Chapter 4 Problem Set 1

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September 29, 2020

1. Assign oxidation numbers to each atom in the following:
   (a) $Na_2SO_4 \rightarrow Na = 1$, $O = -2$, $S = 6$
   (b) ${S_2O_7}^{2-} \rightarrow S = 6$, $O = -2$
   (c) $BF_3 \rightarrow B = 3$, $F = -1$
   (d) ${Zn(OH)_4}^{2-} \rightarrow H = 1$, $O = -2$, $Zn = 2$
2. Balance the following half reactions:
   (a) ${NO_3}^- \longrightarrow {NO_2}^- \rightarrow 2\,H^+ + 2\,e^- + {NO_3}^- \longrightarrow {NO_2}^- + H_2O$
   (b) $ClO^- \longrightarrow Cl^- \rightarrow 2\,H^+ + 2\,e^- + ClO^- \longrightarrow Cl^- + H_2O$
   (c) $H_2O_2 \longrightarrow H_2O \rightarrow 2\,H^+ + 2\,e^- + H_2O_2 \longrightarrow 2\,H_2O$
   (d) $Cr(OH)_3 \longrightarrow {CrO_4}^{2-} \rightarrow Cr(OH)_3 + H_2O \longrightarrow 5\,H^+ + {CrO_4}^{2-} + 3\,e^-$
3. (a) Assign oxidation numbers to all atoms. (b) Determine how many electrons are lost and gained from reactants. (c) Determine which reactant is oxidized and which is reduced. (d) Determine the oxidizing agent and the reducing agent.
   (a) ${ClO_3}^- + S^{2-} + H_2O \longrightarrow Cl^- + S + OH^-$
      i. ${ClO_3}^- \rightarrow Cl = 5$, $O = -2$
      ii. $S^{2-} \rightarrow S = -2$
      iii. $H_2O \rightarrow H = 1$, $O = -2$
      iv. $Cl^- \rightarrow Cl = -1$
      v. $S \rightarrow S = 0$
      vi. $OH^- \rightarrow O = -2$, $H = 1$
      vii. Sulfur loses two electrons, Chlorine gains six electrons
      viii. Sulfur is oxidized because it loses electrons and Chlorine is reduced because it gains electrons
      ix. Chlorine is the oxidizing agent and Sulfur is the Reducing agent

(b) $PbS + 3\,O_2 \longrightarrow 2\,PbO + 2\,SO_2$

i. $PbS \rightarrow Pb = 2$, $S = -2$
ii. $O_2 \rightarrow O_2 = 0$
iii. $PbO \rightarrow Pb = 2$, $O = -2$
iv. $SO_2 \rightarrow S = 4$, $O = -2$
v. Sulfur loses six electrons, Oxygen gains two electrons
vi. Sulfur is oxidized because it lost electrons. Oxygen is reduced because it gains electrons
vii. Sulfur is the reducing agent and Oxygen is the oxidizing agent

4. Balance the following redox reactions:

(a) $IO_3^- + Mn^{2+} \longrightarrow I^- + MnO_2$ (1)

$$\begin{aligned} 6\,H^+ + 6\,e^- + IO_3^- &\longrightarrow I^- + 3\,H_2O \\ 2\,H_2O + Mn^{2+} &\longrightarrow MnO_2 + 4\,H^+ + 2\,e^- \\ 3\,H_2O + 3\,Mn^{2+} + IO_3^- &\longrightarrow 3\,MnO_2 + I^- + 6\,H^+ \end{aligned} \tag{1}$$

(b) $HBrO_3 + Bi \longrightarrow HBrO_2 + Bi_2O_3$ (2)

$$\begin{aligned} 2\,e^- + 2\,H^+ + HBrO_3 &\longrightarrow HBrO_2 + H_2O \\ 2\,Bi + 3\,H_2O &\longrightarrow Bi_2O_3 + 6\,H^+ + 6\,e^- \\ 3\,HBrO_3 + 2\,Bi &\longrightarrow 3\,HBrO_2 + Bi_2O_3 \end{aligned} \tag{2}$$

(c) $H_2O_2 + IO_4^- \longrightarrow IO_2^- + O_2$ (3)

$$\begin{aligned} H_2O_2 &\longrightarrow O_2 + 2\,H^+ + 2\,e^- \\ 4\,e^- + 4\,H^+ + IO_4^- &\longrightarrow IO_2^- + 2\,H_2O \\ 2\,H_2O_2 + IO_4^- &\longrightarrow 2\,O_2 + IO_2^- + 2\,H_2O \end{aligned} \tag{3}$$