

1.1 Particles in the atom and atomic radius

Name: _____ Class: _____ Date: _____ Total: 24 marks

KEY WORDS electron 电子 • proton 质子 • neutron 中子 • nucleon 核子 • shell 壳层

Objective

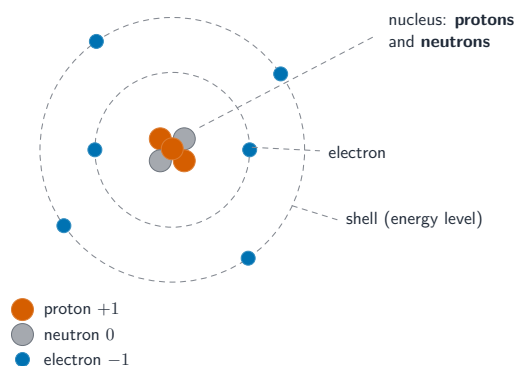
Build the skills to answer exam questions on **particles in the atom and atomic radius** — the **proton** 质子, **neutron** 中子 and **electron** 电子, counting particles in atoms and **ions** 离子, and trends in **atomic radius** 原子半径.

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

1 Worked examples

■ The sub-atomic particles

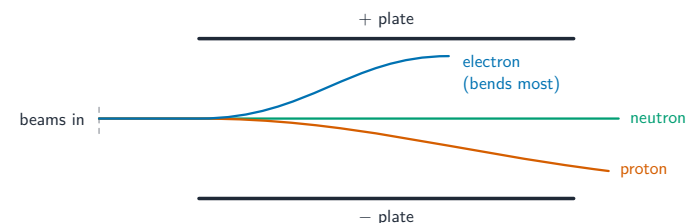


Protons and neutrons sit in the tiny nucleus; electrons move in shells around it

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

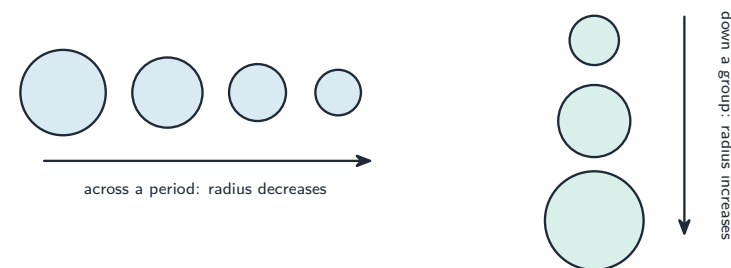
Proton number Z = protons; **nucleon number** A = protons + neutrons; neutrons = $A - Z$. In an ion, electrons = $Z -$ charge. E.g. ${}_{13}^{27}\text{Al}^{3+}$: 13 protons, 14 neutrons, 10 electrons.

■ 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

■ Atomic and ionic radius



Across a period atoms shrink (stronger nuclear pull, same shell); down a group they grow (each step adds a shell)

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.

2 Practice

2.1 State the relative charge and relative mass of a neutron. [2]

2.2 Give the number of protons, neutrons and electrons in $^{40}_{20}\text{Ca}^{2+}$. [3]

3 Exam-style questions

3.1 Which particle is deflected **most** in an electric field, and toward which plate? [1]

- **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

3.2 Across Period 3, the atomic radius decreases because: [1]

- **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

3.3 (a) Explain why a sodium ion, Na^+ , is smaller than a sodium atom. [2]

(b) The ions Na^+ , Mg^{2+} and Al^{3+} all have 10 electrons. State and explain which is smallest. [2]

3.4 Explain why the atomic radius increases down Group 2. [2]

3.5 The table gives the particles in four species.

Species	Protons	Neutrons	Electrons
A	12	12	10
B	8	10	10
C	12	14	12
D	17	18	18

(a) Identify each species, giving its symbol with mass number and any charge. [4]

(b) State which two species contain nuclei of the same element, and explain how you can tell. [2]

(c) Explain, in terms of shells and of the attraction between the nucleus and the outer electrons, why **A** is much smaller than **C**. [3]

(d) Predict, with a reason, whether **D** is larger or smaller than a neutral chlorine atom. [2]

Solutions

2.1 relative charge 0; relative mass 1.

2.2 protons 20; neutrons $40 - 20 = 20$; electrons $20 - 2 = 18$.

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

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

3.3 (a) Na^+ has lost its outer (third) shell, so it has one fewer shell; the remaining electrons are pulled in more strongly by the same nucleus.

(b) Al^{3+} is smallest; it has the most protons (13) for the same 10 electrons, so the strongest pull per electron.

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

3.5 (a) **A** $^{24}\text{Mg}^{2+}$, **B** $^{18}\text{O}^{2-}$, **C** ^{26}Mg , **D** $^{35}\text{Cl}^-$. Mass number = protons + neutrons; the charge is protons – electrons.

(b) **A** and **C** — both have 12 protons, and the proton number is what fixes the element.

(c) **A** has lost both 3s electrons, so its outermost occupied shell is now the second, not the third; the same 12 protons now hold only 10 electrons, so the pull per electron is greater; there is also less electron–electron repulsion, so the remaining shells are drawn in.

(d) Larger. The extra electron adds repulsion within the same third shell while the nuclear charge is unchanged, so the shell expands.