

Balancing Redox Reactions using the Half-Reaction Method

Read from Lesson 1 Part c: [Balancing Redox Reactions](#) in the Chemistry Tutorial Section, Chapter 18 of The Physics Classroom.

Step-by-Step Method: Balancing Redox Reactions

Step 1: Identify Oxidation and Reduction

- Assign oxidation numbers to all atoms.
- Determine which species is **oxidized** and which is **reduced**.
- Write separate **half-reactions** for each process.



Step 2: Balance Each Half-Reaction

- Balance all elements except H and O using coefficients.
- Balance oxygen by adding H_2O .
- Balance hydrogen by adding H^+ (acidic). (Do this also for basic solutions – there is an additional next step.)
- For a basic solution:
 - Neutralize H^+ by adding an equal number of OH^- ions to both sides.
 - Combine H^+ and OH^- to form H_2O .
 - Simplify by canceling water molecules if they appear on both sides.
- Balance charge by adding electrons (e^-).
- Verify with an **atom count** and **charge count**.

Step 3: Equalize Electron Transfer

- Multiply each half-reaction by an integer so that both involve the same number of electrons.
- Apply the multiplier to every term in the equation.

Step 4: Combine and Simplify

- Add the two half-reactions.
- Cancel out identical species on both sides (e.g., electrons, H^+ , H_2O).
- Confirm that both **mass and charge** are balanced.

Example 1: $\text{MnO}_4^- + \text{Cl}^- \rightarrow \text{Mn}^{+2} + \text{Cl}_2$ (in an acidic solution)

Oxidation states:

Reactants: Mn +7, O -2 in KMnO_4 ; Cl -1

Products: Mn +2; Cl 0 in Cl_2 .

Step 1: (Half reactions) $\text{MnO}_4^- \rightarrow \text{Mn}^{+2}$ and $\text{Cl}^- \rightarrow \text{Cl}_2$

Step 2: (Balance mass and charge)

$\text{Cl}^- \rightarrow \text{Cl}_2$ becomes

$2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2 \text{e}^-$

$\text{MnO}_4^- \rightarrow \text{Mn}^{+2}$ becomes

$8 \text{H}^+ + \text{MnO}_4^- \rightarrow \text{Mn}^{+2} + 4 \text{H}_2\text{O}$

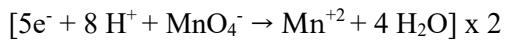
$5\text{e}^- + 8 \text{H}^+ + \text{MnO}_4^- \rightarrow \text{Mn}^{+2} + 4 \text{H}_2\text{O}$

Step 3: (multiply to get 10 e- transferred in each half reaction)

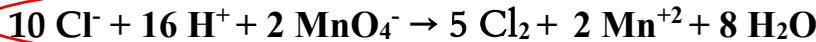
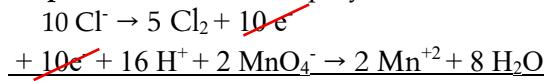
$[2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2 \text{e}^-] \times 5$

$10 \text{Cl}^- \rightarrow 5 \text{Cl}_2 + 10 \text{e}^-$

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Step 4: Combine and Simplify

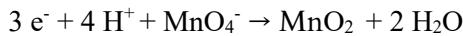


Example 2: $MnO_4^- + CN^- \rightarrow MnO_2 + CNO^-$ (in a basic solution)

Step 1: (Half reactions) $MnO_4^- \rightarrow MnO_2$ and $CN^- \rightarrow CNO^-$

Step 2a: (Balance mass and charge)

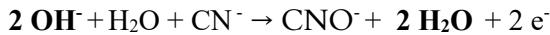
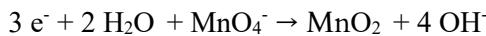
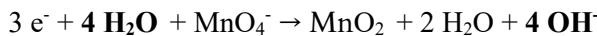
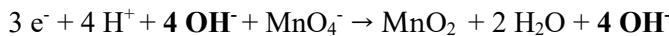
$MnO_4^- \rightarrow MnO_2$ becomes



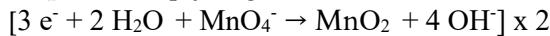
$CN^- \rightarrow CNO^-$ becomes



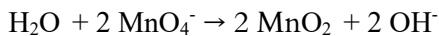
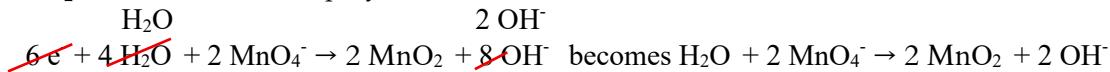
Step 2b: (Neutralize H^+ with OH^- , simplify water molecules.):



Step 3: (multiply to get 6e- transferred in each half reaction)



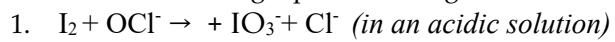
Step 4: Combine and Simplify



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Questions

Balance the following equations using the half-reaction method. Show all work.



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