

## Structured Questions

# The Nuclear Atom

Nuclear Model of the Atom / Subatomic Particles / Isotopes / Interpreting Mass Spectra (HL)

Easy (3 questions)	/17
Medium (3 questions)	/22
Hard (3 questions)	/26
<b>Total Marks</b>	<b>/65</b>

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# Easy Questions

1 (a) Deduce the missing information using section 6 of the data booklet, and complete the following table.

Symbol	Protons	Neutrons	Electrons
$^{23}\text{Na}$			
$^{32}\text{S}^{2-}$			
$^{86}\text{Sr}^{2+}$			

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(3 marks)

(b) A sample of Rh contains the following isotopes. Calculate the relative atomic mass of Rh in the sample. Give your answer to 2 dp.

Isotope	% Abundance
$^{101}\text{Rh}$	85
$^{102}\text{Rh}$	15

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(2 marks)

(c) Deduce the number of protons, neutrons and electrons in an atom of  $^{102}\text{Rh}$ .

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**(2 marks)**

- (d)** Give the atomic symbol of an element which has more protons than neutrons. Use its most common isotope.

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**(1 mark)**

2 (a) The atomic mass of each element in the periodic table is based on the carbon-12 scale.

Describe the composition of an atom of carbon-12.

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(1 mark)

(b) Carbon also exists as the isotope  $^{14}\text{C}$ . How does the composition of this isotope differ from that of carbon-12.

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(1 mark)

(c) The relative abundance of isotopes in a sample of carbon is 94%  $^{12}\text{C}$  and 6%  $^{14}\text{C}$ .

How would this information be obtained.

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(1 mark)

(d) Calculate the relative atomic mass of the carbon sample in part c)

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(1 mark)

- 3 (a)** Boron contains two isotopes  $^{10}\text{B}$  and  $^{11}\text{B}$  with a relative abundance of 20% and 80% respectively.

State the difference between these isotopes of boron.

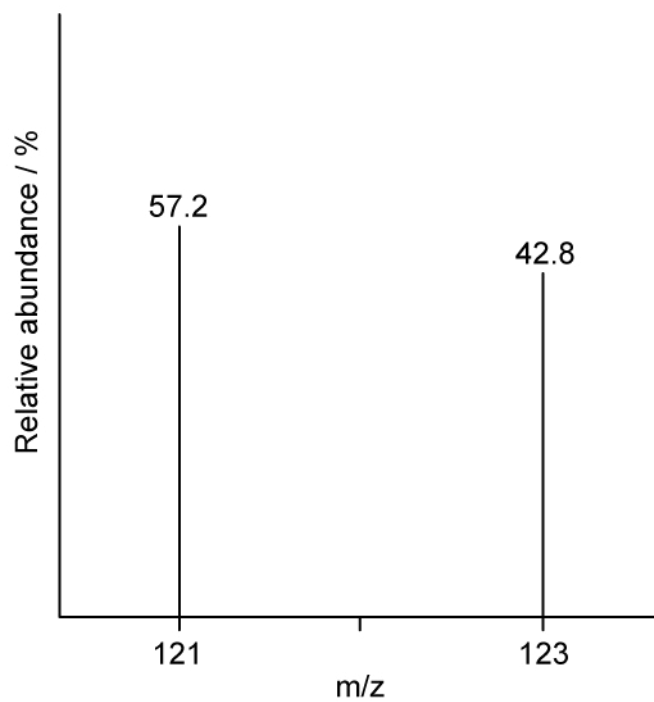
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**(1 mark)**

- (b)** A sample of antimony was analysed in the mass spectrometer and two main isotopes were found,  $^{121}\text{Sb}$  and  $^{123}\text{Sb}$ .

Calculate the number of protons and neutrons in both isotopes of antimony.

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**(3 marks)**

- (c)** The graph represents the mass spectrum of antimony. Use the information in the image to calculate the relative atomic mass of antimony.



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(1 mark)

# Medium Questions

1 (a) Using your knowledge of atomic structure, complete the table below for the particles found in an atom.

Particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

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(3 marks)

(b) The actual mass of protons, neutrons and electrons is given.

	Proton	Neutron	Electron
Mass (kg)	$1.672622 \times 10^{-27}$	$1.674927 \times 10^{-27}$	$9.109383 \times 10^{-31}$

Calculate the mass, in g, of a nitrogen molecule.

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(1 mark)

(c) Oxygen consists of three stable isotopes, oxygen-16, oxygen-17, and oxygen-18.

State the particles present in each isotope and outline what differences would be expected in the chemical reactivity of the three isotopes.

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**(2 marks)**

(d) Suggest why some elements have several isotopes and others, like fluorine, have only one known isotope (known as monoisotopic elements).

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**(1 mark)**



- 2 (a)** Nitrous oxide is used as a sedative in dentistry and has the formula  $\text{N}_2\text{O}$ . Different sources of  $\text{N}_2\text{O}$  contain different ratios of  $^{14}\text{N}$  and  $^{15}\text{N}$ .

State the name of the instrument used to distinguish between  $^{14}\text{N}$  and  $^{15}\text{N}$  and outline two characteristic differences seen in the analysis of  $^{14}\text{N}$  and  $^{15}\text{N}$ .

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**(2 marks)**

- (b)** A sample of nitrous oxide was enriched so that it contained 4% by mass of  $^{15}\text{N}$ . Calculate the relative molecular mass of the resulting nitrous oxide.

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**(2 marks)**

- (c)** Predict and explain, giving two reasons, how the first ionization energy of  $^{15}\text{N}$  would be different to  $^{14}\text{N}$ .

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**(3 marks)**

- (d)** An atom has twice as many protons, and twice as many neutrons, as an atom of  $^{15}\text{N}$ .

Determine the chemical symbol for this atom, including the mass number, and deduce the number of electrons.

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**(2 marks)**

3 (a) *A* and *B* are different chemical elements, from different groups in the Periodic Table.

State why  ${}^m\text{A}$  and  ${}^n\text{A}$  have identical chemical properties, but  ${}^m\text{A}$  and  ${}^p\text{B}$  have different chemical properties.

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(3 marks)

(b) Atoms are made up of three subatomic particles; protons, neutrons and electrons.

Particle	Proton	Neutron	Electron
Mass / kg	$1.673 \times 10^{-27}$	$1.675 \times 10^{-27}$	$9.000 \times 10^{-31}$

Calculate the mass of one atom of carbon in kg.

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(2 marks)

(c)  ${}^{12}\text{C}$ ,  ${}^{13}\text{C}$  and  ${}^{14}\text{C}$  are all isotopes of carbon.

State the difference between these three isotopes in terms of subatomic particles.

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(1 mark)

# Hard Questions

1 (a) Give the full electron configuration of the following atoms and ions.

i) Zinc (II) ion,  $\text{Zn}^{2+}$

[1]

ii) Copper (II) ion,  $\text{Cu}^{2+}$

[1]

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(2 marks)

(b) Chlorine has two naturally occurring isotopes,  $^{35}\text{Cl}$  with a mass of 34.969 and  $^{37}\text{Cl}$  with a mass of 36.966. The relative atomic mass of Cl is 35.5. Calculate the percentage abundance of each isotope.

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(3 marks)

(c) Predict whether the atomic radius of  $^{35}\text{Cl}$  or  $^{37}\text{Cl}$  would be the greater and give a reason for your answer.

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(2 marks)

(d) A sample of cerium, Ce, was analysed in a mass spectrometer. The relative abundances of three of the four main isotopes that were identified are shown in the table below.

A sample of cerium, Ce, has four isotopes that have a known relative abundance. This sample has an  $A_r$  of 140.12.

Isotope	$^{136}\text{Ce}$	$^{138}\text{Ce}$	$^{140}\text{Ce}$	$^m\text{Ce}$
Abundance (%)	0.19	0.25	88.45	To be calculated

Use the data from the table to calculate  $m$ , the mass number and the percentage abundance of isotope  $^m\text{Ce}$ .

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**(4 marks)**

- 2 (a) A sample of element Z was extracted from a meteorite. The table shows the relative abundance of each isotope in a mass spectrum of this sample of Z. Calculate the relative atomic mass of Z and suggest an identity of Z. Give your answer to 1 d.p.

m/z value	64	66	67	68
Relative abundance (%)	38.9	27.8	14.7	18.6

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**(3 marks)**

- (b) A naturally occurring sample of the element boron, B, has two isotopes of mass 10 and 11, and a relative atomic mass of 10.8.

Calculate the relative abundances of both isotopes in the sample of boron, B.

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**(3 marks)**

- (c) Give the full electron configuration of the Cu<sup>+</sup> ion.

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**(1 mark)**

- (d) Calculate the percentage abundance of <sup>63</sup>Cu with a mass of 62.9296 and <sup>65</sup>Cu with a mass of 64.9278, when the average mass of the Cu isotope is 63.546. Give your answer to an appropriate number of significant figures.

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**(3 marks)**

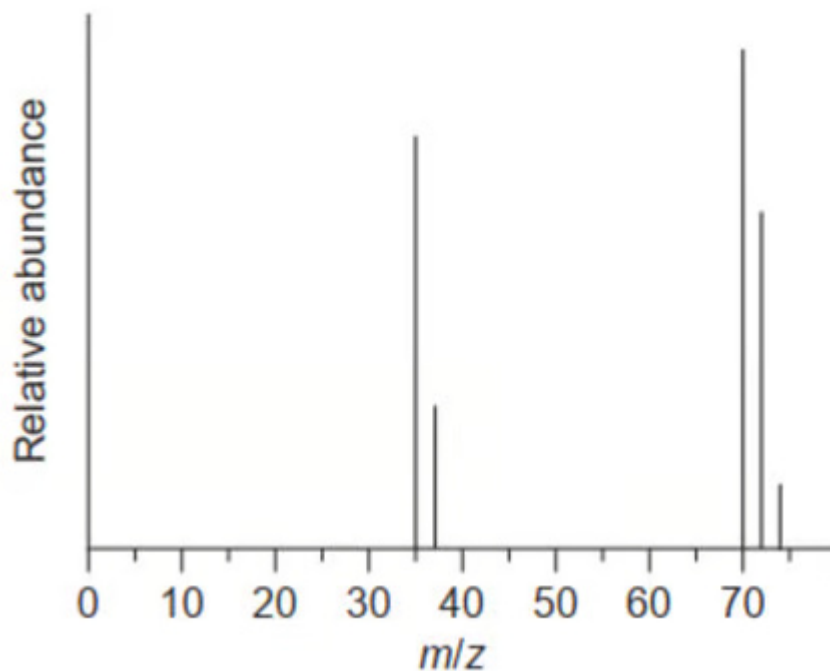
3 (a) Outline why the chlorine atom has a smaller atomic radius than the sulfur atom.

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(2 marks)

(b) The mass spectrum of chlorine gas is shown.



Outline the reason for the two peaks at  $m/z = 35$  and  $37$ .

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(1 mark)

(c) Explain the presence and relative abundance of the peak at  $m/z = 74$ .

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(2 marks)