

1.3 Electrons, energy levels and atomic orbitals

Name: _____ Class: _____ Date: _____

Total: 10 marks

Objective

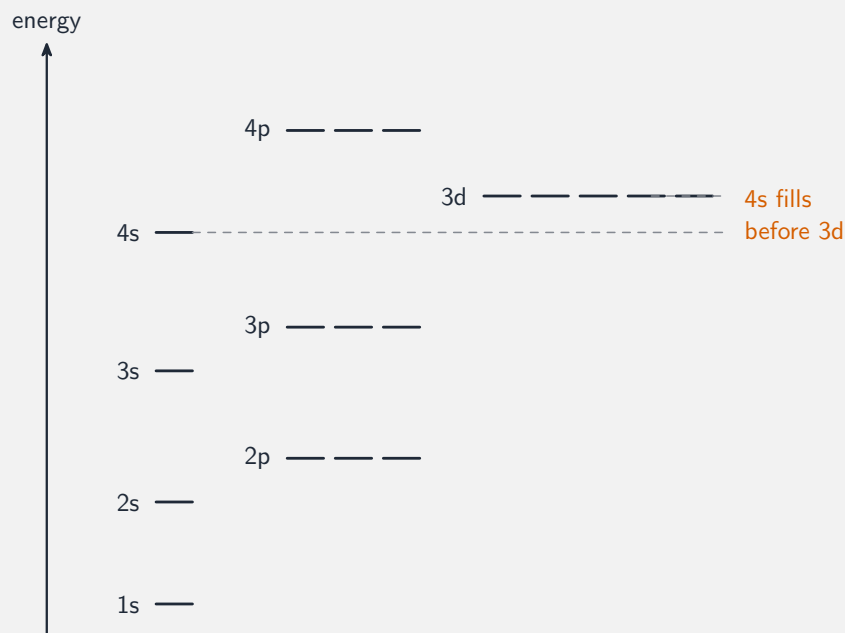
Build the skills to answer exam questions on **electrons, energy levels and atomic orbitals** —shells, sub-shells and orbitals 壳层、亚层和轨道, the order of filling, **electronic configurations** 电子排布, and orbital shapes.

You must be able to:

- describe the orbitals and electron capacity of s, p and d sub-shells
- write the electronic configuration of an atom or ion (full and shorthand)
- use the electrons-in-boxes notation and describe s and p orbital shapes

1 Worked examples

■ Sub-shells and filling order

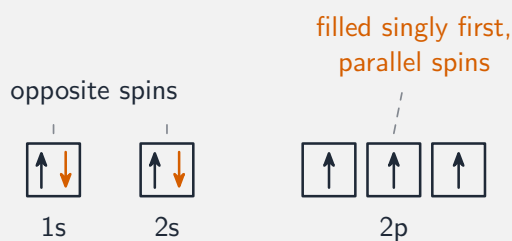


Order of rising energy: $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p$ ($4s$ fills before $3d$)

sub-shell	orbitals	max electrons
s	1	2
p	3	6
d	5	10

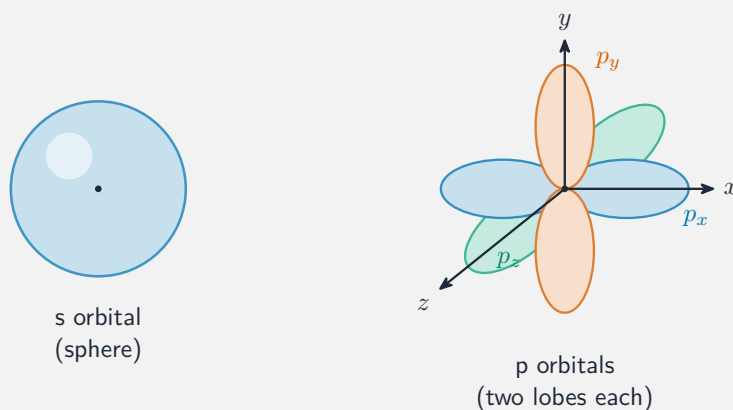
■ Electronic configuration

For iron (Fe, $Z = 26$): $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$, or shorthand $[\text{Ar}] 3d^6 4s^2$. For a transition-metal ion, remove the **4s electrons first**: $\text{Fe}^{3+} = [\text{Ar}] 3d^5$.



Paired electrons point opposite ways; within a sub-shell, orbitals fill singly first (parallel spins)

■ Orbital shapes



An s orbital is a sphere; each p orbital is a dumbbell along one axis

2 Practice

2.1 State the maximum number of electrons in (a) a p sub-shell and (b) a d sub-shell.^[2]

2.2 Write the full electronic configuration of a calcium atom ($Z = 20$). [1]

3 Exam-style questions

3.1 Which sub-shell is filled **before** the 3d sub-shell? [1]

- A 3p
 - B 4s
 - C 4p
 - D 4d
-

3.2 What is the shape of a p orbital? [1]

- A spherical
 - B dumbbell (two lobes)
 - C a flat ring
 - D a cube
-

3.3 (a) Write the shorthand electronic configuration of an iron atom ($Z = 26$). [1]

(b) Write the electronic configuration of the Fe^3 ion, and explain which electrons are lost first. [2]

3.4 Using electrons-in-boxes, explain why the three 2p electrons of nitrogen occupy separate orbitals with parallel spins. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **1.3 Electrons, energy levels and atomic orbitals** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/11 N25 —Q1 (electronic configuration)
- 9701/12 N25 —Q4 (orbitals)
- 9701/22 N25 —Q1 (atomic structure, structured)

Solutions

2.1 (a) 6; (b) 10.

2.2 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$.

3.1 B. 4s is slightly lower in energy than 3d, so it fills first.

3.2 B. A p orbital is a dumbbell (two lobes).

3.3 (a) $[\text{Ar}] 3d^6 4s^2$.

(b) $[\text{Ar}] 3d^5$; the 4s electrons are removed before the 3d electrons.

3.4 each electron is negative and they repel; occupying separate orbitals keeps them apart, lowering repulsion —the lowest-energy (most stable) arrangement.