

Atomic Structure and Mass Spectroscopy Questions

1. (a) Define the term *atomic number* of an atom.

.....

(1)

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

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(1)

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

Mass number	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* of an element.

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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) Explain why the first ionisation energy of krypton is greater than the first ionisation energy of bromine.

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(2)

(f) Explain why the first ionisation energy of rubidium is less than the first ionisation energy of krypton.

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(2)

(Total 12 marks)

2. (a) Give the symbol, including mass number and atomic number, for the isotope which has a mass number of 34 and which has 18 neutrons in each nucleus

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(2)

(b) Give the electronic configuration of the F^- ion in terms of levels and sub-levels.

.....

(1)

(c) Give a reason why it is unlikely that an F^- ion would reach the detector in a mass spectrometer.

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(1)

(d) Some data obtained from the mass spectrum of a sample of carbon are given below.

Ion	$^{12}\text{C}^+$	$^{13}\text{C}^+$
Absolute mass of one ion/g	1.993×10^{-23}	2.158×10^{-23}
Relative abundance/%	98.9	1.1

Use these data to calculate a value for the mass of one neutron, the relative atomic mass of ^{13}C and the relative atomic mass of carbon in the sample. You may neglect the mass of an electron.

Mass of one neutron.

Relative atomic mass of ^{13}C

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Relative atomic mass of carbon in the sample......

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.....

(6)

(Total 10 marks)

3. (a) Write equations to show the chemical processes which occur when the first and the second ionisation energies of lithium are measured.

First ionisation energy equation

Second ionisation energy equation

(3)

(b) (i) Explain why helium has a much higher first ionisation energy than lithium.

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(ii) Explain why beryllium has a higher first ionisation energy than boron.

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(iii) Explain why the second ionisation energy of beryllium is greater than the first ionisation energy.

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.....

(6)
(Total 9 marks)

4. (a) **Figure 1** contains data relating to the relative isotopic abundance of the element titanium, Ti.

Isotope	^{46}Ti	^{47}Ti	^{48}Ti	^{49}Ti	^{50}Ti
% abundance	8.02	7.31	73.81	5.54	5.32

Figure 1

(i) Explain what is meant by the term *relative isotopic abundance*.

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.....

(2)

(ii) Using the data from **Figure 1**, calculate the relative atomic mass, A_r , of titanium.

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(2)

(b) Bromine gas contains the isotopes ^{79}Br and ^{81}Br in almost equal proportions. Part of the spectrum of bromine gas, showing one of the peaks for the molecular ion Br_2^+ , is given in **Figure 2**.

(i) Complete **Figure 2** to show the full spectrum of the molecular ion peaks of Br_2^+ .

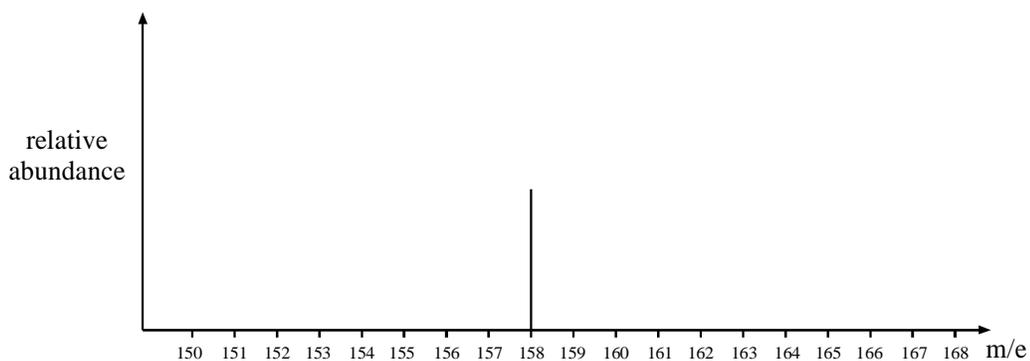


Figure 2

(3)

(ii) Explain the number of peaks present in your diagram.

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(1)

(iii) Explain the ratio of the heights of the peaks shown in your diagram.

.....
.....

(1)

(c) What mass of argon is contained in an 18.6dm^3 container at 20°C , if the pressure is 2.35 atm ?
Note: $1\text{atm} = 101325\text{ Pa}$.

(5)

- (d) Draw dot-and-cross diagrams to show the bonding in NH_3 and in CO_2 .

Diagram of NH_3

Diagram of CO_2

(2)
(Total 16 marks)

Section B

5. (a) Describe, in terms of charge and mass, the properties of protons, neutrons and electrons. Explain fully how these particles are arranged in an atom of ^{14}N .

(6)

- (b) Account for the existence of isotopes.

(2)

- (c) Isotopes can be separated in a mass spectrometer. Show how this is possible by describing the various parts of a mass spectrometer and by discussing the principles of operation of each part.

(14)

- (d) The mass spectrum of an element has peaks with relative intensity and m/z values shown in the table below.

m/z	80	82	83	84	86
Relative intensity	1	5	5	25	8

Identify this element and calculate its accurate relative atomic mass

(4)

- (e) The mass spectrum of a compound has a molecular ion peak at $m/z = 168$. Elemental analysis shows it to contain 42.9% carbon, 2.4% hydrogen and 16.7% nitrogen by mass. The remainder is oxygen.

Calculate the empirical and molecular formulae of this compound

(4)
(Total 30 marks)