

# 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  $^{151}\text{Eu}$  **different** from an atom of  $^{153}\text{Eu}$ ?

.....  
.....

[1]

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

.....  
.....

[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 (%)
$^{151}\text{Eu}$	151.0	47.77
$^{153}\text{Eu}$	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  $^{12}\text{C}$  and  $^{13}\text{C}$ .

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

.....  
.....

[1]

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

Explain why.

.....  
.....

[1]

- (iii) The  $^{12}\text{C}$  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  $^{24}\text{Mg}$ ,  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$ .

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

	protons	neutrons	electrons
$^{24}\text{Mg}$			
$^{25}\text{Mg}$			

[2]

(ii) A sample of magnesium contained  $^{24}\text{Mg}$ : 78.60%;  $^{25}\text{Mg}$ : 10.11%;  $^{26}\text{Mg}$ : 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,  $^{79}\text{Br}$  and  $^{81}\text{Br}$ .

- (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
$^{79}\text{Br}$			
$^{81}\text{Br}$			

[2]

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

$1s^2$  .....

[1]

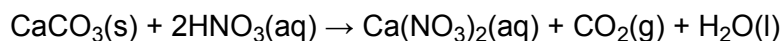
[Total 4 marks]

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

Calcium carbonate,  $\text{CaCO}_3$ , reacts with acids such as nitric acid.

A student neutralised 2.68 g of  $\text{CaCO}_3$  with  $2.50 \text{ mol dm}^{-3}$  nitric acid,  $\text{HNO}_3$ .

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  $\text{H}_2\text{O}$ , by mass.

Calculate the formula of the hydrated calcium nitrate.

[Total 3 marks]

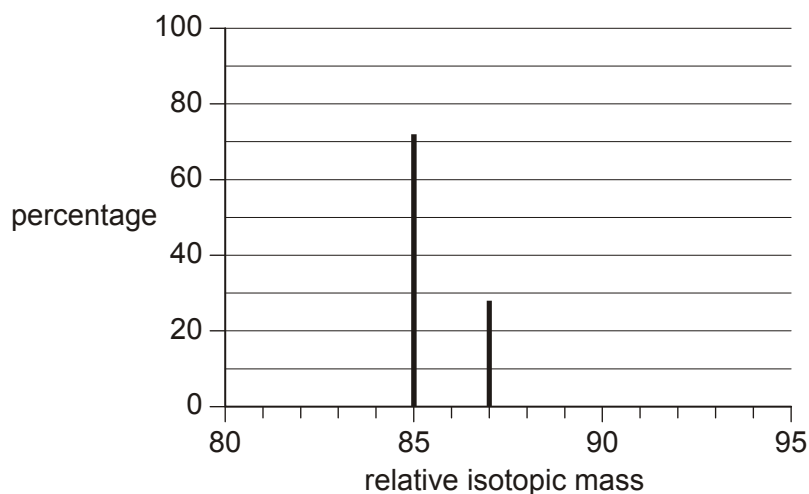
7. Rubidium, atomic number 37, was discovered in 1861 by Bunsen and Kirchoff. Rubidium is in Group 1 of the Periodic Table and the element has two natural isotopes,  $^{85}\text{Rb}$  and  $^{87}\text{Rb}$ .

(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
$^{85}\text{Rb}$				
$^{87}\text{Rb}$				

[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,  $^{24}\text{Mg}$ ,  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$ .

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  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$  isotopes.

	protons	neutrons	electrons
$^{25}\text{Mg}$			
$^{26}\text{Mg}$			

[2]

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

$1s^2$  .....

[1]

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

isotope	$^{24}\text{Mg}$	$^{25}\text{Mg}$	$^{26}\text{Mg}$
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:  $^{121}\text{Sb}$ , 57.21%;  $^{123}\text{Sb}$ , 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,  $^{12}\text{C}$  and  $^{13}\text{C}$ .

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

isotope	protons	neutrons	electrons
$^{12}\text{C}$			
$^{13}\text{C}$			

[Total 2 marks]

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

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

.....

[1]

- (ii) The  $^{13}\text{C}$  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,  $^{46}\text{Ti}$ ,  $^{47}\text{Ti}$  and  $^{48}\text{Ti}$ . The results of the analysis are shown in the table below.

isotope	$^{46}\text{Ti}$	$^{47}\text{Ti}$	$^{48}\text{Ti}$
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
$^{46}\text{Ti}$			
$^{47}\text{Ti}$			

[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,  $^{79}\text{Br}$  and  $^{81}\text{Br}$ .

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

.....  
 .....

[2]

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

.....  
.....

[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]