

Atomic Structure

A-Level Chemistry ■ Topic 1

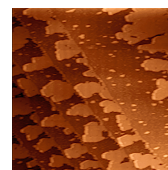
A-Level Chemistry



Atomic Structure

What we will cover

- 1 Inside the atom
- 2 Counting particles & radius
- 3 Isotopes
- 4 Sub-shells & orbitals
- 5 Electronic configuration
- 6 Ionisation energy



real atoms, imaged

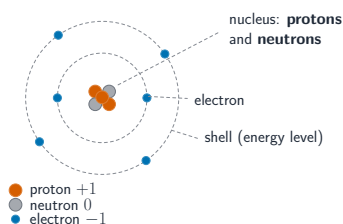
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Inside the atom

Atomic Structure

└ Inside the atom

Inside the atom



A tiny **nucleus** 原子核 of **protons** 质子 (+1) and **neutrons** 中子 (0) holds nearly all the mass; **electrons** 电子 (-1, ~0 mass) move in **shells** 壳层.

Atomic Structure

└ Inside the atom

Counting particles

proton number 质子数 nucleon number 核子数 A neutrons = $A - Z$

Worked example: ${}_{13}^{27}\text{Al}^{3+}$

13 protons; $27 - 13 = 14$ neutrons; $13 - 3 = 10$ electrons (lost 3 to become $3+$)

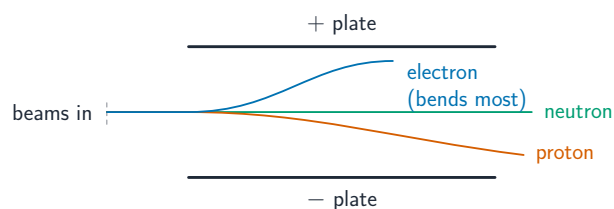
A positive **ion** 离子 (**cation** 阳离子) has fewer electrons than protons; a negative ion (**anion** 阴离子) has more.

Atomic Structure

└ Inside the atom

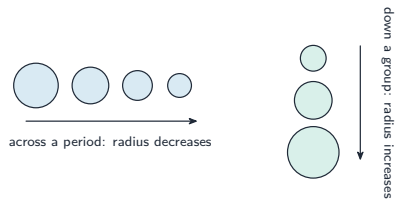
Beams in an electric field

- proton bends to the $-$ plate
- electron bends to the $+$ plate, *far more* (much lighter)
- neutron goes straight (no charge)



Atomic and ionic radius

- across a **period** 周期 – **smaller** (stronger **nuclear charge** 核电荷, same shell)
 - down a **group** 族 – **larger** (each step adds a shell)
- A cation is smaller than its atom; an anion larger.



Isotopes

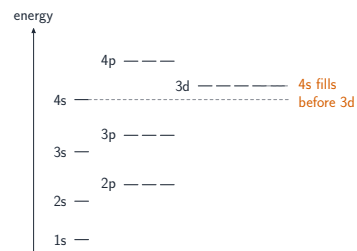


Isotopes 同位素: same protons, different neutrons. Same **chemical** properties (same electrons); different **physical** ones (mass, density).

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Electrons

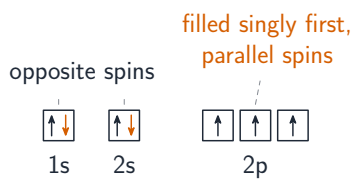
Sub-shells and energy order



Shells split into **sub-shells** 亚层 s (2), p (6), d (10), made of **orbitals** 轨道 (2 electrons each).

Fill lowest energy first – note 4s fills before 3d.

Electronic configuration

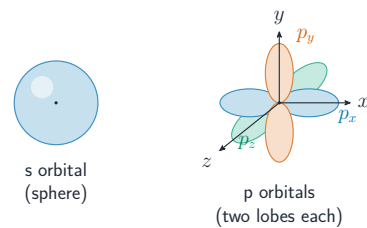


Electronic configuration 电子排布: Fe = $[\text{Ar}] 3d^6 4s^2$.

- paired electrons have opposite **spin** 自旋
- orbitals fill singly first (less repulsion)

Ions lose 4s before 3d:
 $\text{Fe}^{3+} = [\text{Ar}] 3d^5$.

Shapes of orbitals

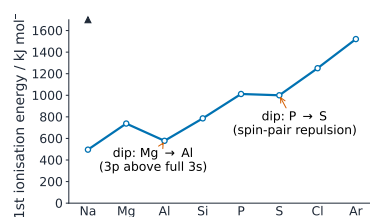


- an **s orbital** s 轨道 is a **sphere** 球形
 - a **p orbital** p 轨道 is a dumbbell; the three point along x, y, z
- A **free radical** 自由基 has an unpaired electron.

3 Ionisation energy

Atomic Structure
Ionisation energy

First ionisation energy



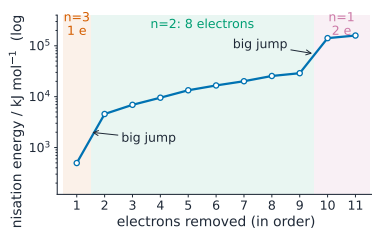
First ionisation energy 第一电离能:
 $X(g) \rightarrow X^+(g) + e^-$.

- rises across a period (more nuclear charge)
- dips at Al (3p < 3s) and S (spin-pair repulsion 自旋成对排斥)

The dips are evidence for sub-shells.

Atomic Structure
Ionisation energy

Successive ionisation energies



Each successive ionisation energy 逐级电离能 is larger (a more positive ion).

Big jumps reveal the shells: sodium's 2, 8, 1 pattern. Electrons removed before the first jump = the group number.

4 Recap

Atomic Structure
Recap

Topic 1 – key takeaways

1 The atom

nucleus (p,n) + electrons in shells

2 Isotopes

same protons, different neutrons

3 Configuration

s, p, d sub-shells; 4s fills before 3d

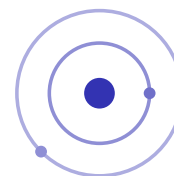
4 Ionisation energy

dips show sub-shells; jumps show shells

Atomic Structure
Recap

Check yourself

- 1 How many neutrons in $^{37}_{17}\text{Cl}$?
- 2 Which fills first, 4s or 3d?
- 3 Why does first IE dip from Mg to Al?
- 4 What do big jumps in successive IE reveal?



Answers 1. 20 2. 4s 3. Al's electron leaves a higher-energy 3p sub-shell 4. the shells