

F321: Atoms, Bonds and Groups

Atoms, Isotopes and Relative Atomic Masses

70 Marks

1. Isotopes of europium have differences and similarities.

- (i) In terms of protons, neutrons and electrons, how is an atom of ^{151}Eu **different** from an atom of ^{153}Eu ?

.....
.....

[1]

- (ii) In terms of protons, neutrons and electrons, how is an atom of ^{151}Eu **similar** to an atom of ^{153}Eu ?

.....
.....

[1]

[Total 2 marks]

2. Europium, atomic number 63, is used in some television screens to highlight colours. A chemist analysed a sample of europium using mass spectrometry. The results are shown in the table below.

isotope	relative isotopic mass	abundance (%)
^{151}Eu	151.0	47.77
^{153}Eu	153.0	52.23

- (a) Define the term *relative isotopic mass*.

.....
.....
.....
.....

[2]

- (b) Using the table above, calculate the relative atomic mass of the europium sample.
Give your answer to **two** decimal places.

answer = ...

[2]

[Total 4 marks]

3. Carbon occurs in a wide range of compounds and is essential to living systems.

Two isotopes of carbon are ^{12}C and ^{13}C .

- (i) State what is meant by the term *isotopes*.

.....
.....

[1]

- (ii) Isotopes of carbon have the same chemical properties.

Explain why.

.....
.....

[1]

- (iii) The ^{12}C isotope is used as the standard measurement of relative masses.

Define the term *relative isotopic mass*.

.....
.....
.....
.....

[2]

[Total 4 marks]

4. The Group 2 element magnesium was first isolated by Sir Humphry Davy in 1808.

Magnesium has three stable isotopes, which are ^{24}Mg , ^{25}Mg and ^{26}Mg .

- (i) Complete the table below to show the atomic structures of ^{24}Mg and ^{25}Mg .

	protons	neutrons	electrons
^{24}Mg			
^{25}Mg			

[2]

- (ii) A sample of magnesium contained ^{24}Mg : 78.60%; ^{25}Mg : 10.11%; ^{26}Mg : 11.29%.

Calculate the relative atomic mass of this sample of Mg.

Give your answer to **four** significant figures.

answer = ...

[2]

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

.....

.....

.....

.....

.....

[3]

[Total 7 marks]

5. The Group 7 element bromine was discovered by Balard in 1826. Bromine gets its name from the Greek *bromos* meaning stench.

Bromine consists of a mixture of two isotopes, ^{79}Br and ^{81}Br .

- (i) What is meant by the term *isotopes*?

.....

.....

[1]

- (ii) Complete the table below to show the atomic structures of the bromine isotopes.

	protons	neutrons	electrons
^{79}Br			
^{81}Br			

[2]

- (iii) Write the full electronic configuration of a bromine atom.

$1s^2$

[1]

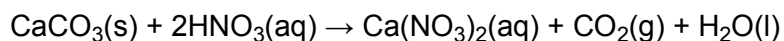
[Total 4 marks]

6. Calcium and its compounds, have properties typical of Group 2 in the Periodic Table.

Calcium carbonate, CaCO_3 , reacts with acids such as nitric acid.

A student neutralised 2.68 g of CaCO_3 with 2.50 mol dm^{-3} nitric acid, HNO_3 .

The equation for this reaction is shown below.



The student left the solution of calcium nitrate formed to crystallise. Crystals of hydrated calcium nitrate formed containing 30.50% of H_2O , by mass.

Calculate the formula of the hydrated calcium nitrate.

[Total 3 marks]

7. Rubidium, atomic number 37, was discovered in 1861 by Bunsen and Kirchoff. Rubidium is in Group 1 of the Periodic Table and the element has two natural isotopes, ^{85}Rb and ^{87}Rb .

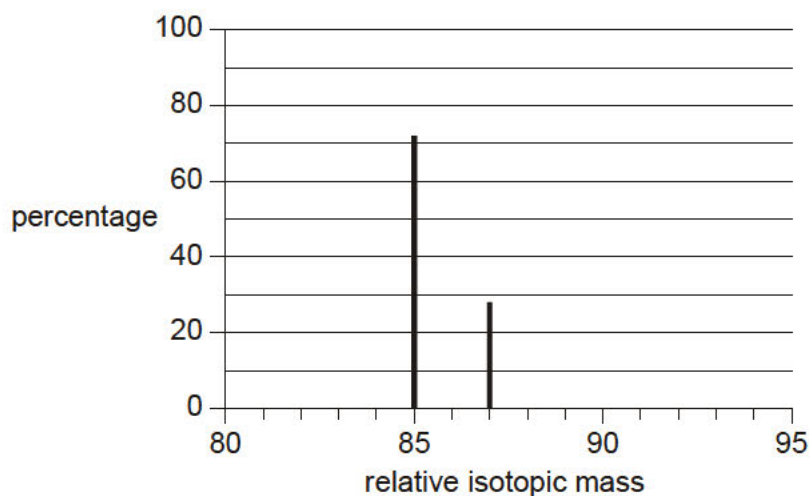
(a) Explain the term *isotopes*.

.....

.....

[1]

(b) A sample of rubidium was analysed in a mass spectrometer to produce the mass spectrum below.



(i) Use this mass spectrum to help you complete the table below.

isotope	percentage	number of		
		protons	neutrons	electrons
^{85}Rb				
^{87}Rb				

[3]

(ii) Calculate the relative atomic mass of this rubidium sample. Give your answer to three significant figures.

$$A_r = \dots\dots\dots$$

[2]

- (c) Which isotope is used as the standard against which the masses of the two rubidium isotopes are measured?

.....

[1]

[Total 7 marks]

8. Magnesium exists naturally as a mixture of its isotopes, ^{24}Mg , ^{25}Mg and ^{26}Mg .

The isotopes in magnesium can be separated by mass spectrometry. The diagram below shows a mass spectrometer.

- (i) Complete the table below to show the composition of the ^{25}Mg and ^{26}Mg isotopes.

	protons	neutrons	electrons
^{25}Mg			
^{26}Mg			

[2]

- (ii) Complete the electronic configuration of an atom of ^{24}Mg .

$1s^2$

[1]

- (iii) Results from the mass spectrum of a sample of magnesium are shown below.

isotope	^{24}Mg	^{25}Mg	^{26}Mg
relative isotopic mass	24.00	25.00	26.00
% abundance	78.60	10.11	11.29

Calculate the relative atomic mass of the sample of magnesium.
Give your answer to two decimal places.

answer

[2]

[Total 5 marks]

9. Antimony, Sb, is a metal used in alloys to make lead harder. Bullets contain about 1% of antimony for this reason.

Antimony has two main isotopes.

- (i) What do you understand by the term *isotopes*?

.....

.....

[1]

- (ii) Complete the table below to show the properties of particles that make up isotopes.

	proton	neutron	electron
relative mass			
relative charge			

[2]

[Total 3 marks]

10. Relative atomic mass, A_r , can be used to compare the masses of atoms of different elements.

- (i) Explain what you understand by the term *relative atomic mass*.

.....

.....

.....

[3]

- (ii) The antimony in a bullet was analysed by a forensic scientist to help solve a crime. The antimony was found to have the following percentage composition by mass: ^{121}Sb , 57.21%; ^{123}Sb , 42.79%.

Calculate a value for the relative atomic mass of the antimony. Give your answer to 4 significant figures.

A_r

[2]

[Total 5 marks]

11. Carbon is in the p-block of the Periodic Table. Naturally occurring carbon contains a mixture of two isotopes, ^{12}C and ^{13}C .

Complete the table below for the atomic structure of the isotopes ^{12}C and ^{13}C .

isotope	protons	neutrons	electrons
^{12}C			
^{13}C			

[Total 2 marks]

12. A sample of carbon was found to contain 95% of ^{12}C and 5% of ^{13}C .

- (i) How could this information be obtained experimentally?

.....

[1]

- (ii) The ^{13}C isotope has a relative isotopic mass of 13.00.
Define the term *relative isotopic mass*.

.....
.....
.....

[2]

- (iii) Calculate the relative atomic mass of this sample of carbon to three significant figures.

$A_r =$

[2]

[Total 5 marks]

13. The element titanium, Ti, atomic number 22, is a metal that is used in the aerospace industry for both airframes and engines.

A sample of titanium for aircraft construction was analysed using a mass spectrometer and was found to contain three isotopes, ^{46}Ti , ^{47}Ti and ^{48}Ti . The results of the analysis are shown in the table below.

isotope	^{46}Ti	^{47}Ti	^{48}Ti
relative isotopic mass	46.00	47.00	48.00
percentage composition	8.9	9.8	81.3

- (a) (i) Explain the term *isotopes*.

.....

[1]

- (ii) Complete the table below for atoms of two of the titanium isotopes.

isotope	protons	neutrons	electrons
^{46}Ti			
^{47}Ti			

[2]

- (b) Using the information in the first table, calculate the relative atomic mass of this sample of titanium.

Give your answer to three significant figures.

[2]

[Total 5 marks]

14. The Group 7 element bromine was discovered in 1826. Bromine gets its name from the Greek *brōmos* meaning stench because of its strong smell.

Bromine consists of a mixture of two isotopes, ^{79}Br and ^{81}Br .

- (i) What is the difference between the atomic structures of ^{79}Br and ^{81}Br ?

.....

[2]

- (ii) State **two** similarities between the atomic structures of ^{79}Br and ^{81}Br .

.....

.....

[2]

[Total 4 marks]

- 15.** A fifty pence coin contains nickel alloyed with a metal **A**.

Nickel exists as a mixture of three isotopes, nickel-58, nickel-60 and nickel-62.

Complete the table below to show the atomic structures of the isotopes in metallic nickel.

isotope	protons	neutrons	electrons
nickel-58			
nickel-60			
nickel-62			

[Total 3 marks]

- 16.** Metal **A** can be identified from its relative atomic mass.

Analysis of a fifty pence coin showed that two isotopes of metal **A** were present with the following percentage abundances.

isotope	isotope 1	isotope 2
relative isotopic mass	63.0	65.0
% abundance	77.2	22.8

- (i) What analytical method is used to obtain this information?

.....

[1]

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

.....

.....

.....

.....

[3]

- (iii) Calculate the relative atomic mass of the sample of metal **A**.

Give your answer to three significant figures.

answer

[2]

- (iv) Use your answer to (iii) and the Data Sheet to suggest the identify of metal **A**.

.....

[1]

[Total 7 marks]