19.1 Oxidation-Reduction Review

Rules for Assigning Oxidation Numbers

1. An atom in its elemental state has an oxidation number of 0.

   $Na_{(s)}$ $Mg_{(s)}$ $C_{(s)}$ $O_{2(g)}$

2. A monatomic ion has an oxidation number identical to its charge

   $Na^{+}_{(aq)}$ $Mg^{2+}_{(aq)}$ $O^{2-}_{(aq)}$ $Cl^{-}_{(aq)}$

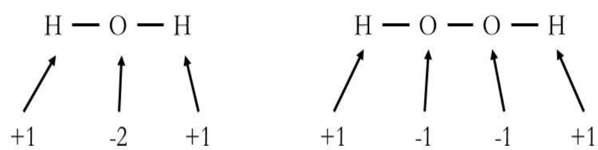
3. Other exceptions:

   1. Hydrogen can be either +1 (bonding to nonmetal) or –1 (bonding to metal)

      HCl vs. NaH

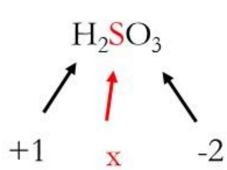
      +1 -1

   2. Oxygen *usually* has an oxidation number of -2 but when bonded to itself, it has an oxidation number of -1.



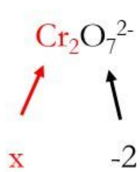
   3. Halogens *usually* have an oxidation number of -1 *except* bonding to oxygen

4. The sum of the oxidation numbers is 0 for a neutral compound and is equal to the net charge for a polyatomic ion



2(+1) + x + 3(-2) = 0 (net charge)

x = ????



2(x) + 7(-2) = -2 (net charge)

x = ????

Balancing Redox Reaction in Acidic Solution-Half Method

$$I^{1-}_{(aq)} \quad + \quad Cr_2O_7^{2-}_{(aq)} \rightarrow Cr^{3+}_{(aq)} \quad + \quad IO_3^{1-}_{(aq)}$$

1. **Assign Oxidation number**

   I = -1 Cr =+6 O= -2 → Cr = +3 I= +5 O = -2

2. **Split into Oxidation half and Reduction half**

   OX (1/2): $I^{-}_{(aq)} \rightarrow IO_3^{-}_{(aq)}$

   RED (1/2): $Cr_2O_7^{2-}_{(aq)} \rightarrow Cr^{3+}_{(aq)}$

3. **Balancing Oxidation-Half:**

   a. **Balance all other atoms except O and H**

   $I^{-}_{(aq)} \rightarrow IO_3^{-}_{(aq)}$

   b. **Balance O by adding $H_2O_{(l)}$**

   $3H_2O_{(l)} + I^{-}_{(aq)} \rightarrow IO_3^{-}_{(aq)}$

   c. **Balancing H by adding $H^{+}_{(aq)}$**

   $3\ H_2O_{(l)} + I^{-}_{(aq)} \rightarrow IO_3^{-}_{(aq)} + 6H^{+}_{(aq)}$

   d. **Balancing charges by adding appropriate number of e- (to the right)**

   $3\ H_2O_{(l)} + I^{-}_{(aq)} \rightarrow IO_3^{-}_{(aq)} + 6\ H^{+}_{(aq)} + 6e-$

   0 -1 → -1 +6 -6

4. Balancing Reduction-Half:

a. Balance all other atoms except O and H

$Cr_2O_7^{2-}{}_{(aq)} \rightarrow 2\ Cr^{3+}{}_{(aq)}$

b. Balance O by adding $H_2O_{(l)}$

$Cr_2O_7^{2-}{}_{(aq)} \rightarrow 2\ Cr^{3+}{}_{(aq)} + 7\ H_2O_{(l)}$

c. Balance H by adding $H^+{}_{(aq)}$

$14\ H^+{}_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} \rightarrow 2\ Cr^{3+}{}_{(aq)} + 7\ H_2O_{(l)}$

d. Balancing charges by adding appropriate number of e- (to the left)

$6e^- + 14\ H^+{}_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} \rightarrow 2Cr^{3+}{}_{(aq)} + 7\ H_2O_{(l)}$

-6 14+ -2 → +6 0

5. Combined the two balanced half reactions then write the net equation by cancelling the electrons.

OX (1/2): $3\ H_2O_{(l)} + I^-{}_{(aq)} \rightarrow IO_3^-{}_{(aq)} + 6\ H^+{}_{(aq)} + 6e^-$

RED (1/2): $6e^- + 14\ H^+{}_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} \rightarrow 2Cr^{3+}{}_{(aq)} + 7\ H_2O_{(l)}$

Net-Equation: $I^-{}_{(aq)} + Cr_2O_7^{2-}(aq) + 8H^+{}_{(aq)} \rightarrow 2Cr^{3+}{}_{(aq)} + 4H_2O_{(l)} + IO_3^-{}_{(aq)}$

Acidic solution is indicated by the presence to $H^+{}_{(aq)}$ in the net-equation

*neutralize H+ with -OH $+ 8\ {}^-OH_{(aq)} \rightarrow + 8\ {}^-OH_{(aq)}$

$= 8\ H_2O_{(l)}$

Net-Equation in Basic

$I^-{}_{(aq)} + Cr_2O_7^{2-}(aq) + 4H_2O_{(l)} \rightarrow 2Cr^{3+}{}_{(aq)} + 8\ {}^-OH_{(aq)} + IO_3^-{}_{(aq)}$