Balance the following half-reactions:

1. $S_2O_8^{2-} \rightarrow HSO_4^-$ (acidic solution)

2. $N_2H_4 \rightarrow N_2$ (basic solution)

$$S_2O_8^{2-} + 2H^+ + 2e^- \rightarrow 2HSO_4^-$$

$$N_2H_4 + 4OH^- \rightarrow N_2 + 4H_2O + 4e^-$$

$$4OH^- + N_2H_4 \rightarrow N_2 + 4H^+ + 4e^-$$

$$+ 4OH^-$$

$$4H_2O$$

Balancing Redox Equations Using Half-Reactions

An **overall redox equation** can be obtained by:

1. breaking into separate reduction and oxidation half-reactions
2. balancing each half
3. adding the two half reactions together once the number of e- lost in oxidation are balanced by the e- gained by reduction

ex. Balance the following redox reaction:

$$ClO_4^- + I_2 \rightarrow Cl^- + IO_3^-$$

$$5(8e^- + 8H^+ + ClO_4^- \rightarrow Cl^- + 4H_2O)$$

$$4(6H_2O + I_2 \rightarrow 2IO_3^- + 12H^+ + 10e^-)$$

$$40e^- + 40H^+ + 5ClO_4^- + 24H_2O + 4I_2 \rightarrow 5Cl^- + 20H_2O + 8IO_3^- + 48H^+ + 40e^-$$

$$4H_2O + 4I_2 + 5ClO_4^- \rightarrow 5Cl^- + 8IO_3^- + 8H^+$$

Balanced redox equations **do not show e-** and the **number of atoms and the total charge** are balanced on both sides of the equation.

In **basic solutions**, the final equation can be converted by adding equal numbers of hydroxide molecules to both sides of the the equation and cancelling out the water molecules

$$5ClO_4^- + 4I_2 + 4H_2O \rightarrow 5Cl^- + 8IO_3^- + 8H^+$$

- for basic solution, add $8OH^-$ to both sides

$$5ClO_4^- + 4I_2 + 4H_2O \rightarrow 5Cl^- + 8IO_3^- + 8H^+$$

- cancel out water:

In some redox reactions, it is possible for the same chemical to undergo oxidation and reduction. Such a reaction is called **disproportionation**.

$$ClO_2^- \rightarrow ClO_3^- + Cl^-$$

The two half-reactions are:

$$ClO_2^- \rightarrow ClO_3^-$$

$$ClO_2^- \rightarrow Cl^-$$

Balanced redox equation is:

$$3ClO_2^- \rightarrow 2ClO_3^- + Cl^-$$

Balance the following redox reactions by the oxidation number method:

a) $MnO_4^- + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+}$ (acidic)

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

$(Fe^{2+} \rightarrow Fe^{3+} + 1e^-)\,5$

$8H^+ + MnO_4^- + 5Fe^{2+} + Mn^{2+} + 4H_2O + 5Fe^{3+}$

b) $S^{2-} + ClO_3^- \rightarrow Cl^- + S$ (basic)

$(S^{2-} \rightarrow S + 2e^-)\,3$

$6e^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O$

$6OH^- + 3S^{2-} + 6H^+ + ClO_3^- \rightarrow 3S + Cl^- + 6OH^- + 3H_2O$

$3H_2O + 3S^{2-} + ClO_3^- \rightarrow 3S + Cl^- + 6OH^-$

c) $Zn + As_2O_3 \rightarrow AsH_3 + Zn^{2+}$ (basic)

$(Zn \rightarrow Zn^{2+} + 2e^-)\,6$

$(12e^- + 12H^+ + As_2O_3 \rightarrow 2AsH_3 + 3H_2O)$

$+20H^-\ 12H^+ + As_2O_3 + 6Zn \rightarrow 6Zn^{2+} + 2AsH_3 + 3H_2O + 12OH^-$

$9H_2O + As_2O_3 + 6Zn \rightarrow 6Zn^{2+} + 2AsH_3 + 12OH^-$

d) $P_4 \rightarrow H_2PO_2^- + PH_3$ (acidic)

$(8H_2O + P_4 \rightarrow 4H_2PO_2^- + 8H^+ + 4e^-)\,3$

$12e^- + 12H^+ + P_4 \rightarrow 4PH_3$

$24H_2O + 3P_4 + \text{~~12H}^+\text{~~} + P_4 \rightarrow 12H_2PO_4^- + \text{~~24H}^+\text{~~}\ 12$

$24H_2O + 4P_4 \rightarrow 12H_2PO_4^- + 12H^+$

$\div 4$

$6H_2O + P_4 \rightarrow 3H_2PO_4^- + 3H^+$

Balance the following redox reaction (acidic)

$$Mn^{2+} + HBiO_3 \rightarrow Bi^{3+} + MnO_4^-$$

$$2Mn^{2+} + 5HBiO_3 + 9H^+ \rightarrow 5Bi^{3+} + 2MnO_4^- + 7H_2O$$