

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]

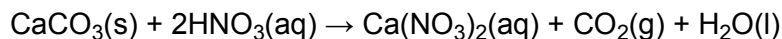
[Total 4 marks]

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]

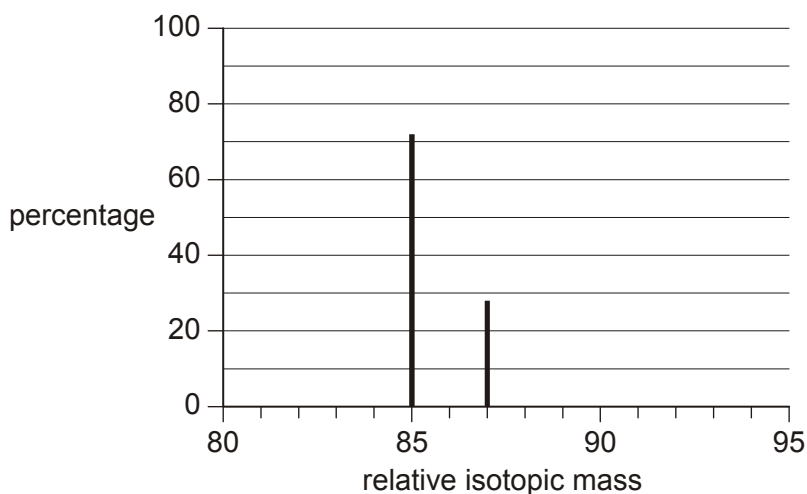
7. Rubidium, atomic number 37, was discovered in 1861 by Bunsen and Kirchoff. Rubidium is in Group 1 of the Periodic Table and the element has two natural isotopes, ^{85}Rb and ^{87}Rb .

(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]