▶ Video explanation (YouTube Short)

Potassium Dichromate: Preparation and Oxidising Action

In 1954 a police breathalyser used an orange solution that turned green when a driver who had drunk alcohol breathed through it. The orange chemical was acidified potassium dichromate, $K_2Cr_2O_7$. These notes cover how it is made, the chromate–dichromate change with pH, and why it is a strong oxidising agent (NCERT 4.4.1).

1. Preparation from chromite ore

1. **Fusion:** chromite ore ($FeCr_2O_4$) is fused with sodium carbonate in free access of air:
   $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$
   Fe_2O_3 is insoluble and is filtered off; the solution of **sodium chromate (yellow)** remains.
2. **Acidification:** with sulphuric acid the yellow chromate becomes **orange sodium dichromate**:
   $2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$
3. **Conversion to the potassium salt:** sodium dichromate is more soluble than potassium dichromate, so adding KCl gives orange crystals of $K_2Cr_2O_7$:
   $Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$

> Potassium dichromate is preferred in the laboratory: it is less soluble, crystallises well, does not absorb moisture from air, and can be weighed accurately (a **primary standard** in volumetric analysis).

2. Chromate ⇄ dichromate: a pH change, not redox

$2CrO_4^{2-}$ (yellow) $+ 2H^+ \rightleftharpoons Cr_2O_7^{2-}$ (orange) $+ H_2O$

$Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$

- In acid, dichromate (orange) is favoured; in base, chromate (yellow).
- Cr is **+6** in both: no electrons move, so it is **not a redox reaction**.

Structures

- **Chromate**, CrO_4^{2-}: tetrahedral (Cr at the centre, four O at the corners).
- **Dichromate**, $Cr_2O_7^{2-}$: two tetrahedra sharing one corner oxygen; Cr–O–Cr angle ≈ 126°.

3. Oxidising action in acid

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ ($E^\circ = 1.33$ V)

- The ion takes **six electrons**; each Cr goes from **+6 to +3**, and the colour changes from **orange to green**.

Reducing agent	Ionic equation (acidified $K_2Cr_2O_7$)
iron(II)	$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$
iodide	$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$

hydrogen sulphide	$Cr_2O_7^{2-} + 8H^+ + 3H_2S \rightarrow 2Cr^{3+} + 3S + 7H_2O$
tin(II)	$Cr_2O_7^{2-} + 14H^+ + 3Sn^{2+} \rightarrow 2Cr^{3+} + 3Sn^{4+} + 7H_2O$

Breathalyser: ethanol in the breath is oxidised (towards ethanoic acid) and the orange Cr(VI) is reduced to green Cr(III).

Safety: chromium(VI) compounds such as dichromate are toxic and cancer-causing; they are handled with gloves and never tasted or inhaled.

4. Worked examples

Example 1

Q. What is the change in oxidation state of Cr when dichromate oxidises Fe^{2+}? **A.** +6 → +3; each Cr gains 3 electrons, the ion gains 6, so it oxidises 6 Fe^{2+}.

Example 2

Q. A yellow solution of K_2CrO_4 turns orange on adding H_2SO_4. Is Cr oxidised? **A.** No; Cr is +6 in both CrO_4^{2-} and $Cr_2O_7^{2-}$. Acid shifts the equilibrium to dichromate.

Example 3

Q. Why is KCl added to sodium dichromate solution? **A.** $K_2Cr_2O_7$ is less soluble than $Na_2Cr_2O_7$, so it crystallises out.

Example 4

Q. How many moles of I_2 are formed by 1 mol of $Cr_2O_7^{2-}$? **A.** 6 electrons oxidise 6 I^- to 3 I_2: 3 mol.

5. Common mistakes

- ✗ "The yellow → orange change is a redox reaction." ✓ Cr is +6 in both.
- ✗ "Green is the colour of dichromate." ✓ Green is the product, Cr^{3+}.
- ✗ "Dichromate gains 3 electrons." ✓ Each Cr gains 3; the ion gains 6.

6. Key takeaways

- Chromite + Na_2CO_3 + air → yellow Na_2CrO_4; acid → orange $Na_2Cr_2O_7$; + KCl → $K_2Cr_2O_7$ crystals.
- Chromate ⇄ dichromate depends on pH; Cr stays +6.
- In acid, $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$: a strong oxidising agent, orange → green.

Practice questions

1. (MCQ) The ore used to make $K_2Cr_2O_7$ is: (a) haematite (b) chromite (c) bauxite (d) pyrolusite
2. (MCQ) The oxidation state of Cr in $Cr_2O_7^{2-}$ is: (a) +3 (b) +4 (c) +6 (d) +7
3. (MCQ) Adding NaOH to an orange dichromate solution makes it: (a) green (b) yellow (c) purple (d) colourless
4. (MCQ) In acid, one $Cr_2O_7^{2-}$ accepts: (a) $2e^-$ (b) $3e^-$ (c) $5e^-$ (d) $6e^-$
5. (Very short) Write the equation for the fusion of chromite with sodium carbonate.

6. (Very short) What is the Cr–O–Cr angle in dichromate?
7. (Short) Why is the chromate–dichromate change not a redox reaction?
8. (Short) Write the ionic equation for the reaction of acidified $K_2Cr_2O_7$ with iodide.
9. (Short) Describe the preparation of $K_2Cr_2O_7$ from chromite ore in three steps.
10. (HOTS) How does a dichromate breathalyser show alcohol in the breath?

Answer key

1. (b) chromite.
2. (c) +6.
3. (b) yellow.
4. (d) $6e^-$.
5. $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$.
6. About 126°.
7. Cr is +6 in both CrO_4^{2-} and $Cr_2O_7^{2-}$; only H^+/OH^- and water are involved.
8. $Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$.
9. Fuse with Na_2CO_3 in air → Na_2CrO_4 (filter off Fe_2O_3); acidify → $Na_2Cr_2O_7$; add KCl → $K_2Cr_2O_7$ crystallises.
10. Ethanol reduces orange acidified $Cr_2O_7^{2-}$ (Cr +6) to green Cr^{3+} (Cr +3); the colour change shows alcohol is present.

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