Ligand Exchange and Stability Map

Cambridge International AS & A Level Chemistry · Topic 28 Ligand exchange, colour and stability

1 Copper and cobalt

28.2.1, 28.2.7

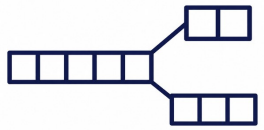
- OH^-: blue $Cu(OH)_2$; blue $Co(OH)_2$
- NH_3: deep blue $[Cu(NH_3)_4(H_2O)_2]^{2+}$
- Cl^-: yellow $[CuCl_4]^{2-}$
- Cl^-: blue $[CoCl_4]^{2-}$



2 Splitting d orbitals

28.3.1, 28.3.2

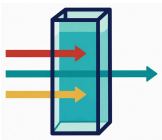
- Degenerate to **non-degenerate**
- Octahedral: two higher, three lower
- Tetrahedral: three higher, two lower
- The gap: ΔE

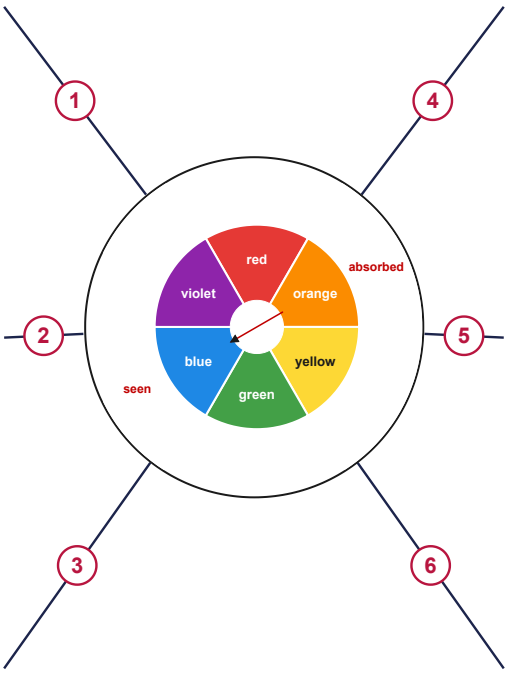


3 Colour

28.3.3–28.3.5

- An electron absorbs light
- We see the **complementary** colour
- Different ligands change ΔE
- So the colour changes





4 Kstab

28.5.1–28.5.3

- Equilibrium constant for forming a complex
- $[H_2O]$ is left out
- Larger Kstab: a more stable complex
- Stepwise constants multiply



5 Exchange by Kstab

28.5.4

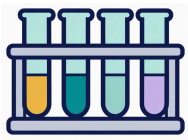
- A ligand of larger Kstab replaces one of smaller
- Hence $EDTA^{4-}$ replaces NH_3
- Compare values at the same temperature
- A large Kstab: a stable complex



6 Redox feasibility

28.2.8

- Use E⊖ values
- E⊖cell positive: feasible
- Check each step
- Air can oxidise low states



Colour changes of copper and cobalt ligand exchange

From	Reagent	To	Colour change
$[Cu(H_2O)_6]^{2+}$	excess NH_3	$[Cu(NH_3)_4(H_2O)_2]^{2+}$	blue to deep blue
$[Cu(H_2O)_6]^{2+}$	conc HCl	$[CuCl_4]^{2-}$	blue to yellow
$[Co(H_2O)_6]^{2+}$	conc HCl	$[CoCl_4]^{2-}$	pink to blue
$[Co(H_2O)_6]^{2+}$	excess NH_3	$[Co(NH_3)_6]^{2+}$	pink to pale brown

Worked examples

Kstab expression

- $Cu^{2+} + 4Cl^- \rightleftharpoons [CuCl_4]^{2-}$
- $[[CuCl_4]^{2-}] \div [Cu^{2+}][Cl^-]^4$
- **Units: $mol^{-4}\ dm^{12}$**

Comparing Kstab

- $[Cu(H_2O)_6]^{2+} + 4NH_3$
- Kstab of ammine is larger
- **NH_3 replaces H_2O**

Feasibility

- $2Co^{3+} + 2Cl^-$
- E⊖cell = +1.82 − 1.36
- **+0.46 V: feasible**

E⊖ values come from Topic 24; redox titrations are on their own map.

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