Exercise walk-through

Colour of complexes ▪ 28.3

eXercise

You must be able to

- define degenerate and non-degenerate d orbitals
- describe the splitting in octahedral and tetrahedral complexes
- explain colour in terms of the frequency of light absorbed (ΔE)

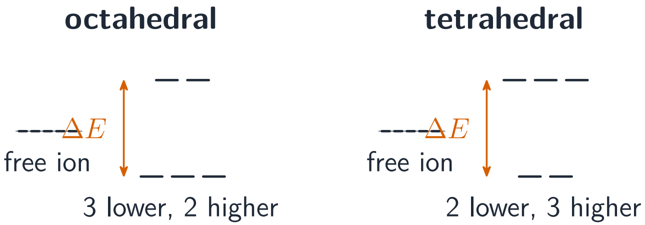
Method — d-orbital splitting and colour

Ligands split the five ***degenerate*** *d orbitals into two* ***non-degenerate*** *sets separated by a gap* ΔE

- **octahedral:** three lower + two higher.
- **tetrahedral:** two lower + three higher.

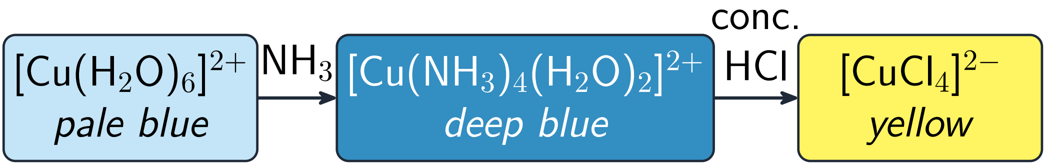
A complex absorbs light whose energy equals $\Delta\mathrm{E}$, promoting a d electron to the higher set. We **see** the **complementary colour** of the light absorbed. Different ligands give a different $\Delta\mathrm{E} \rightarrow$ different colour (why ligand exchange changes colour).

Method — d-orbital splitting and colour



the complex absorbs light of energy ΔE, so we see the **complementary colour**

Method — d-orbital splitting and colour



Ligand exchange changes the complex colour

Practice 2.1 ▪ 1 mark

Define **degenerate** d orbitals.

Solution 2.1

Method: d-orbital splitting and colour

Worked steps

d orbitals that have the same energy **B1**.

Practice 2.2 ▪ 1 mark

State how the five d orbitals split in an **octahedral** complex.

Solution 2.2

Method: d-orbital splitting and colour

Worked steps

into a lower set of three and a higher set of two orbitals **B1**.

Exam-style 3.1 ▪ 1 mark

A transition-metal complex is coloured because an electron is promoted:

A out of the atom

B between two non-degenerate d orbitals

C into the nucleus

D between s orbitals

Solution 3.1

Method: d-orbital splitting and colour

- **A** out of the atom
- **B** between two non-degenerate d orbitals ✓
- **C** into the nucleus
- **D** between s orbitals

Worked steps

B. An electron is promoted between two non-degenerate d orbitals.

Exam-style 3.2 ▪ 1 mark

The colour we see is:

A the colour of light absorbed

B the complementary colour of the light absorbed

C always green

D white

Solution 3.2

A the colour of light absorbed

B the complementary colour of the light absorbed ✓

C always green

D white

Worked steps

B. We see the complementary colour of the light absorbed.

Exam-style 3.3 ▪ 3 marks

Explain, in terms of d orbitals, why $[Cu(H_2O)_6]^{2+}$ is coloured.

Solution 3.3

Worked steps

the ligands split the d orbitals into two sets separated by ΔE **M1**; the complex absorbs light of energy equal to ΔE, promoting a d electron to the higher set **M1**; the colour seen is the complementary colour of the light absorbed **A1**.

Exam-style 3.4 ▪ 2 marks

Explain why changing the ligand around a transition-metal ion changes the colour of the complex.

Solution 3.4

Method: d-orbital splitting and colour

Worked steps

a different ligand gives a different splitting energy ΔE **M1**; so a different frequency of light is absorbed, and a different complementary colour is seen **A1**.