

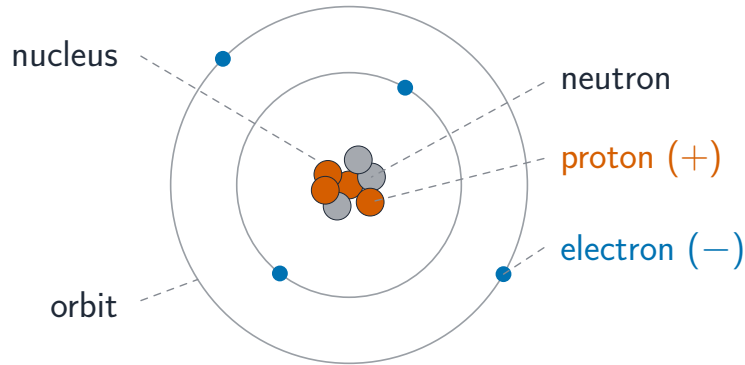
Exercise walk-through

5.1

The nuclear model of the atom

IGCSE Physics

Read the atom from its nucleus



Model of the atom; not to scale.

A tiny positive **nucleus** holds nearly all the mass. Negative electrons move around it; most of the atom is empty space.



Z counts protons and identifies the element.
 A counts protons plus neutrons.

A neutral atom has one electron for each proton.

Try it: which particles does the notation count?

A neutral boron atom has nucleon number 11 and proton number 5.



Find its numbers of protons, neutrons and electrons. Explain why the number of electrons is not subtracted from 11.

Now compare the neutral atoms ${}^{12}_6\text{C}$ and ${}^{14}_6\text{C}$.

What changes? What stays the same? Explain why they are **isotopes** of one element.

Count nucleons first, then use neutrality

The nucleon number counts particles in the nucleus; electrons are outside it.

$$N = A - Z = 11 - 5 = 6 \quad \text{neutrons in boron}$$

Neutral atom	Protons	Neutrons	Electrons
${}^1_5\text{B}$	5	6	5
${}^{12}_6\text{C}$	6	6	6
${}^{14}_6\text{C}$	6	8	6

Both carbon atoms have six protons, so they are the same element. Their different neutron counts give different nucleon numbers.

Isotopes have the same Z but different A . Neutral isotopes also have the same electron count and similar chemical behaviour.

Try it: does a positive ion gain a proton?

A neutral sodium atom has 11 protons, 12 neutrons and 11 electrons. It **loses one electron** to form an **ion** .

Write the new particle counts and the sign of its charge. Has the element changed?
Have A or Z changed?

A neutral chlorine atom has 17 protons, 18 neutrons and 17 electrons. It **gains one electron**.

Predict its charge. Explain both signs by comparing positive and negative charges.

Ion formation changes electrons, not the nucleus

After the change	Protons	Neutrons	Electrons
Sodium loses one electron	11	12	10
Chlorine gains one electron	17	18	18

Each proton has relative charge $+1$; each electron has relative charge -1 ; neutrons carry no charge.

$$q_{\text{rel}} = N_{\text{p}} - N_{\text{e}} = 11 - 10 = +1 \quad (\text{Na}^+)$$

$$q_{\text{rel}} = N_{\text{p}} - N_{\text{e}} = 17 - 18 = -1 \quad (\text{Cl}^-)$$

Losing electrons makes a positive ion; gaining electrons makes a negative ion. Neither process changes A , Z or the element.

Exercises 2.1·2.2

2.1 State what is meant by an isotope.

[1]

2.2 For ${}_{11}^{23}\text{Na}$, write down the number of protons and the number of neutrons.

[2]

Exercises 2.1·2.2

2.1 State what is meant by an isotope. [1]

2.1

- atoms of the same element (same proton number) with different numbers of neutrons
-

2.2 For ${}_{11}^{23}\text{Na}$, write down the number of protons and the number of neutrons. [2]

2.2

- protons = 11
- neutrons = $23 - 11 = \mathbf{12}$

Exercise 3.1

3.1 In the alpha-scattering experiment, most alpha particles pass straight through the foil. This shows the atom is: [1]

☐

A solid throughout

B mostly empty space

C negatively charged

D very large

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3.1 B

- most passing straight through shows the atom is mostly empty space

Exercise 3.2 (a)

3.2 The nuclide ${}^{40}_{19}\text{K}$ is given.

(a) State the number of protons, neutrons and electrons in a neutral atom. [3]

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(a) State the number of protons, neutrons and electrons in a neutral atom. [3]

(a) protons = 19

- neutrons = $40 - 19 = \mathbf{21}$
- electrons = 19

Exercise 3.2 (b)

3.2 The nuclide ${}^{40}_{19}\text{K}$ is given.

(b) An isotope of potassium is ${}^{39}_{19}\text{K}$. State how its nucleus differs from ${}^{40}_{19}\text{K}$. [1]

Exercise 3.2 (b)

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(b) An isotope of potassium is ${}^{39}_{19}\text{K}$. State how its nucleus differs from ${}^{40}_{19}\text{K}$. [1]

(b) it has one fewer neutron (20 instead of 21)

Exercise 3.3

3.3 Explain why a very few alpha particles bounce almost straight back off the gold foil.[2]

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3.3

- the nucleus is very small, very dense and positively charged
- a head-on approach is strongly repelled, so the positive alpha particle bounces back