

UNIT 5 • COORDINATION COMPOUNDS

# Colour in Coordination Compounds

Unlocking the relationship between d-orbital splitting, absorbed light, and the visible spectrum.



# Essential Terminology

## Complementary Colour

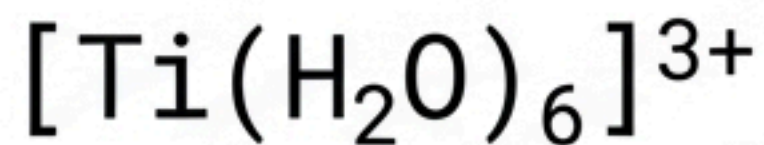
The color observed by the human eye. It is the color generated from the wavelengths left over after a specific wavelength of white light is absorbed by the complex.

## d-d Transition

The excitation of an electron from a lower-energy d orbital to a higher-energy d orbital within the same principal quantum level, triggered by the absorption of light.

# Wavelengths & Complementary Colors

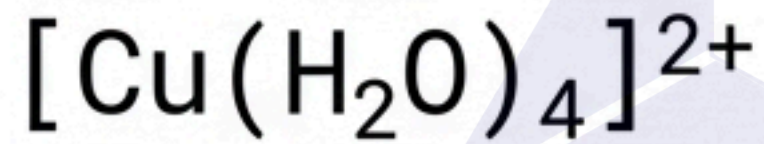
What a complex absorbs dictates what we see.



Absorbed: Blue-Green (498nm)



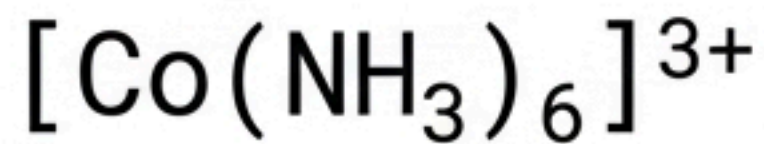
Observed: Violet



Absorbed: Red (600nm)



Observed: Blue



Absorbed: Blue (475nm)



Observed: Yellow Orange



# You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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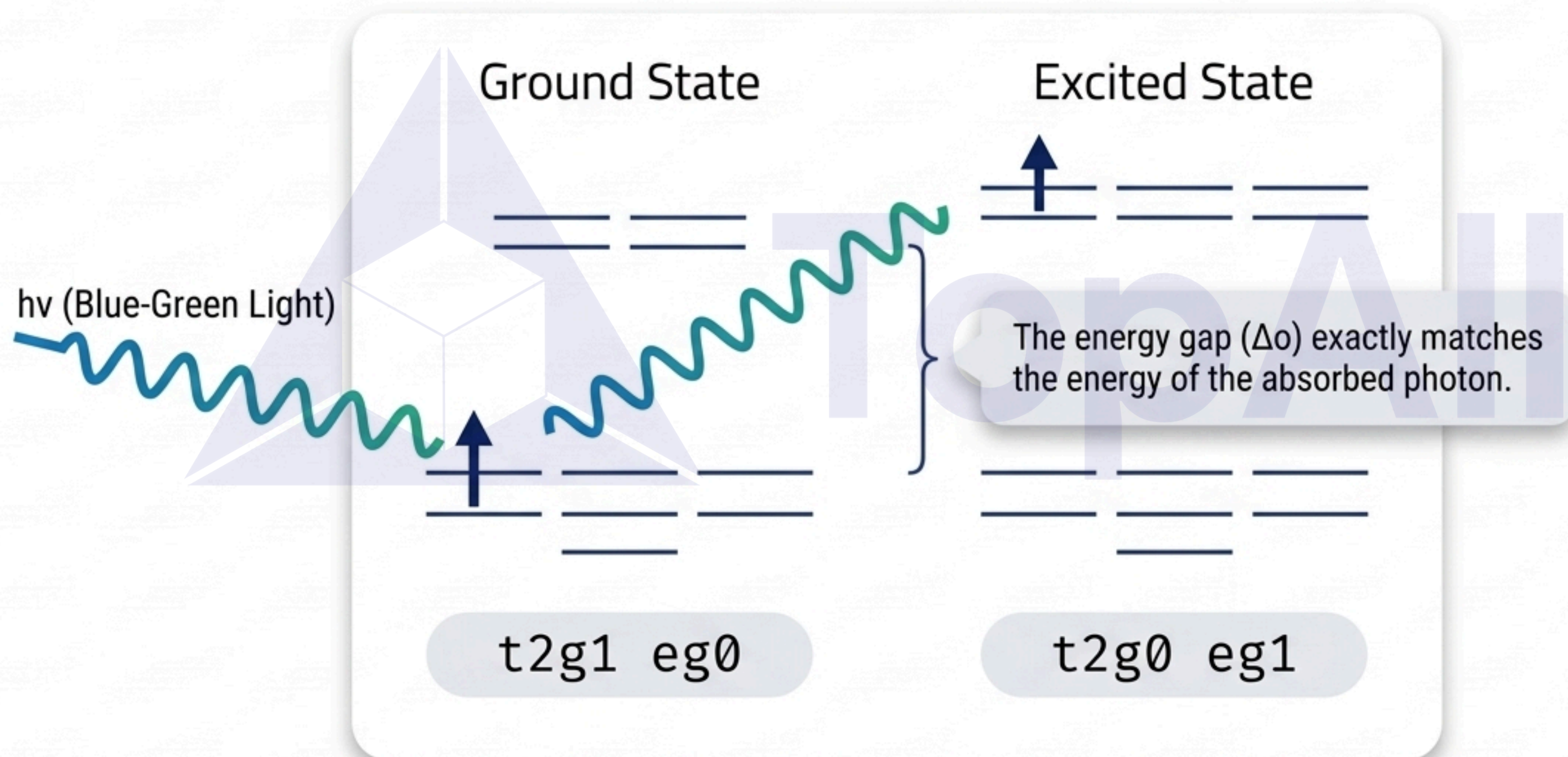
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# The Mechanism: d-d Transition



# The Ligand Dependency

In the absence of ligands, crystal field splitting does not occur. No splitting = No color.

Anhydrous  $\text{CuSO}_4$



No water ligands present -> No d-orbital splitting -> Cannot absorb visible light.  
Substance appears white/colourless.

Hydrated  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$



$\text{H}_2\text{O}$  ligands present  
-> d-orbitals split into  $t_{2g}$  and  $e_g$   
-> Absorbs red light, appears bright blue.

# Real-World Application: Gemstones

The exact same transition metal ion can produce wildly different colors depending on the surrounding crystal lattice (which acts as the ligand environment).



## Ruby

$\text{Cr}^{3+}$  ions embedded in an  $\text{Al}_2\text{O}_3$  (alumina) lattice. Absorbs yellow/green light  $\rightarrow$  Appears deep Red.



## Emerald

$\text{Cr}^{3+}$  ions embedded in a  $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$  (beryl) lattice. The different environment shifts absorption to yellow-red and blue  $\rightarrow$  Appears Green.

# Exam Trap: Watch for “Anhydrous” or “Heating”

Signal Words: **Anhydrous** **Dehydrated** **Upon Heating**

## The Trap:

Questions will ask for the color of a complex like  $[\text{Ti}(\text{H}_2\text{O})_6]\text{Cl}_3$  after it is heated.

## The Solution:

Heating removes the  $\text{H}_2\text{O}$  ligands. Without ligands, there is zero crystal field splitting. The substance will always turn colourless. Do not choose a shifted color option!

# Summary

- The color of a coordination compound is the complementary color to the specific wavelength of light absorbed during a d-d electron transition (e.g.,  $t_{2g} \rightarrow e_g$ ).
- Color is strictly dependent on ligand-induced splitting. If a complex loses its ligands (becomes anhydrous), d-orbital splitting disappears, and the compound becomes completely colourless.



# You've Learned the Theory.

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