

1.4 Ionisation energy

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS ionisation energy 电离能 • first ionisation energy 第一电离能
 • successive ionisation energies 逐级电离能 • spin-pair repulsion 自旋成对排斥 • shielding 屏蔽

Objective

Build the skills to answer exam questions on **ionisation energy** 电离能 — defining the **first ionisation energy** 第一电离能, writing equations, explaining trends, and using **successive ionisation energies** 逐级电离能.

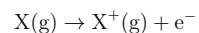
You must be able to:

- define first ionisation energy and write equations for first and successive ionisations
- explain trends across a period (and the dips) and down a group
- deduce electronic configuration and group from successive ionisation energy data

1 Worked examples

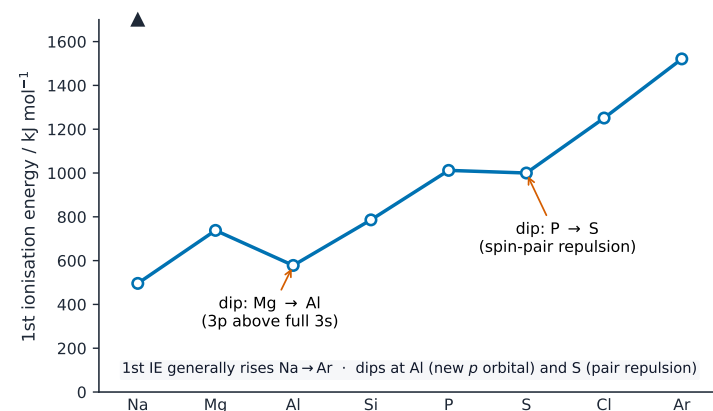
■ First ionisation energy

The energy to remove one electron from each atom in one mole of **gaseous** atoms, forming one mole of gaseous +1 ions:



It depends on **nuclear charge** (more protons → higher), **atomic radius** (further out → lower), and **shielding** (more inner shells → lower).

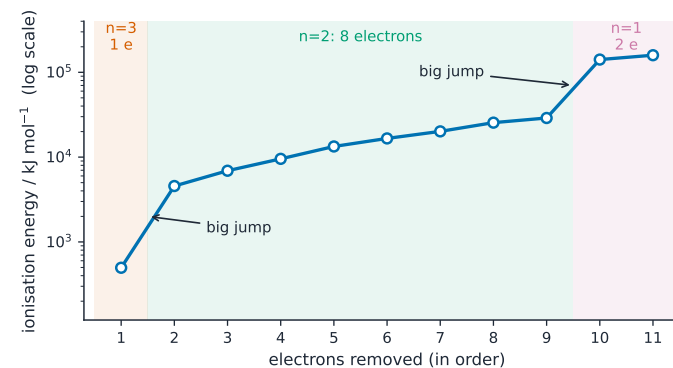
■ Trends across Period 3



IE rises across the period but dips at Al (3p above 3s) and at S (spin-pair repulsion) — evidence for sub-shells

It rises across a period (rising nuclear charge, similar shielding) and falls down a group (more shielding, larger radius). The two dips: **Mg→Al** (Al's electron is in a higher 3p sub-shell) and **P→S** (S has a paired 3p electron, so spin-pair repulsion makes it easier to remove).

■ Successive ionisation energies



big jump = next electron from a shell closer to the nucleus (shell structure)

Big jumps reveal the shell structure (Na = 2,8,1); the electrons removed before the first big jump = the group number

2 Practice

2.1 Write an equation, with state symbols, for the first ionisation energy of magnesium.[2]

2.2 State **two** factors that affect the size of an ionisation energy. [2]

3 Exam-style questions

3.1 Why is the second ionisation energy of an element always larger than the first? [1]

- | | |
|---|---|
| A | B |
| C | D |
- A the atom is now a gas
B the electron is removed from a more positive ion
C there are more neutrons
D shielding increases

3.2 The first ionisation energy of sulfur is lower than that of phosphorus because: [1]

- | | |
|---|---|
| A | B |
| C | D |
- A sulfur has fewer protons
B sulfur's removed electron is one of a pair in a 3p orbital (spin-pair repulsion)
C sulfur is in a different period
D sulfur has more shielding

3.3 Explain why the first ionisation energy decreases down Group 2. [3]

3.4 The first six ionisation energies of an element (kJ mol^{-1}) are: 590, 1150, 4940, 6480, 8120, 10500. Deduce which group the element is in, and explain your answer. [2]
