How to Identify What is Oxidized or Reduced in a Reaction

Once you have identified a redox reaction by the change in oxidation state, now you can tell what was oxidized or reduced!

a. A substance that has the element that has been oxidized (LOST electrons) will have an oxidation number that becomes more positive (or less negative).

b. A substance that has the element that has been reduced (GAINED electrons) will have an oxidation number that becomes more negative (or less positive).

Balancing Redox Reactions: We split redox reactions into two separate half-reactions

- The oxidation half-reaction has electrons as a product.
- The reduction half-reaction has electrons as a reactant.

Oxidation Half-Reaction	**Reduction Half-Reaction**
$Zn(s) \rightarrow Zn^{2+}(aq) + 2\,e^-$	$Fe^{2+}(aq) + 2\,e^- \rightarrow Fe(s)$

Reduction Potential Values: a measure of the tendency of a chemical species to gain electrons (aka be reduced). Reduction potential is measured in volts (V), or millivolts (mV). Reduction potential values are measured relative to the potential for H^+ to gain electrons to become H_2.

How to read a Reduction Potential Chart

1. The more positive $E°_{red}$ (V), the more likely it is to be reduced (gain electrons).
2. The more negative $E°_{red}$ (V), the less likely it is to be reduced (gain electrons).

Table 1. Standard Reduction Potentials at 25 °C

Reduction Half Reaction				E°
$Co^{3+}(aq) + e^-$	→	$Co^{2+}(aq)$	less potential to be oxidized (lose e^-)	1.92 V
$Au^+(aq) + e^-$	→	$Au(s)$		1.69 V
$Mn^{3+}(aq) + e^-$	→	$Mn^{2+}(aq)$		1.54 V
$Au^{3+}(aq) + 3e^-$	→	$Au(s)$		1.498 V
$Ag^+(aq) + e^-$	→	$Ag(s)$		0.80 V
$Cu^+(aq) + e^-$	→	$Cu(s)$		0.52 V
$Cu^{2+}(aq) + 2e^-$	→	$Cu(s)$		0.34 V
$2H^+(aq) + 2e^-$	→	$H_2(g)$		0.00 V
$Pb^{2+}(aq) + 2e^-$	→	$Pb(s)$		−0.13 V
$Ni^{2+}(aq) + 2e^-$	→	$Ni(s)$		−0.26 V
$Co^{2+}(aq) + 2e^-$	→	$Co(s)$		−0.28 V
$Cd^{2+}(aq) + 2e^-$	→	$Cd(s)$	more potential to be oxidized	−0.41 V
$Zn^{2+}(aq) + 2e^-$	→	$Zn(s)$		−0.76 V
$Mn^{2+}(aq) + 2e^-$	→	$Mn(s)$		−1.18 V
$Al^{3+}(aq) + 3e^-$	→	$Al(s)$		−1.66 V

more potential to be reduced (gain e^-) →

less potential to be reduced →

When comparing two species:

- Substance with the **greater** (more positive/less negative) **reduction potential** will be reduced
- Substance with the **smaller** (less positive/more negative) **reduction potential** will be oxidized

3. Switching the Sign of the reduction potential will give you the oxidation potential ($E°_{oxidation}$)

$$-E_{red} = E_{ox}$$

Let's try!

1. Is the following reaction a redox reaction? *If* the reaction is redox, identify what was oxidized and reduced!

Yes, redox! Al = oxidized, O_2 = reduced

$$4\,Al(s) + 3\,O_2(g) \rightarrow 2\,Al_2O_3(s)$$

ϕ ϕ +3, −2

2. Rank these metals in order of the most easily oxidized to the least easily oxidized: Cu, Ni, Ag, Pb

Ni, Pb, Cu, Ag

$E°_{red}$: −0.76, −0.13, 0.34/0.52 (Cu^+ Cu^{2+}), 0.80

Directions: Write the half reaction for each of the follow redox reactions, identify what is being reduced and what is being oxidized, then write the correction reduction or oxidation potential next to each half-reaction.

3. Fe^{2+} Cd^{2+} + Zn → Cd Cd^{2+} + Zn^{2+}

ox: $Zn \rightarrow Zn^{2+} + 2e^-$ $\quad E°_{ox} = -E°_{red} = +0.76V$

red: $Cd^{2+} + 2e^- \rightarrow Cd$ $\quad E°_{red} = -0.41V$

4. $2\,Ag^+$ + Ni → Ni^{2+} + 2 Ag

ox: $Ni \rightarrow Ni + 2e^-$ $\quad E°_{ox} = -E°_{red} = +0.25V$

red: $Ag^+ + e^- \rightarrow Ag$ $\quad E°_{red} = +0.80V$

Multiple Choice Practice FTW!

1. A balanced equation for the reaction of copper metal with nitric acid is shown below. Which of the following represents a true statement about the reaction?

$$3\,Cu(s) + 8\,H^+(aq) + 2\,NO_3^-(aq) \rightarrow 3\,Cu^{2+}(aq) + 4\,H_2O(l) + 2\,NO(g)$$

ϕ +1 +5, −2 +2 +1, −2 +2, −2

(a.) The oxidation state of nitrogen changed from +5 to +2.

b. Hydrogen ions are oxidized to form $H_2O(l)$.

c. The oxidation state of oxygen changes from −1 to −2.

d. Copper metal is reduced to a copper (II) ion.

$E^\circ_{red}(X) > E^\circ_{red}(Y)$ $E^\circ_{red}(Z) > E^\circ_{red}(X)$

2. A strip of metal X is placed into a solution containing Y^{2+} ions and no reaction occurs. When metal X is placed in a separate solution containing Z^{2+} ions, metal Z starts to form on the strip. Which of the following choices organizes the reduction potentials for metals X, Y, and Z from greatest to least?

a. X > Y > Z b. Y > Z > X (c.) Z > X > Y d. Y > X > Z

+1, -2 +7, -2 +3, -2 +4, -2 +7, -2 -2, +1

$$2\,H_2O(l) + 4\,MnO_4^-(aq) + 3\,ClO_2^-(aq) \rightarrow 4\,MnO_2(aq) + 3\,ClO_4^-(aq) + 4\,OH^-(aq)$$

3. Which species is reduced in the reaction represented above?

a. MnO_2 b. ClO_2^- (c.) MnO_4^- d. ClO_4^-

4. In the reaction below, a piece of solid nickel is added to a solution of potassium dichromate.

$$14\,H^+(aq) + Cr_2O_7^{2-}(aq) + 3\,Ni(s) \rightarrow 2\,Cr^{3+}(aq) + 3\,Ni^{2+}(aq) + 7\,H_2O(l)$$

+1 +6, -2 0 +3 +2 +1, -2

Which species is being oxidized and which is being reduced?

	Oxidized	Reduced
a.	$Cr_2O_7^{2-}(aq)$	$Ni(s)$
b.	$Cr^{3+}(aq)$	$Ni^{2+}(aq)$
(c.)	$Ni(s)$	$Cr_2O_7^{2-}(aq)$
d.	$Ni^{2+}(aq)$	$Cr^{3+}(aq)$