

Balancing Redox reactions in an acid or a base

Redox reactions in acidic solutions

- I will tell you if it is in an acidic solution.
- These have special rules.
- Separate the reaction into half reactions.
- Balance all elements except hydrogen and oxygen.
- Balance oxygen by adding H₂O (which is always prevalent in an acidic solution)
- Balance hydrogen by adding H⁺.
- Then balance the charge by adding electrons to whichever side is more positive.
- Recombine your two half equations.

Example

- In an acidic solution
- $\text{Cr}_2\text{O}_7^{2-} + \text{Cl}^- \rightarrow \text{Cr}^{3+} + \text{Cl}_2$
- Half reactions
- $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{3+}$
- $\text{Cl}^- \rightarrow \text{Cl}_2$

Here we go

- $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{3+}$
- $\text{Cr}_2\text{O}_7^{2-} \rightarrow 2 \text{Cr}^{3+}$
- $\text{Cr}_2\text{O}_7^{2-} \rightarrow 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$
- $\text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ \rightarrow 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$
- $\text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ + 6 \text{e}^- \rightarrow 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$

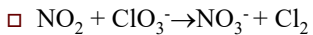
Other side

- $\text{Cl}^- \rightarrow \text{Cl}_2$
- $2 \text{Cl}^- \rightarrow \text{Cl}_2$
- $2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2 \text{e}^-$
- I have to equal 6e^- so multiply by 3
- $6 \text{Cl}^- \rightarrow 3 \text{Cl}_2 + 6 \text{e}^-$

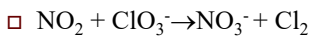
Combine my half reactions

- $\text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ + 6 \text{e}^- \rightarrow 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$
- $6 \text{Cl}^- \rightarrow 3 \text{Cl}_2 + 6 \text{e}^-$
- And you get
- $\text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ + 6 \text{Cl}^- \rightarrow 2 \text{Cr}^{3+} + 3 \text{Cl}_2 + 7 \text{H}_2\text{O}$
- The electrons cancel out .

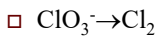
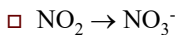
Balance in an acidic solution



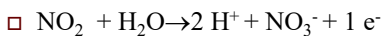
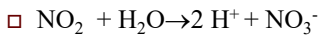
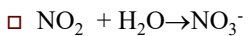
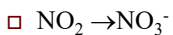
Balance in an acidic solution



Half reactions



Nitrate side



Chlorate

- $\text{ClO}_3^- \rightarrow \text{Cl}_2$
- $2 \text{ClO}_3^- \rightarrow \text{Cl}_2$
- $2 \text{ClO}_3^- \rightarrow \text{Cl}_2 + 6 \text{H}_2\text{O}$
- $2 \text{ClO}_3^- + 12 \text{H}^+ \rightarrow \text{Cl}_2 + 6 \text{H}_2\text{O}$
- $2 \text{ClO}_3^- + 12 \text{H}^+ + 10 \text{e}^- \rightarrow \text{Cl}_2 + 6 \text{H}_2\text{O}$

- You will have 10 x the first reaction

- $10 \text{NO}_2 + 10 \text{H}_2\text{O} \rightarrow 20 \text{H}^+ + 10 \text{NO}_3^- + 10 \text{e}^-$

Put them together

- $2 \text{ClO}_3^- + 12 \text{H}^+ + 10 \text{NO}_2 + 10 \text{H}_2\text{O}$
- $\rightarrow \text{Cl}_2 + 6 \text{H}_2\text{O} + 20 \text{H}^+ + 10 \text{NO}_3^-$

- Notice the H^+ and the water can also cancel out
- $2 \text{ClO}_3^- + 10 \text{NO}_2 + 4 \text{H}_2\text{O} \rightarrow \text{Cl}_2 + 8 \text{H}^+ + 10 \text{NO}_3^-$

Example

- In an acidic solution
- $\text{MnO}_4^- + \text{H}_2\text{O}_2 \rightarrow \text{Mn}^{2+} + \text{O}_2$

Example

- In an acidic solution
- $\text{MnO}_4^- + \text{H}_2\text{O}_2 \rightarrow \text{Mn}^{2+} + \text{O}_2$

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

Top Equation

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

Bottom Equation

- $\text{H}_2\text{O}_2 \rightarrow \text{O}_2$
- $\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2 \text{H}^+$
- $\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2 \text{H}^+ + 2 \text{e}^-$
- I need to equal 5 e⁻ so...
- That won't work...
- $2\text{MnO}_4^- + 16 \text{H}^+ + 10 \text{e}^- \rightarrow 2 \text{Mn}^{2+} + 8 \text{H}_2\text{O}$
- $5 \text{H}_2\text{O}_2 \rightarrow 5 \text{O}_2 + 10 \text{H}^+ + 10 \text{e}^-$

Add them together

- $2\text{MnO}_4^- + 16\text{H}^+ + 10\text{e}^- \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O}$
- $5\text{H}_2\text{O}_2 \rightarrow 5\text{O}_2 + 10\text{H}^+ + 10\text{e}^-$
- And you get
- $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{O}_2 \rightarrow 2\text{Mn}^{2+} + 5\text{O}_2 + 8\text{H}_2\text{O}$
- Notice the H^+ canceled out as well.

Balancing Redox Equations in a basic solution

- Follow all rules for an acidic solution.
- After you have completed the acidic reaction add OH^- to each side to neutralize any H^+ .
- Combine OH^- and H^+ to make H_2O .
- Cancel out any extra waters from both sides of the equation.

Example

- We will use the same equation as before
- In a basic solution
- $\text{MnO}_4^- + \text{H}_2\text{O}_2 \rightarrow \text{Mn}^{2+} + \text{O}_2$

- Balanced in an acidic solution
- $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{O}_2 \rightarrow 2\text{Mn}^{2+} + 5\text{O}_2 + 8\text{H}_2\text{O}$

Basic solution

- Since this is a basic solution we can't have excess H^+ .
- We will add OH^- to each side to neutralize all H^+
- $2 MnO_4^- + 6 H^+ + 5 H_2O_2 + 6 OH^-$
 $\rightarrow 2 Mn^{2+} + 5 O_2 + 8 H_2O + 6 OH^-$
- We added 6 OH^- because there were 6 H^+

Cont.

- $H^+ + OH^- \rightarrow H_2O$
- Combine the hydroxide and hydrogen on the reactant side to make water
- $2 MnO_4^- + 6 H_2O + 5 H_2O_2$
 $\rightarrow 2 Mn^{2+} + 5 O_2 + 8 H_2O + 6 OH^-$
- Cancel out waters on both sides
- $2 MnO_4^- + 5 H_2O_2$
 $\rightarrow 2 Mn^{2+} + 5 O_2 + 2 H_2O + 6 OH^-$

Another example

- In a basic solution
- $MnO_4^- + SO_3^{2-} \rightarrow MnO_4^{2-} + SO_4^{2-}$

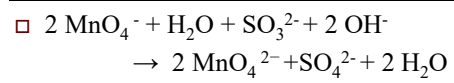
Another example

- In a basic solution
- $\text{MnO}_4^- + \text{SO}_3^{2-} \rightarrow \text{MnO}_4^{2-} + \text{SO}_4^{2-}$
- Half reactions
- $\text{MnO}_4^- \rightarrow \text{MnO}_4^{2-}$
- $\text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-}$

Half reactions

- $\text{MnO}_4^- \rightarrow \text{MnO}_4^{2-}$
- $\text{MnO}_4^- + e^- \rightarrow \text{MnO}_4^{2-}$
- $\text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-}$
- $\text{H}_2\text{O} + \text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-}$
- $\text{H}_2\text{O} + \text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-} + 2 \text{H}^+$
- $\text{H}_2\text{O} + \text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-} + 2 \text{H}^+ + 2e^-$
- Double the top reaction

- $2 \text{MnO}_4^- + 2 e^- \rightarrow 2 \text{MnO}_4^{2-}$
- $\text{H}_2\text{O} + \text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-} + 2 \text{H}^+ + 2e^-$
- Combine them
- $2 \text{MnO}_4^- + \text{H}_2\text{O} + \text{SO}_3^{2-} \rightarrow 2 \text{MnO}_4^{2-} + \text{SO}_4^{2-} + 2 \text{H}^+$
- Add OH⁻
- $2 \text{MnO}_4^- + \text{H}_2\text{O} + \text{SO}_3^{2-} + 2 \text{OH}^- \rightarrow 2 \text{MnO}_4^{2-} + \text{SO}_4^{2-} + 2 \text{H}^+ + 2 \text{OH}^-$



□ finishing

