spectrometer, the isotopes of Scandium must be ionized for two reasons. State reason.

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(2)

(e) A $^{43}\text{Sc}^+$ ion travels along a flight tube of length 1.35 m. The ion has a constant kinetic energy (KE) of 1.30×10^{-12} J

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

m = mass of the ion / kg


v = speed of ion / ms^{-1}

Calculate the time it takes for the $^{43}\text{Sc}^+$ ion to reach the detector by traveling down the flight tube.


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

(5)

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