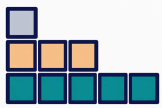
Electronic Configuration Map

Cambridge International AS & A Level Chemistry · Topic 1 Atomic structure · Electronic configuration

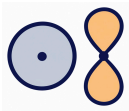
1 Shells, sub-shells, orbitals 1.3.1–1.3.2

- Shell = **principal quantum number n**
- Shell n has **n sub-shells**
- s: 1 orbital (2 e^-); p: 3 (6 e^-); d: 5 (10 e^-)
- **Orbital**: up to 2 electrons, opposite spins
- Shells hold 2, 8, 18, 32: $2n^2$



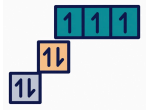
2 s and p orbitals 1.3.8

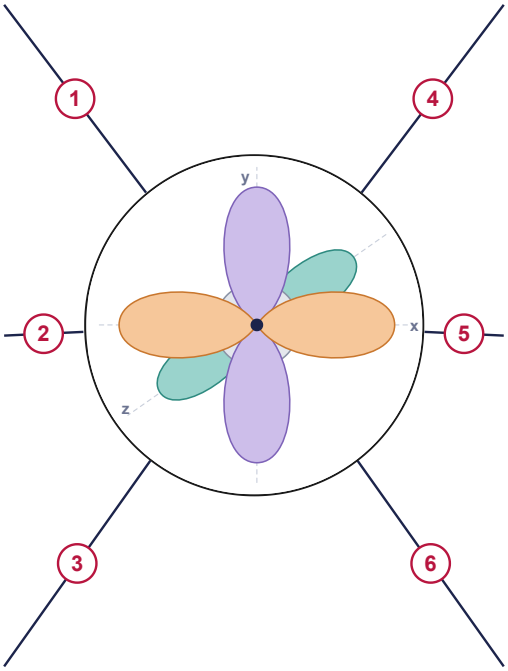
- **s**: a **sphere** centred on the nucleus
- 2s larger than 1s, 3s larger again
- **p**: a **dumbbell**, two lobes
- **Three** p orbitals: along x, y and z
- At 90° to each other, equal energy



3 Order and ground state 1.3.3

- Lowest energy first: 1s 2s 2p 3s 3p
- **4s before 3d**, then 4p
- **Ground state**: the lowest-energy arrangement
- Superscripts add up to Z
- Shorthand: [Ne], [Ar]





4 Boxes and repulsion 1.3.5, 1.3.7

- One box per orbital; half-arrows for spin
- **Singly before pairing**, parallel spins
- Pairing costs **spin-pair repulsion**
- 3d and 4s close in energy
- **Cr** $3d^5\ 4s^1$; **Cu** $3d^{10}\ 4s^1$



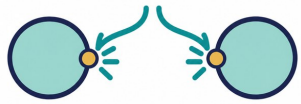
5 Configurations of ions 1.3.6

- Positive ions: **remove** electrons
- Negative ions: **add** electrons
- Transition elements: **4s lost before 3d**
- Fe^{2+} [Ar] $3d^6$; Fe^{3+} [Ar] $3d^5$
- Cu^+ [Ar] $3d^{10}$; Cu^{2+} [Ar] $3d^9$



6 Free radicals 1.3.9

- **Free radical**: one or more **unpaired** electrons
- Cl• ($3p^5$), H• ($1s^1$), CH_3•
- Odd number of electrons (NO, NO_2): a radical
- Cl^- and Ar ($3p^6$): not radicals
- Formed by homolytic fission



Configurations from hydrogen to krypton

unpaired electrons from electrons-in-boxes

Species	Z	Configuration	Unpaired	Note
N	7	$1s^2\ 2s^2\ 2p^3$	3	half-full 2p
Cl	17	[Ne] $3s^2\ 3p^5$	1	free radical, Cl•
Ti	22	[Ar] $3d^2\ 4s^2$	2	
Cr	24	[Ar] $3d^5\ 4s^1$	6	exception
Fe^{3+}	26	[Ar] $3d^5$	5	4s lost first
Cu	29	[Ar] $3d^{10}\ 4s^1$	1	exception
Se	34	[Ar] $3d^{10}\ 4s^2\ 4p^4$	2	

The exceptions and the traps

Chromium and copper

- Cr [Ar] $3d^5\ 4s^1$, not $3d^4\ 4s^2$
- Cu [Ar] $3d^{10}\ 4s^1$, not $3d^9\ 4s^2$
- lower-energy arrangements

4s in and out

- 4s fills before 3d
- 4s is emptied before 3d
- Ti^{2+} [Ar] $3d^2$, not [Ar] $4s^2$

Radical or not?

- count the unpaired electrons
- any unpaired: a free radical
- all paired: not a radical

Removing electrons one at a time gives ionisation energies: evidence for these shells and sub-shells (Ionisation energy).

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