

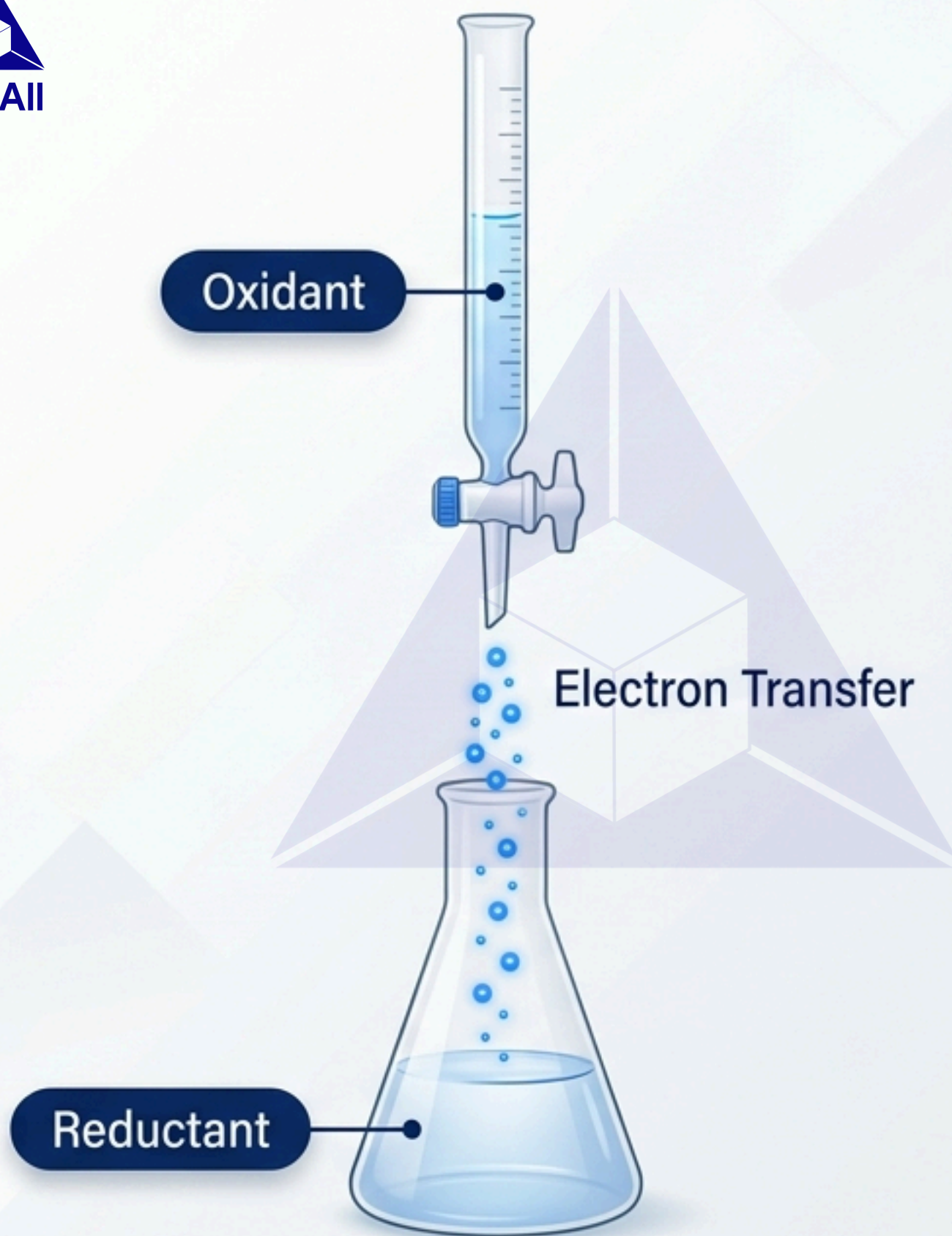
JEE Advanced Chemistry

Chapter 7: Redox Reactions

# Redox Titrations & Indicators

Mastering Equivalence Points, Self-Indicators, and the Iodine-Thiosulphate Method.





## Formula Bank

### How it Works

**Redox titrations** determine the strength of a solution using a redox-sensitive indicator.

The method tracks the direct transfer of electrons until the complete consumption of a reactant.

### Key Takeaway

#### Key Takeaway: The Two Points

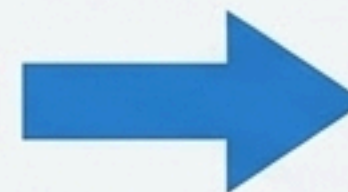
- **Equivalence Point:** The exact theoretical point where reductant and oxidant are strictly equal in terms of mole stoichiometry.
- **End Point:** The practical, visible point where the indicator changes colour to signal the reaction is over.

# $\text{KMnO}_4$ : The Self-Indicator

The Permanganate ion ( $\text{MnO}_4^-$ ) is intensely coloured. It acts as its own indicator—no external chemicals are needed to signal the endpoint.



Colourless



Pale Pink

## Formula Bank

## How it Works

Typical **Reductants** Titrated:

- $\text{Fe}^{2+}$  or  $\text{C}_2\text{O}_4^{2-}$  (Oxalate).

## JEE Trap Alert

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**Trap:** Thinking  $\text{KMnO}_4$  is the reducing agent.

**Truth:**  $\text{MnO}_4^-$  is a powerful **oxidant**. The visible pink endpoint only appears after the reductant is completely oxidized.



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$$E=mc^2$$



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# Minimal Overshoot: The $10^{-6}$ mol/L Threshold

- ✓ The visible endpoint is achieved just after the last bit of reductant is consumed.
- ✓ The very first lasting tinge of pink appears at an incredibly tiny concentration of  $\text{MnO}_4^-$ .



**Concentration  
Threshold:**  
 **$10^{-6} \text{ mol L}^{-1}$**   
(or  $10^{-6} \text{ mol dm}^{-3}$ )

## Key Takeaway

Because the human eye can detect this intense pink colour at such a low concentration, there is a minimal overshoot in colour beyond the exact stoichiometric equivalence point.

# Dichromate Titrations: Needing a Little Help

## The Reagent ( $\text{K}_2\text{Cr}_2\text{O}_7$ )

- Dichromate ( $\text{Cr}_2\text{O}_7^{2-}$ ) is NOT a self-indicator.
- It does not feature the dramatic auto-colour change seen in Permanganate.

## The Indicator (Diphenylamine)

- An external indicator is strictly required.
- Diphenylamine is oxidized immediately after the equivalence point (once the primary reactant is entirely consumed).
- Colour Change: Produces an **intense blue** colour to visually signal the endpoint.

# Iodometric Titrations: Starch & Thiosulphate

*Used for reagents that oxidize  $I^-$  to  $I_2$  (e.g.,  $Cu^{2+}$ ). Note:  $I_2$  stays in solution with KI as  $KI_3$ .*

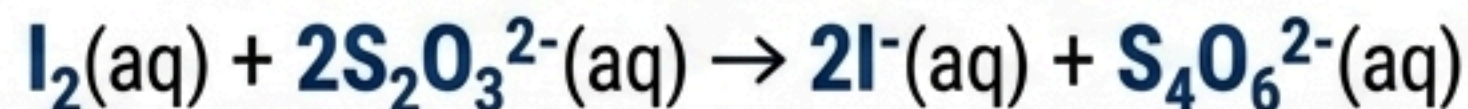
## Step 1: Liberation



- Action: Add Starch indicator  $\rightarrow$  forms an intense blue complex with the liberated  $I_2$ .



## Step 2: Titration



- Action: Titrate with Thiosulphate ( $S_2O_3^{2-}$ ).
- Endpoint: The intense blue colour disappears the exact moment  $I_2$  is fully consumed.

# Exam Snapshot: Redox Titration Matrix

| Titration Type                    | Indicator Used                      | Endpoint Colour Change                | Key Trait                                 |
|-----------------------------------|-------------------------------------|---------------------------------------|-------------------------------------------|
| $\text{KMnO}_4$                   | Self-Indicator ( $\text{MnO}_4^-$ ) | Colourless $\rightarrow$ Pale Pink    | Minimal overshoot ( $10^{-6} \text{ M}$ ) |
| $\text{K}_2\text{Cr}_2\text{O}_7$ | Diphenylamine (External)            | $\rightarrow$ Intense Blue            | Oxidized just after equivalence           |
| Iodine-Thiosulphate               | Starch (External)                   | Intense Blue $\rightarrow$ Colourless | Tracks $\text{I}_2$ consumption           |

## JEE Trap Alert

Don't mix up the blues! Diphenylamine turns blue at the end of the reaction. The Starch-Iodine complex starts blue and loses its colour at the exact endpoint.



# You've Learned the Theory.

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