

1.2 ISOTOPES

Learning outcomes

Candidates should be able to:

1. Define the term isotope in terms of the number of protons and neutrons
2. Understand the notation ${}^x_y\text{A}$ for isotopes, where x is the mass or nucleon number and y is the atomic or proton number
3. State that and explain why isotopes of the same element have the same chemical properties
4. State that and explain why isotopes of the same element have different physical properties, limited to mass and density

Introduction

- All atoms of the same element have the same number of protons. However, they may have different numbers of neutrons. **Atoms of the same element that have different numbers of neutrons** are called isotopes.
- Isotopes are atoms of the same element with different mass numbers.
- Isotopes of a particular element have the **same chemical properties** because they have **the same number of electrons**.
- They have slightly different physical properties, such as small differences in density or mass, due to their varying numbers of neutrons.

1. Potassium also has two stable isotopes. Both isotopes have the same chemical properties.
Explain why both isotopes of potassium have the same chemical properties.

[1]

2. A sample of magnesium contains three isotopes, ${}^{25}\text{Mg}$, ${}^{26}\text{Mg}$ and **X**.
The percentage abundance of the three isotopes is shown in Table 1.1.

isotope of Mg	Mass /a.m.u.	percentage abundance /%
X		78.99
${}^{25}\text{Mg}$	24.99	10.00
${}^{26}\text{Mg}$	25.98	11.01

- State **one** similarity and **one** difference in the properties of these isotopes of magnesium.
Explain your answer.

[2]

3. *Hydron* is a general term used to represent the ions ${}^1\text{H}^{+1}$, ${}^2\text{H}^{+1}$ and ${}^3\text{H}^{+1}$.
State, in terms of subatomic particles in the nucleus, what is the same about each of these ions and what is different?

[1]

4. Complete Table 2.2 to show the numbers of protons and neutrons in the isotopes of magnesium. [2]

isotope	number of protons	number of neutrons
magnesium-24		
magnesium-25		
magnesium-26		

5. Atoms with nuclei containing an odd number of protons tend to have fewer isotopes than those with an even number of protons.

Gallium has two stable isotopes, ^{69}Ga and ^{71}Ga .

Complete Table 1.1 to show the numbers of protons, neutrons and electrons in the two stable isotopes of gallium. [2]

isotope	number of protons	number of neutrons	number of electrons
^{69}Ga			
^{71}Ga			

6. Pelopium was the suggested name for a new element discovered in a mineral.

Pelopium was later found to be a mixture of niobium, Nb, and tantalum, Ta.

Only one naturally occurring isotope exists for each of Nb and Ta.

Complete Table 1.1.

[2]

isotope	relative isotopic mass	number of protons	number of neutrons
$^{93}_{41}\text{Nb}$	92.91		
$^{181}_{73}\text{Ta}$	180.95		

7. Table 1.1 gives some details of the stable naturally occurring isotopes of rhodium and iridium.

Table 1.1

isotope	number of protons	number of neutrons	total number of electron shells
$^{103}_{45}\text{Rh}$		58	
$^{191}_{77}\text{Ir}$			6
$^{193}_{77}\text{Ir}$			6

Complete the table.

[2]

8. Table 1.2 shows the relative abundances of isotopes in a sample of an alloy containing rhodium and iridium only.

isotope	relative isotopic mass	relative abundance in alloy
$^{103}_{45}\text{Rh}$	102.91	50.00
$^{191}_{77}\text{Ir}$	190.96	15.18
$^{193}_{77}\text{Ir}$	192.96	34.82

- (i) Use Table 1.2 to calculate the relative atomic mass, A_r , of iridium in the alloy.
Give your answer to two decimal places.

relative atomic mass of iridium = [2]

1. The table shows the numbers of protons, neutrons and electrons in four different particles, W, X, Y, and Z.

	number of protons	number of neutrons	number of electrons
W	32	40	32
X	32	40	34
Y	32	42	32
Z	34	40	34

Which pair represents the atoms of two isotopes of the same element?

- A** W and Y **B** W and Z **C** X and Y **D** X and Z

2. A single ^{32}P nucleus can be produced when a single ^{32}S nucleus joins with particle X. In the process, a proton is emitted.
What is particle X?

- A** a deuteron, $^2\text{H}^+$ **B** an electron **C** a neutron **D** a proton

9. Chromium, Cr, and its compounds are widely used in many chemical reactions.

(a) Cr exists as four stable isotopes.

(i) The most common isotope of Cr is chromium-52.

Determine the number of protons, neutrons and electrons in an atom of chromium-52.

number of protons neutrons electrons [1]

(ii) Describe how an atom of chromium-54 differs from an atom of chromium-52. Refer to numbers of particles in your answer.

.....

..... [1]

(iii) The relative isotopic masses of the isotopes of Cr can be determined using mass spectrometry. State what other information is needed to calculate the relative atomic mass, A_r , of Cr.

..... [1]

(iv) Atoms of ^{52}Cr , ^{53}Cr and ^{54}Cr make up more than 95% of naturally occurring chromium atoms. The A_r of naturally occurring Cr is 51.996. Suggest what these statements imply about the relative isotopic mass of the fourth stable isotope of chromium.

..... [1]

10. Manganese, Mn, and its compounds are widely used in many chemical reactions.

(a) Mn is usually found as a single isotope, manganese-55.

(i) Determine the number of protons, neutrons and electrons in an atom of manganese-55.

number of protons neutrons electrons [1]

(iii) A sample of manganese from the Moon is found to contain manganese-53 in addition to manganese-55. State the two pieces of information needed to determine the relative atomic mass, A_r , of manganese in this sample.

1

2 [2]

(b) The shorthand electronic configuration of manganese is $[\text{Ar}] 3d^5 4s^2$.

(i) Complete the full electronic configuration of manganese.

..... $3d^5 4s^2$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of manganese.

..... [1]

*****This is not a complete note. It is to guide you. It is recommended to study the prescribed textbooks along with this material. *****