Exercise walk-through

Particles in the atom and atomic radius ▪ 1.1

eXercise

You must be able to

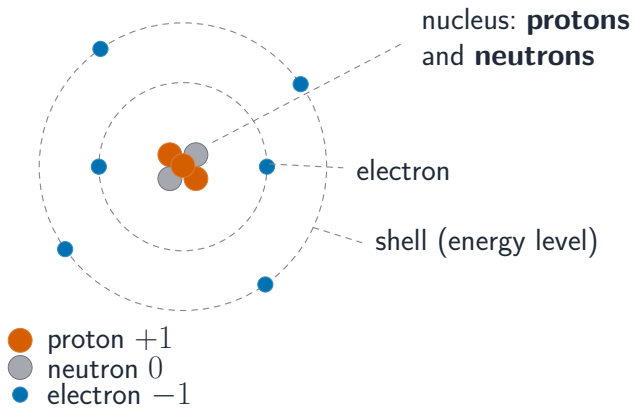
- describe the relative charge and mass of protons, neutrons and electrons
- count protons, neutrons and electrons in an atom or ion from Z, A and charge
- describe the behaviour of particle beams in an electric field and explain radius trends

Method — The sub-atomic particles

particle	relative charge	relative mass
proton	$+1$	1
neutron	0	1
electron	-1	$\frac{1}{1836}$ (≈ 0)

Proton number Z = protons; **nucleon number** A = protons + neutrons; neutrons $= A - Z$. In an ion, electrons $= Z-$ charge. E.g. $^{27}_{13}\mathrm{Al}^{3+}$: 13 protons, 14 neutrons, 10 electrons.

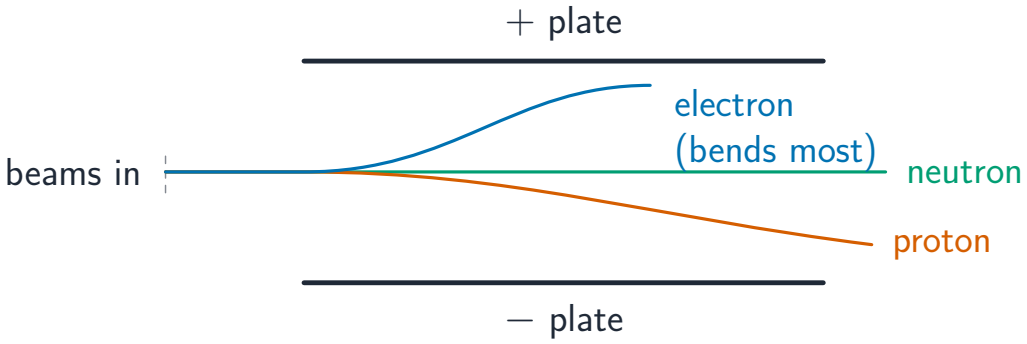
Method — The sub-atomic particles



An atom with a central nucleus of protons and neutrons, surrounded by electrons in shells

Method — Beams in an electric field

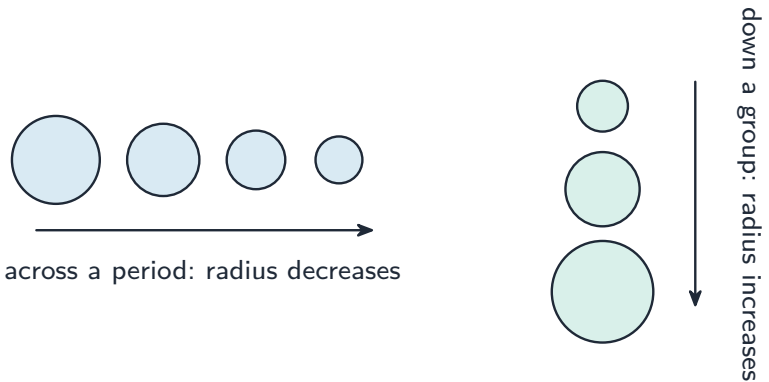
The proton bends to the − plate; the electron bends the opposite way and far more (it is lighter); the neutron goes straight



Method — Atomic and ionic radius

A **cation** 阳离子 is smaller than its atom (lost a shell); an **anion** 阴离子 is larger (more electron repulsion). Among ions with the same electrons, more protons $\rightarrow$ smaller.

Method — Atomic and ionic radius



A row of atoms shrinking across a period and a column growing down a group

Practice 2.1 ▪ 2 marks

State the relative charge and relative mass of a neutron.

Solution 2.1

Method: The sub-atomic particles

Worked steps

relative charge 0; relative mass 1 B1 *each*.

Practice 2.2 ▪ 3 marks

Give the number of protons, neutrons and electrons in $^{40}_{20}\mathrm{Ca}^{2+}$.

Solution 2.2

Method: The sub-atomic particles

Worked steps

protons 20; neutrons $40 - 20 = 20$; electrons $20 - 2 = 18$ B1 *each*.

Exam-style 3.1 ▪ 1 mark

Which particle is deflected **most** in an electric field, and toward which plate?

A the proton, toward the positive plate

B the electron, toward the positive plate

C the neutron, toward the negative plate

D the electron, toward the negative plate

Solution 3.1

Method: Beams in an electric field

A the proton, toward the positive plate

B the electron, toward the positive plate ✓

C the neutron, toward the negative plate

D the electron, toward the negative plate

Worked steps

B. The electron is lightest, so it deflects most, toward the positive plate.

Exam-style 3.2 ▪ 1 mark

Across Period 3, the atomic radius decreases because:

A more shells are added

B the nuclear charge increases while shielding stays about the same

C the electrons repel each other more

D the atoms gain neutrons

Solution 3.2

Method: Atomic and ionic radius

A more shells are added

B the nuclear charge increases while shielding stays about the same ✓

C the electrons repel each other more

D the atoms gain neutrons

Worked steps

B. The rising nuclear charge with similar shielding pulls the outer shell in.

Exam-style 3.3 ▪ 2 marks

(a) Explain why a sodium ion, Na , is smaller than a sodium atom.
(b) The ions Na , Mg^{2} and Al^{3} all have 10 electrons. State and explain which is smallest.

Solution 3.3

Method: Atomic and ionic radius

Worked steps

(a) Na has lost its outer (third) shell, so it has one fewer shell **M1**; the remaining electrons are pulled in more strongly by the same nucleus **A1**.
(b) Al^{3} is smallest **M1**; it has the most protons (13) for the same 10 electrons, so the strongest pull per electron **A1**.

Exam-style 3.4 ▪ 2 marks

Explain why the atomic radius increases down Group 2.

Solution 3.4

Method: Atomic and ionic radius

Worked steps

each step down Group 2 adds a shell, so the outer electrons are further out **M1** and more shielded from the nucleus **A1**.