

## Balancing an oxidation–reduction reaction: The Half-Reaction method.

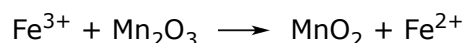
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Balancing an electrochemical reaction in acidic aqueous solution is performed in the presence of  $\text{H}_2\text{O}(\ell)$  and  $\text{H}^+(\text{aq})$ . In this case, any of these two species can be added if necessary to balance the reaction.

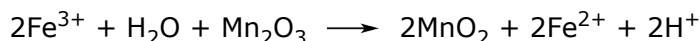
### Steps for balancing a redox reaction (in an acidic solution)

1. Separate the reactions in two half-reactions that will both be balanced individually.
2. Balance the elements other than "O" and "H"
3. Balance "O" by adding  $\text{H}_2\text{O}(\ell)$
4. Balance "H" by adding  $\text{H}^+(\text{aq})$
5. Balance the charges by adding the appropriate number of electrons ( $e^-$ )
6. Make sure that the number of electrons is the same in both half reactions
7. Add the two half reactions together and cancel-out the electrons

Example: Balance the following reaction using the half reaction method



|        |  |   |
|--------|--|---|
| Step 1 | $\text{Mn}_2\text{O}_3 \longrightarrow \text{MnO}_2$   | $\text{Fe}^{3+} \longrightarrow \text{Fe}^{2+}$                   |
| Step 2 | $\text{Mn}_2\text{O}_3 \longrightarrow 2\text{MnO}_2$  |   |
| Step 3 | $\mathbf{H_2O} + \text{Mn}_2\text{O}_3 \longrightarrow 2\text{MnO}_2$  |   |
| Step 4 | $\text{H}_2\text{O} + \text{Mn}_2\text{O}_3 \longrightarrow 2\text{MnO}_2 + \mathbf{2H^+}$   |   |
| Step 5 | $\text{H}_2\text{O} + \text{Mn}_2\text{O}_3 \longrightarrow 2\text{MnO}_2 + 2\text{H}^+ + \mathbf{2e^-}$   | $e^- + \text{Fe}^{3+} \longrightarrow \text{Fe}^{2+}$             |
| Step 6 | $\text{H}_2\text{O} + \text{Mn}_2\text{O}_3 \longrightarrow 2\text{MnO}_2 + 2\text{H}^+ + \mathbf{2e^-}$   | $\mathbf{2e^-} + 2\text{Fe}^{3+} \longrightarrow 2\text{Fe}^{2+}$ |
| Step 7 | $\mathbf{2e^-} + 2\text{Fe}^{3+} + \text{H}_2\text{O} + \text{Mn}_2\text{O}_3 \longrightarrow 2\text{MnO}_2 + 2\text{Fe}^{2+} + 2\text{H}^+ + \mathbf{2e^-}$ |   |



### IMPORTANT

Electrons are negative particles that carry electrical charge. Since it is an actual physical entity, it cannot be "mathematically" subtracted in a chemical reaction.

