Name: _____ Period: _____
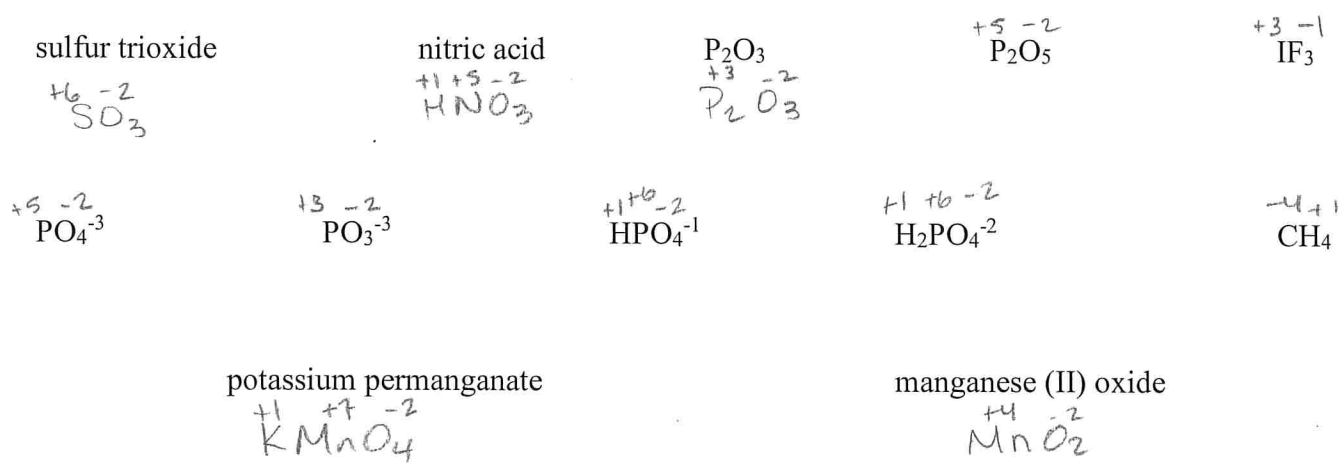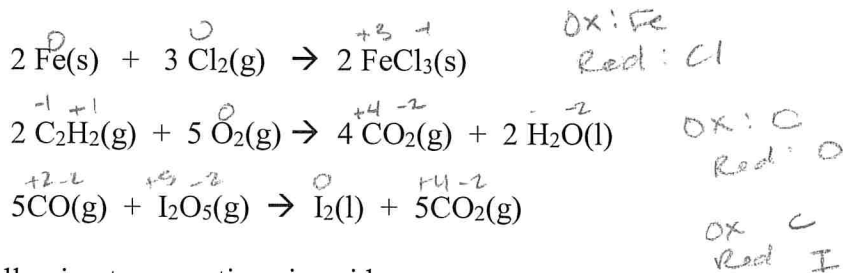
AP Chemistry

Balancing Redox Reactions
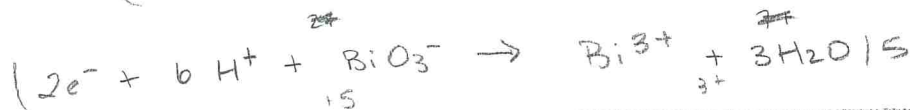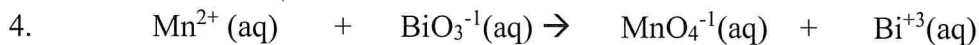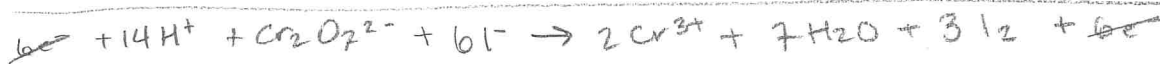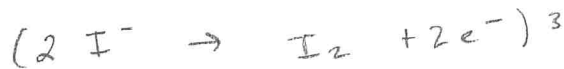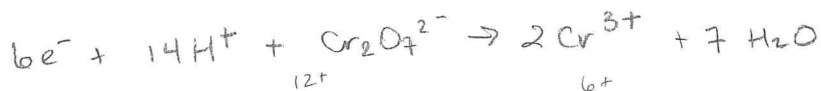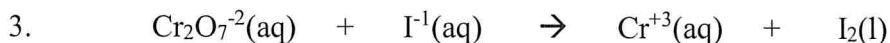
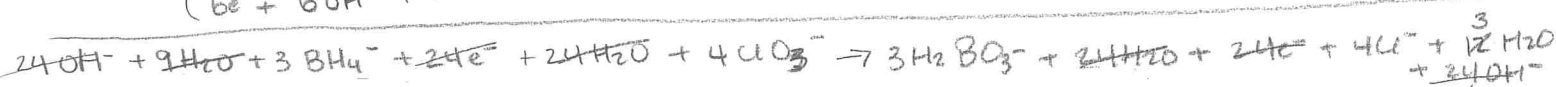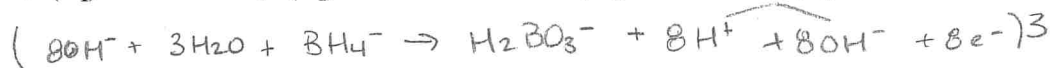1. Determine the oxidation state of each of the elements in the following:

sulfur trioxide

$\overset{+6\ -2}{SO_3}$

nitric acid

$\overset{+1\ +5\ -2}{HNO_3}$

$\overset{+3\quad -2}{P_2O_3}$
P_2O_3

$\overset{+5\ -2}{P_2O_5}$
P_2O_5

$\overset{+3\ -1}{IF_3}$
IF_3

$\overset{+5\ -2}{PO_4^{-3}}$

$\overset{+3\ -2}{PO_3^{-3}}$

$\overset{+1\ +6\ -2}{HPO_4^{-1}}$

$\overset{+1\ +6\ -2}{H_2PO_4^{-2}}$

$\overset{-4\ +1}{CH_4}$

potassium permanganate

$\overset{+1\ +7\ -2}{KMnO_4}$

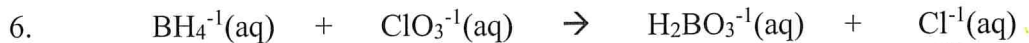manganese (II) oxide

$\overset{+4\ -2}{MnO_2}$

2. For each of the following, assign oxidation numbers then label which element is oxidized and which is reduced.

$\overset{0}{2\ Fe(s)} + \overset{0}{3\ Cl_2(g)} \rightarrow \overset{+3\ -1}{2\ FeCl_3(s)}$
Ox: Fe
Red: Cl

$\overset{-1\ +1}{2\ C_2H_2(g)} + \overset{0}{5\ O_2(g)} \rightarrow \overset{+4\ -2}{4\ CO_2(g)} + \overset{-2}{2\ H_2O(l)}$
Ox: C
Red: O

$\overset{+2\ -2}{5CO(g)} + \overset{+5\ -2}{I_2O_5(g)} \rightarrow \overset{0}{I_2(l)} + \overset{+4\ -2}{5CO_2(g)}$
Ox C
Red I

Balance the following two reactions in acid

3. $Cr_2O_7^{-2}(aq) + I^{-1}(aq) \rightarrow Cr^{+3}(aq) + I_2(l)$

$6e^- + 14H^+ + \underset{12+}{Cr_2O_7^{2-}} \rightarrow \underset{6+}{2\ Cr^{3+}} + 7\ H_2O$

$(2\ I^- \rightarrow I_2 + 2e^-)\ 3$

$6e^- + 14H^+ + Cr_2O_7^{2-} + 6I^- \rightarrow 2\ Cr^{3+} + 7H_2O + 3\ I_2 + 6e^-$

$14H^+ + Cr_2O_7^{2-} + 6I^- \rightarrow 2\ Cr^{3+} + 7H_2O + 3\ I_2$

4. $Mn^{2+}(aq) + BiO_3^{-1}(aq) \rightarrow MnO_4^{-1}(aq) + Bi^{+3}(aq)$

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

$(2e^- + 6H^+ + \underset{+5}{BiO_3^-} \rightarrow \underset{3+}{Bi^{3+}} + 3H_2O)\ 5$

$8\ H_2O + 2\ Mn^{2+} + 10e^- + 30H^+ + 5BiO_3^- \rightarrow 2\ MnO_4^- + 16H^+ + 10e^- + 5Bi^{3+} + 15H_2O$

$2\ Mn^{2+} + 14\ H^+ + 5BiO_3^- \rightarrow 2\ MnO_4^- + 5\ Bi^{3+} + 7\ H_2O$

Balance the following two reactions in base

5. $MnO_4^{-1}(aq) + C_2O_4^{-2}(aq) \rightarrow MnO_2(s) + CO_3^{-2}(aq)$

$(3e^- + 4OH^- + 4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O + 4OH^-)2$

$(4OH^- + 2H_2O + C_2O_4^{2-} \rightarrow 2CO_3^{2-} + 4H^+ + 4OH^- + 2e^-)3$

$6e^- + 8H_2O + 2MnO_4^- + 4OH^- + 6H_2O + 3C_2O_4^{2-} \rightarrow 2MnO_2 + 4H_2O + 8OH^- + 6CO_3^{2-} + 12H_2O + 6e^-$

✓ $2MnO_4^- + 4OH^- + 3C_2O_4^{2-} \rightarrow 2MnO_2 + 2H_2O + 6CO_3^{2-}$
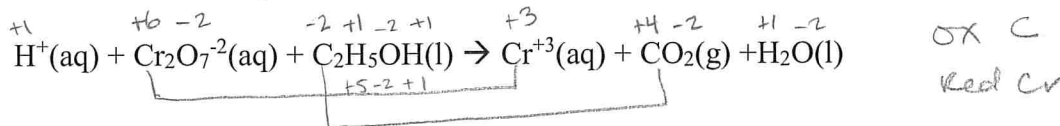
6. $BH_4^{-1}(aq) + ClO_3^{-1}(aq) \rightarrow H_2BO_3^{-1}(aq) + Cl^{-1}(aq)$

$(8OH^- + 3H_2O + BH_4^- \rightarrow H_2BO_3^- + 8H^+ + 8OH^- + 8e^-)3$

$(6e^- + 6OH^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O + 6OH^-)4$

$24OH^- + 9H_2O + 3BH_4^- + 24e^- + 24H_2O + 4ClO_3^- \rightarrow 3H_2BO_3^- + 24H_2O + 24e^- + 4Cl^- + 12H_2O + 24OH^-$
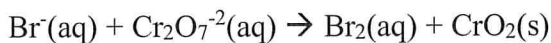
✓ $3BH_4^- + 4ClO_3^- \rightarrow 3H_2BO_3^- + 4Cl^- + 3H_2O$

7. Potassium dichromate is a bright orange compound that can be reduced to a blue violet solution of Cr^{+3} ions. Under certain conditions potassium dichromate reacts with ethyl alcohol (C_2H_5OH) according to the equation below. Identify the atoms that are oxidized and those that are reduced.

$\overset{+1}{H^+}(aq) + \overset{+6\ -2}{Cr_2O_7^{-2}}(aq) + \overset{-2\ +1\ -2\ +1}{C_2H_5OH}(l) \rightarrow \overset{+3}{Cr^{+3}}(aq) + \overset{+4\ -2}{CO_2}(g) + \overset{+1\ -2}{H_2O}(l)$

$+5\ -2\ +1$

ox C
Red Cr

8. Balance the equation for the reaction between permanganate and bromide ions in acidic solution.

$Br^-(aq) + Cr_2O_7^{-2}(aq) \rightarrow Br_2(aq) + CrO_2(s)$

$(2Br^- \rightarrow Br_2 + 2e^-)2$

$4e^- + 6H^+ + Cr_2O_7^{2-} \rightarrow 2CrO_2 + 3H_2O$

$4Br^- + 4e^- + 6H^+ + Cr_2O_7^{2-} \rightarrow 2CrO_2 + 3H_2O + 2Br_2 + 4e^-$

✓ $4Br^- + 6H^+ + Cr_2O_7^{2-} \rightarrow 2CrO_2 + 3H_2O + 2Br_2$

9. Balance the following oxidation-reduction reaction that occurs in basic solution

$Pb(s) + MnO_4^{-1}(aq) \rightarrow PbO_2(aq) + MnO_2$

$(4OH^- + 2H_2O + Pb \rightarrow PbO_2 + 4H^+ + 4OH^- + 4e^-)3$

$(3e^- + 4OH^- + 4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O + 4OH^-)4$

$12OH^- + 6H_2O + 3Pb + 12e^- + 16H_2O + 4MnO_4^- \rightarrow 3PbO_2 + 12H_2O + 12e^- + 4MnO_2 + 8H_2O + 16OH^-$

✓ $3Pb + 2H_2O + 4MnO_4^- \rightarrow 3PbO_2 + 4MnO_2 + 4OH^-$