# Colour formation

Got it 👍 Let me explain this **in simple language** step by step:

**Why are transition metal compounds coloured?**

1. **White light** (like sunlight) is made of many colours (red, orange, yellow, green, blue, violet, etc.).
2. When white light falls on a **transition metal ion** (like Fe²⁺, Cu²⁺, Ni²⁺, etc.), the ion does **not absorb all the colours**.
   * It **absorbs some colours** of light.
   * The **remaining colours** are reflected or transmitted to our eyes.
   * What we see is the **complementary colour** (the opposite of the absorbed one).

**What happens inside the atom?**

* Transition metals have **d orbitals** (a type of electron orbital).
* Normally, all five d orbitals have the **same energy**.
* But when **ligands** (like H₂O, NH₃, etc.) surround the metal ion and form a **complex**, the d orbitals **split into two groups**:
  + **t₂g (lower energy)** = dxy, dyz, dzx
  + **e g (higher energy)** = dx²–y², dz²

**How colour forms**

* When white light falls on the complex:
  + An electron from the **lower-energy (t₂g)** orbital **jumps** to the **higher-energy (e g)** orbital.
  + This jump is called a **d–d transition**.
  + To jump, the electron **absorbs a certain colour** of light (specific wavelength).
  + The **remaining colours** reach our eyes → that’s the colour we see.

👉 Example:

* If the complex **absorbs red light**, we see the complementary colour → **green**.
* If it absorbs yellow, we may see **violet**.

**When do complexes look colourless?**

* If the **d orbitals are completely filled (d¹⁰)** or **completely empty (d⁰)**:
  + No electron can jump between orbitals.
  + So no light is absorbed.
  + The compound appears **white or colourless**.

👉 Example:

* Zn²⁺ (3d¹⁰) → **colourless**.
* Sc³⁺ (3d⁰) → **colourless**.

**Table examples (simple view):**

| **Ion (Complex)** | **d-electrons** | **Unpaired electrons** | **Colour** |
| --- | --- | --- | --- |
| Ti³⁺ [Ti(H₂O)₆]³⁺ | 3d¹ | 1 | Violet |
| V³⁺ [V(H₂O)₆]³⁺ | 3d² | 2 | Green |
| Cr²⁺ [Cr(H₂O)₆]²⁺ | 3d⁴ | 4 | Blue |
| Mn²⁺ [Mn(H₂O)₆]²⁺ | 3d⁵ | 5 | Pink |
| Fe²⁺ [Fe(H₂O)₆]²⁺ | 3d⁶ | 4 | Green |
| Cu²⁺ [Cu(H₂O)₆]²⁺ | 3d⁹ | 1 | Blue |
| Zn²⁺ [Zn(H₂O)₆]²⁺ | 3d¹⁰ | 0 | Colourless |

✅ **In short:**  
Transition metal complexes are coloured because their **d-orbitals split into two levels**, and electrons jump between them by **absorbing some colours of light**. The colour we see is the **leftover (complementary) light**.

Do you want me to also make a **diagram sketch explanation** (showing orbital splitting and colour absorption) so it’s even clearer?

## Cheatsheet

Perfect 👍 I’ll make you a **cheat sheet for colour formation in transition metal complexes** so you can revise quickly before your exam.

**🎨 Colour Formation in Transition Metal Complexes – Cheat Sheet**

**🔹 Key Idea**

* **Transition metal complexes** often appear coloured.
* Colour is due to **d–d transitions**: electrons jumping between split d orbitals.

**🔹 White Light & Colour**

* White light = all colours (ROYGBIV).
* Complex absorbs some colours → the **remaining/complementary colour** is seen.

👉 Example: Absorbs red → appears green.

**🔹 d-Orbital Splitting**

* In free atom: all 5 d orbitals have same energy (degenerate).
* In a complex: ligands split them into 2 groups:
  + **t₂g (lower energy):** dxy, dyz, dzx
  + **e g (higher energy):** dx²–y², dz²

Electrons jump:  
t₂g → e g (absorbs energy from visible light)

**🔹 Conditions for Colour**

✅ **Partially filled d-orbitals** (d¹ to d⁹) → coloured.  
❌ **Empty (d⁰) or full (d¹⁰)** → no d–d transition → colourless.

**🔹 Examples Table**

| **Ion (Complex)** | **d-electrons** | **Colour** |
| --- | --- | --- |
| [Ti(H₂O)₆]³⁺ (3d¹) | Violet |  |
| [V(H₂O)₆]³⁺ (3d²) | Green |  |
| [Cr(H₂O)₆]²⁺ (3d⁴) | Blue |  |
| [Mn(H₂O)₆]²⁺ (3d⁵) | Pink |  |
| [Fe(H₂O)₆]²⁺ (3d⁶) | Green |  |
| [Co(H₂O)₆]²⁺ (3d⁷) | Pink |  |
| [Ni(H₂O)₆]²⁺ (3d⁸) | Blue-green |  |
| [Cu(H₂O)₆]²⁺ (3d⁹) | Blue |  |
| [Zn(H₂O)₆]²⁺ (3d¹⁰) | Colourless |  |

**🔹 Colourless Complexes**

* d⁰: e.g., Sc³⁺, V⁵⁺
* d¹⁰: e.g., Zn²⁺, Cd²⁺, Hg²⁺

**🔹 Moral**

* **Colour ↔ d–d transition.**
* **No d–d transition ↔ colourless.**

✅ That’s all you need to revise before exam!

Do you want me to also make this into a **visual one-page PDF cheatsheet** with diagrams (orbital splitting + colour wheel for complementary colours)?