A-LEVEL CHEMISTRY • EXERCISE SHEET

28.3 Colour of complexes

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS degenerate 简并 • complementary colour 互补色 • non-degenerate 非简并 • colour of complexes 配合物 • complex 配合物

Objective

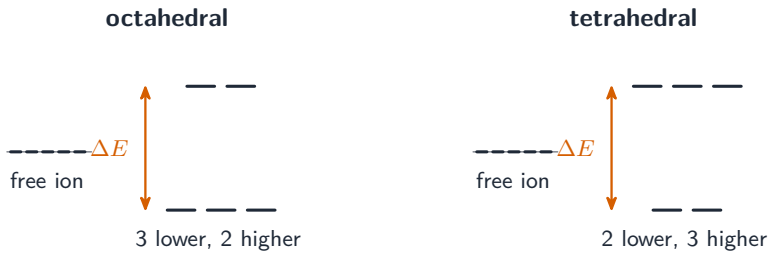
Build the skills to answer exam questions on the **colour of complexes** 配合物的颜色 — **d-orbital splitting** d 轨道分裂 and why transition complexes are coloured.

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)

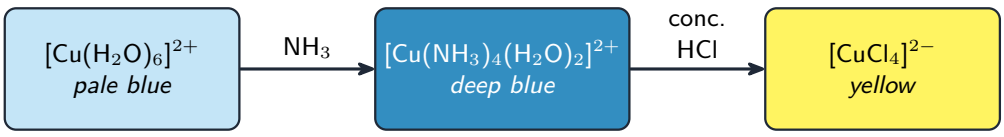
1 Worked examples

■ d-orbital splitting and colour



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

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



Ligand exchange changes the complex colour

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

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

2 Practice

2.1 Define **degenerate** d orbitals. [1]

2.2 State how the five d orbitals split in an **octahedral** complex. [1]

3 Exam-style questions

3.1 A transition-metal complex is coloured because an electron is promoted: [1]

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

3.2 The colour we see is: [1]

- **A** the colour of light absorbed
- **B** the complementary colour of the light absorbed
- **C** always green
- **D** white

3.3 Explain, in terms of d orbitals, why $[Cu(H_2O)_6]^{2+}$ is coloured. [3]

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

the complex. [2]

Solutions

2.1 d orbitals that have the same energy.

2.2 into a lower set of three and a higher set of two orbitals.

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

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

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

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