Balancing REDOX Reactions: Learn and Practice - KEY

Are these reactions are REDOX reactions? If yes, then balance the reaction using the half-reaction method.

1. $\underline{2}Au^{3+}(aq) + \underline{6}I^{-}(aq) \rightarrow \underline{2}Au(s) + \underline{3}I_2(s)$

To balance elements: Insert coefficients.

Oxidation ½ reaction: $2I^{-} \rightarrow I_2$

Reduction ½ reaction: $Au^{3+} \rightarrow Au$

To balance charge: Add electrons.

Oxidation ½ reaction: $2I^{-} \rightarrow I_2 + 2e^{-}$

Reduction ½ reaction: $Au^{3+} + 3e^{-} \rightarrow Au$

To balance electrons: Multiply by coefficients.

Oxidation ½ reaction: $3x(2I^{-} \rightarrow I_2 + 2e^{-})$

New Oxidation ½ reaction: $6I^{-} \rightarrow 3I_2 + 6e^{-}$

Reduction ½ reaction: $2x(Au^{3+} + 3e^{-} \rightarrow Au)$

New Reduction ½ reaction: $2Au^{3+} + 6e^{-} \rightarrow 2Au$

Combine:

Oxidation ½ reaction: $6I^{-} \rightarrow 3I_2 + 6e^{-}$

Reduction ½ reaction: $+ 2Au^{3+} + 6e^{-} \rightarrow 2Au$

Combined Balanced Equation: $6I^{-} + 2Au^{3+} \rightarrow 3I_2 + 2\,Au$

2. $Cu(s) + \underline{2}Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + \underline{2}Ag(s)$

To balance elements: Insert coefficients.

Oxidation ½ reaction: $Cu \rightarrow Cu^{2+}$

Reduction ½ reaction: $Ag^{+} \rightarrow Ag$

To balance charge: Add electrons.

Oxidation ½ reaction: $Cu \rightarrow Cu^{2+} + 2e^{-}$

Reduction ½ reaction: $Ag^{+} + 1e^{-} \rightarrow Ag$

To balance electrons: Multiply by coefficients.

Oxidation ½ reaction: $Cu \rightarrow Cu^{2+} + 2e^-$

Reduction ½ reaction: $2x(Ag^+ + 1e^- \rightarrow Ag)$

New Reduction ½ reaction: $2Ag^+ + 2e^- \rightarrow 2Ag$

Combine:

Oxidation ½ reaction: $Cu \rightarrow Cu^{2+} + 2e^-$

Reduction ½ reaction: $+ 2Ag^+ + 2e^- \rightarrow 2Ag$

Combined Balanced Equation: $Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$

3. $\_\_BaSO_3\ (s) \rightarrow \_\_BaO\ (s) + \_\_SO_2\ (g)$

NOT A REDOX REACTION. Also, it is already balanced :)

Balance the following reactions using the half-reaction method in an ***acidic*** solution.

1. $3NbO_2 + 2W + 2H_2O \rightarrow 3Nb + 2WO_4^{2-} + 4H^+$

To balance elements (other than O and H): Insert coefficients.

Oxidation ½ reaction: $W \rightarrow WO_4^{2-}$

Reduction ½ reaction: $NbO_2 \rightarrow Nb$

To balance oxygens: Add water.

Oxidation ½ reaction: $4H_2O + W \rightarrow WO_4^{2-}$

Reduction ½ reaction: $NbO_2 \rightarrow Nb + 2H_2O$

To balance hydrogens: Add H^+ (since we're in acidic solutions).

Oxidation ½ reaction: $4H_2O + W \rightarrow WO_4^{2-} + 8H^+$

Reduction ½ reaction: $4H^+ + NbO_2 \rightarrow Nb + 2H_2O$

To balance charge: Add electrons.

Oxidation ½ reaction: $4H_2O + W \rightarrow WO_4^{2-} + 8H^+ + 6e^-$

Reduction ½ reaction: $4e^- + 4H^+ + NbO_2 \rightarrow Nb + 2H_2O$

To balance electrons: Multiply by coefficients.

Oxidation ½ reaction: $2x(4H_2O + W \rightarrow WO_4^{2-} + 8H^+ + 6e^-)$

New Oxidation ½ reaction: $8H_2O + 2W \rightarrow 2WO_4^{2-} + 16H^+ 12e^-$

Reduction ½ reaction: $3x(4e^- + 4H^+ + NbO_2 \rightarrow Nb + 2H_2O)$

New Reduction ½ reaction: $12e^- + 12H^+ + 3NbO_2 + 12e^- \rightarrow 3Nb + 6H_2O$

Combine:

Oxidation ½ reaction: $8H_2O + 2W \rightarrow 2WO_4^{2-} + 16H^+ 12e^-$

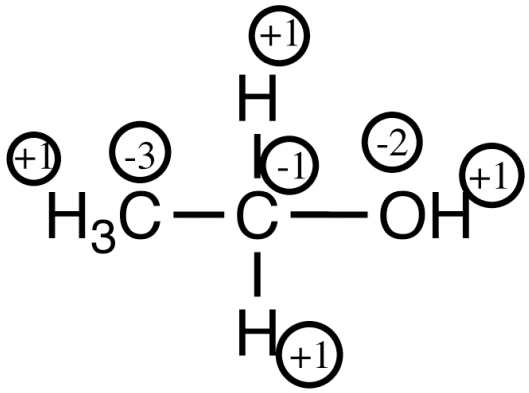
Reduction ½ reaction: $12\ e^- + 12H^+ + 3NbO_2 + 12e^- \rightarrow 3Nb + 6H_2O$

Combined Balanced Equation: $3NbO_2 + 2W + 2H_2O \rightarrow 2WO_4^{2-} + 3Nb + 4H^+$

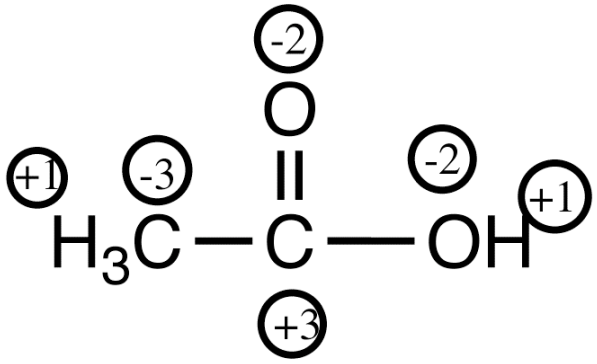
2. $5C_2H_5OH\ (aq) + 4MnO_4^-\ (aq) + 12H^+ \rightarrow 4Mn^{2+}\ (aq) + 5CH_3COOH\ (aq) + 11H_2O$

Here the assignment of oxidation numbers can be challenging. Refer to the following diagrams for the assignment of oxidation numbers on the hydrocarbons!

Ethanol:



Acetic Acid:



To balance elements (other than O and H): Insert coefficients.

Oxidation ½ reaction: $C_2H_5OH \rightarrow CH_3COOH$

Reduction ½ reaction: $MnO_4^- \rightarrow Mn^{2+}$

To balance oxygens: Add water.

Oxidation ½ reaction: $H_2O + C_2H_5OH \rightarrow CH_3COOH$

Reduction ½ reaction: $MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

To balance hydrogens: Add H^+ (since we're in acidic solutions).

Oxidation ½ reaction: $H_2O + C_2H_5OH \rightarrow CH_3COOH + 4H^+$

Reduction ½ reaction: $8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

To balance charge: Add electrons.

Oxidation ½ reaction: $H_2O + C_2H_5OH \rightarrow CH_3COOH + 4H^+ + 4e^-$

Reduction ½ reaction: $8H^+ + MnO_4^- + 5e^- \rightarrow Mn^{2+} + 4H_2O$

To balance electrons: Multiply by coefficients.

Oxidation ½ reaction: $5x(H_2O + C_2H_5OH \rightarrow CH_3COOH + 4H^+ + 4e^-)$

New Oxidation ½ reaction: $5H_2O + 5C_2H_5OH \rightarrow 5CH_3COOH + 20H^+ + 20e^-$

Reduction ½ reaction: $4x(8H^+ + MnO_4^- + 5e^- \rightarrow Mn^{2+} + 4H_2O)$

New Reduction ½ reaction: $32H^+ + 4MnO_4^- + 20e^- \rightarrow 4Mn^{2+} + 16H_2O$

Combine:

Oxidation ½ reaction: $5H_2O + 5C_2H_5OH \rightarrow 5CH_3COOH + 20H^+ + 20e^-$

Reduction ½ reaction: $+ 32H^+ + 4MnO_4^- + 20e^- \rightarrow 4Mn^{2+} + 16H_2O$

Combined Balanced Equation: $12H^+ + 5C_2H_5OH + 4MnO_4^- \rightarrow 5CH_3COOH + 4Mn^{2+} + 11H_2O$

3. $ClO^- + 2ZnO + 6H^+ \rightarrow Cl^- + 2Zn^{3+} + 3H_2O$

To balance elements (other than O and H): Insert coefficients.

Oxidation ½ reaction: $ZnO \rightarrow Zn^{3+}$

Reduction ½ reaction: $ClO^- \rightarrow Cl^-$

To balance oxygens: Add water.

Oxidation ½ reaction: $ZnO \rightarrow Zn^{3+} + H_2O$

Reduction ½ reaction: $ClO^- \rightarrow Cl^- + H_2O$

To balance hydrogens: Add H^+ (since we're in acidic solutions).

Oxidation ½ reaction: $2H^+ + ZnO \rightarrow Zn^{3+} + H_2O$

Reduction ½ reaction: $2H^+ + ClO^- \rightarrow Cl^- + H_2O$

To balance charge: Add electrons.

Oxidation ½ reaction: $2H^+ + ZnO \rightarrow Zn^{3+} + H_2O + 1e^-$

Reduction ½ reaction: $2H^+ + ClO^- + 2e^- \rightarrow Cl^- + H_2O$

To balance electrons: Multiply by coefficients.

Oxidation ½ reaction: $2x(2H^+ + ZnO \rightarrow Zn^{3+} + H_2O + 1e^-)$

New Oxidation ½ reaction: $4H^+ + 2ZnO \rightarrow 2Zn^{3+} + 2H_2O + 2e^-$

Reduction ½ reaction: $2H^+ + ClO^- + 2e^- \rightarrow Cl^- + H_2O$

Combine:

Oxidation ½ reaction: $4H^+ + 2ZnO \rightarrow 2Zn^{3+} + 2H_2O + 2e^-$

Reduction ½ reaction: $+ 2H^+ + ClO^- + 2e^- \rightarrow Cl^- + H_2O$

Combined Balanced Equation: $6H^+ + 2ZnO + ClO^- \rightarrow 2Zn^{3+} + Cl^- + 3H_2O$

Balance the following reactions using the half-reaction method in a ***basic*** solution.

1. $2NH_3 + 2ClO^- \rightarrow 1N_2H_2 + 2Cl^- + 2H_2O$

To balance elements (other than O and H): Insert coefficients.

Oxidation ½ reaction: $2NH_3 \rightarrow N_2H_2$

Reduction ½ reaction: $ClO^- \rightarrow Cl^-$

To balance oxygens: Add water.

Oxidation ½ reaction: $2NH_3 \rightarrow N_2H_2$

Reduction ½ reaction: $ClO^- \rightarrow Cl^- + H_2O$

To balance hydrogens: Add H^+.

Oxidation ½ reaction: $2NH_3 \rightarrow N_2H_2 + 4H^+$

Reduction ½ reaction: $2H^+ + ClO^- \rightarrow Cl^- + H_2O$

BUT it is a BASIC solution. Add OH^- to BOTH sides (enough to combine with all H^+)

Oxidation ½ reaction: $4OH^- + 2NH_3 \rightarrow N_2H_2 + 4H^+ + 4OH^-$

Combine to make water: $4OH^- + 2NH_3 \rightarrow N_2H_2 + 4H_2O$

Reduction ½ reaction: $2OH^- + 2H^+ + ClO^- \rightarrow Cl^- + H_2O + 2OH^-$

Combine to make water: $2H_2O + ClO^- \rightarrow Cl^- + H_2O + 2OH^-$

Cancel any waters on both sides: $H_2O + ClO^- \rightarrow Cl^- + 2OH^-$

To balance charge: Add electrons.

Oxidation ½ reaction: $4OH^- + 2NH_3 \rightarrow N_2H_2 + 4H_2O + 4e^-$

Reduction ½ reaction: $2e^- + H_2O + ClO^- \rightarrow Cl^- + 2OH^-$

To balance electrons: Multiply by coefficients.

Oxidation ½ reaction: $4OH^- + 2NH_3 \rightarrow N_2H_2 + 4H_2O + 4e^-$

Reduction ½ reaction: $2x(2e^- + H_2O + ClO^- \rightarrow Cl^- + 2OH^-)$

NEW Reduction ½ reaction: $2H_2O + 2ClO^- + 4e^- \rightarrow 2Cl^- + 4OH^-$

Combine:

Oxidation ½ reaction: $4OH^- + 2NH_3 \rightarrow N_2H_2 + 4H_2O + 4e^-$

Reduction ½ reaction: $+ \ 2H_2O + 2ClO^- + 4e^- \rightarrow 2Cl^- + 4OH^-$

Combined Balanced Equation:

$2NH_3 + 2ClO^- \rightarrow 2Cl^- + N_2H_2 + 2H_2O$

2. $Fe + NiO_2 + 2H_2O \rightarrow Fe(OH)_2 + Ni(OH)_2$

To balance elements (other than O and H): Insert coefficients.

Oxidation ½ reaction: $Fe \rightarrow Fe(OH)_2$

Reduction ½ reaction: $NiO_2 \rightarrow Ni(OH)_2$

To balance oxygens: Add water.

Oxidation ½ reaction: $Fe + 2H_2O \rightarrow Fe(OH)_2$

Reduction ½ reaction: $NiO_2 \rightarrow Ni(OH)_2$

To balance hydrogens: Add H^+.

Oxidation ½ reaction: $Fe + 2H_2O \rightarrow Fe(OH)_2 + 2H^+$

Reduction ½ reaction: $NiO_2 + 2H^+ \rightarrow Ni(OH)_2$

BUT it is a BASIC solution. Add OH^- to BOTH sides (enough to combine with all H^+)

Oxidation ½ reaction: $Fe + 2H_2O + 2OH^- \rightarrow Fe(OH)_2 + 2H^+ + 2OH^-$

Combine H^+ and OH^-: $Fe + 2H_2O + 2OH^- \rightarrow Fe(OH)_2 + 2H_2O$

Cancel Extra H_2O: $\mathbf{Fe + 2OH^- \rightarrow Fe(OH)_2}$

Reduction ½ reaction: $NiO_2 + 2H^+ + 2OH^- \rightarrow Ni(OH)_2 + 2OH^-$

Combine H^+ and OH^-: $NiO_2 + 2H_2O \rightarrow Ni(OH)_2 + 2OH^-$

Cancel Extra H_2O: $\mathbf{NiO_2 + 2H_2O \rightarrow Ni(OH)_2 + 2OH^-}$

To balance charge: Add electrons.

Oxidation ½ reaction: $Fe + 2OH^- \rightarrow Fe(OH)_2 + 2e^-$

Reduction ½ reaction: $NiO_2 + 2H_2O + 2e^- \rightarrow Ni(OH)_2 + 2OH^-$

To balance electrons: Multiply by coefficients.

Not necessary! $2e^-$ are already on either side!

Combine:

Oxidation ½ reaction: $Fe + 2OH^- \rightarrow Fe(OH)_2 + 2e^-$

Reduction ½ reaction: $+ NiO_2 + 2H_2O + 2e^- \rightarrow Ni(OH)_2 + 2OH^-$

Combined Balanced Equation: $Fe + 2H_2O + NiO_2 \rightarrow Ni(OH)_2 + Fe(OH)_2$

3. $2MnO_4^- + 3CN^- + H_2O \rightarrow 2MnO_2 + 3CNO^- + 2OH^-$

To balance elements (other than O and H): Insert coefficients.

Oxidation ½ reaction: $CN^- \rightarrow CNO^-$

Reduction ½ reaction: $MnO_4^- \rightarrow MnO_2$

To balance oxygens: Add water.

Oxidation ½ reaction: $CN^- + H_2O \rightarrow CNO^-$

Reduction ½ reaction: $MnO_4^- \rightarrow MnO_2 + 2H_2O$

To balance hydrogens: Add H^+.

Oxidation ½ reaction: $CN^- + H_2O \rightarrow CNO^- + 2H^+$

Reduction ½ reaction: $MnO_4^- + 4H^+ \rightarrow MnO_2 + 2H_2O$

BUT it is a BASIC solution. Add OH^- to BOTH sides (enough to combine with all H^+)

Oxidation ½ reaction: $CN^- + H_2O + 2OH^- \rightarrow CNO^- + 2H^+ + 2OH^-$

Combine H^+ and OH^-: $CN^- + H_2O + 2OH^- \rightarrow CNO^- + 2H_2O$

Cancel Extra H_2O: $\mathbf{CN^- + 2OH^- \rightarrow CNO^- + H_2O}$

Reduction ½ reaction: $MnO_4^- + 4H^+ + 4OH^- \rightarrow MnO_2 + 2H_2O + 4OH^-$

Combine H^+ and OH^-: $MnO_4^- + 4H_2O \rightarrow MnO_2 + 2H_2O + 4OH^-$

Cancel Extra H_2O: $\mathbf{MnO_4^- + 2H_2O \rightarrow MnO_2 + 4OH^-}$

To balance charge: Add electrons.

Oxidation ½ reaction: $CN^- + 2OH^- \rightarrow CNO^- + H_2O + 2e^-$

Reduction ½ reaction: $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$

To balance electrons: Multiply by coefficients.

Oxidation ½ reaction: $3x(CN^- + 2OH^- \rightarrow CNO^- + H_2O + 2e^-)$

New Oxidation ½ reaction: $\mathbf{3CN^- + 6OH^- \rightarrow 3CNO^- + 3H_2O + 6e^-}$

Reduction ½ reaction: $2x(MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-)$

New Reduction ½ reaction: $\mathbf{2MnO_4^- + 4H_2O + 6e^- \rightarrow 2MnO_2 + 8OH^-}$

Combine: $3CN^- + 6OH^- \rightarrow 3CNO^- + 3H_2O + 6e^-$

$+ \quad 2MnO_4^- + 4H_2O + 6e^- \rightarrow 2MnO_2 + 8OH^-$

Combined Balanced Equation: $3CN^- + 2MnO_4^- + H_2O \rightarrow 3CNO^- + 2MnO_2 + 2OH^-$