Atoms, Isotopes and Relative Atomic Masses

Total mark – 17

Question: 1

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]

1. (i) ^{153}Eu has (2) more neutrons

OR

^{153}Eu has 90 neutrons **AND** ^{151}Eu has 88 neutrons ✓

ALLOW *There are a different number of neutrons*
IGNORE *Correct references to protons / electrons*
DO NOT ALLOW *Incorrect references to protons / electrons*

1

(ii) (It has the) same number of protons **AND** electrons

OR

Both have 63 protons and 63 electrons ✓

ALLOW *Same number of protons* ***AND*** *same electron configuration*

DO NOT ALLOW *'Same number of protons' without reference to electrons (and vice versa)*

1

[2]

Question: 2

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]

2. (a) **Mass** of the **isotope** compared to 1/12th
OR
mass of the **atom** compared to 1/12th ✓

(the mass of a) carbon-12 **OR** ^{12}C (atom) ✓

IGNORE *Reference to average* ***OR*** *weighted mean (i.e. correct definition of relative atomic mass will score both marks)*

ALLOW *mass of a* ***mole*** *of the isotope/atom with 1/12th the mass of a* ***mole OR*** *12* ***g*** *of carbon-12 for two marks.*

ALLOW 2 marks for:

*'****Mass*** *of the isotope* ***OR mass*** *of the atom compared to* ^{12}C *atom given a mass of 12.0'*
i.e. 'given a mass of 12' ***OR*** *C12 is 12 communicates the same idea as 1/12th.'*

ALLOW *12C* ***OR*** *C12*

ALLOW 2 marks for:

$$\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon} - 12}$$

i.e. fraction is equivalent to 'compared to'

ALLOW 1 mark for *a mix of mass of atom and mass of mole of atoms, i.e. 'mass of the isotope/mass of an atom compared with 1/12th the mass of a* ***mole OR*** *12 g of carbon-12.'*

DO NOT ALLOW *mass of 'ions' OR mass of element*

2

(b) $\frac{(151 \times 47.77) + (153 \times 52.23)}{100}$

OR

72.1327 + 79.9119
OR

152.0446 (calculator value) ✓

$A_r = 152.04$ ✓

ALLOW *Correct answer for two marks*

ALLOW *One mark for ECF from transcription error in first sum provided final answer is to 2 decimal points and is to between 151 and 153 and is a correct calculation of the transcription*

2

[4]

Question: 3

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]

3. (i) (atoms of the) same element **OR** same atomic no.
OR no. of protons

AND

with different numbers of neutrons **OR** different masses ✓

IGNORE *'same number of electrons'*

DO NOT ALLOW *'different numbers of electrons'*

DO NOT ALLOW *'different relative atomic masses'*

DO NOT ALLOW *'elements with different numbers of neutrons'* ***without*** *mention of same protons* ***OR*** *same atomic number*

1

(ii) **same** (number of) **electrons** (in the outer shell)

OR

same **electron** configuration **OR** structure ✓

DO NOT ALLOW *different number of protons*

IGNORE *'same number of protons'*

IGNORE *'they are both carbon'* ***OR*** *'they are both the same element'*

1

Question: 4

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]

4. (i)

	protons	**neutrons**	**electrons**
^{24}Mg	12	12	12
^{25}Mg	12	13	12

^{24}Mg line correct ✓
^{25}Mg line correct ✓
mark by ***row***

2

(ii) $\frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100}$

OR 18.8640 + 2.5275 + 2.9354

OR 24.3269 ✓

A_r = 24.33 (to 4 sig figs) ✓

ALLOW *two marks for A_r = 24.33 with no working out*

ALLOW *one mark for ecf from incorrect sum provided final answer is between 24 and 26 and is to 4 significant figures, e.g. 24.3235 ✗ gives ecf of 24.32 ✓*

2

Question: 5

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]

5.	(i)	atoms of the same element with different numbers of neutrons/different masses **(1)**	1
	(ii)	^{79}Br 35 protons, 44 neutrons, 35 electrons **(1)** ^{81}Br 35 protons, 46 neutrons, 35 electrons **(1)**	2
	(iii)	$(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^5$ **(1)**	1

Question: 6

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.

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

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]

6. Molar mass of anhydrous calcium nitrate = 164.1 g mol^{-1} **(1)**
Ratio $Ca(NO_3)_2 : H_2O$ = 69.50/164.1 : 30.50/18
or 0.4235 : 1.694 or 1 : 4 **(1)**
Formula = $Ca(NO_3)_2 \cdot 4H_2O$ **(1)**

[3]