Redox

1. In the following, give the oxidation number for the indicated atoms.

   a. S in Na_2SO_3 **4+**   d. C in Na_2CO_3 **4+**   g. S in $H_2S_2O_7$ **6+**

   b. Mn in $KMnO_4$ **7+**   e. N in NO_2 **4+**   h. S in Al_2S_3 **2−**

   c. N in $Ca(NO_3)_2$ **5+**   f. S in HSO_4^- **6+**   i. Mn in $MnCl_2$ **2+**

2. Some of the following unbalanced reactions are oxidation-reduction reactions, and some are not. In each case is the reaction redox? If yes, name the element reduced, the element oxidized, the oxidizing agent, and the reducing agent.

   a. $BaCl_2 + Na_2SO_4 \rightarrow NaCl + BaSO_4$
   NOT REDOX

   b. $H_2 + N_2 \rightarrow NH_3$

__N__	__H__	__N_2__	__H_2__
element reduced	element oxidized	the oxidizing agent	the reducing agent

   c. $C + H_2O \rightarrow CO + H_2$

__H⁺__	__C°__	__H_2O__	__C__
element reduced	element oxidized	the oxidizing agent	the reducing agent

   d. $AgNO_3 + FeCl_3 \rightarrow AgCl + Fe(NO_3)_3$
   NOT REDOX

   e. $H_2CO_3 \rightarrow H_2O + CO_2$
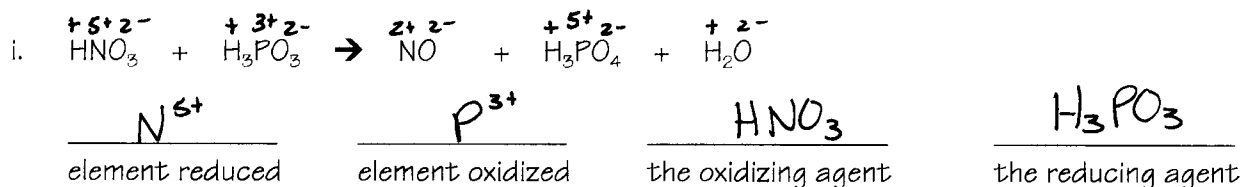   **NOT REDOX**

~~element reduced~~	~~element oxidized~~	~~the oxidizing agent~~	~~the reducing agent~~

   f. $MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$
   NOT REDOX

g. $\overset{+\ -}{H_2O_2} + \overset{2+\ 2-}{PbS} \rightarrow \overset{2+\ 6+\ 2-}{PbSO_4} + \overset{+\ 2-}{H_2O}$

O^-	S^{2-}	H_2O_2	PbS
element reduced	element oxidized	the oxidizing agent	the reducing agent

h. $\overset{+\ -}{KCl} + \overset{+\ 6+\ 2-}{H_2SO_4} \rightarrow \overset{+\ +\ 6+\ 2-}{KHSO_4} + \overset{+\ -}{HCl}$
NOT REDOX

i. $\overset{+5+2-}{HNO_3} + \overset{+\ 3+\ 2-}{H_3PO_3} \rightarrow \overset{2+\ 2-}{NO} + \overset{+5+\ 2-}{H_3PO_4} + \overset{+\ 2-}{H_2O}$

N^{5+}	P^{3+}	HNO_3	H_3PO_3
element reduced	element oxidized	the oxidizing agent	the reducing agent

j. $\overset{+5+2-}{HNO_3} + \overset{o}{I_2} \rightarrow \overset{+6+\ 2-}{HIO_3} + \overset{4+\ 2-}{NO_2} + \overset{+\ 2-}{H_2O}$

N^{5+}	I^o	HNO_3	I_2
element reduced	element oxidized	the oxidizing agent	the reducing agent

k. $\overset{+\ 2-}{Na_2S} + \overset{+\ 5+\ 2-}{AgNO_3} \rightarrow \overset{+\ 2-}{Ag_2S} + \overset{+\ 5+}{NaNO_3}$
NOT REDOX

l. $\overset{+}{H^+} + \overset{5+\ 2-}{NO_3^-} + \overset{2+}{Fe^{2+}} \rightarrow \overset{+\ 2-}{H_2O} + \overset{2+\ 2-}{NO} + \overset{3+}{Fe^{3+}}$

N^{5+}	Fe^{2+}	NO_3^-	Fe^{2+}
element reduced	element oxidized	the oxidizing agent	the reducing agent

m. $\overset{2+\ -}{FeBr_2} + \overset{o}{Br_2} \rightarrow \overset{3+\ -}{FeBr_3}$

Br^o	Fe^{2+}	Br_2	$FeBr_2$
element reduced	element oxidized	the oxidizing agent	the reducing agent

n. $\overset{2+\ 2-}{S_2O_3^{2-}} + \overset{o}{I_2} \rightarrow \overset{2.5+\ 2-}{S_4O_6^{2-}} + \overset{-}{I^-}$

I^o	S^{2+}	I_2	$S_2O_3^{2-}$
element reduced	element oxidized	the oxidizing agent	the reducing agent

o. $\overset{+}{H_2}\overset{-}{O_2}$ + $\overset{7+}{M}\overset{2-}{nO_4^-}$ → $\overset{0}{O_2}$ + $\overset{2+}{Mn^{2+}}$

Mn^{7+}	O^-	MnO_4^-	H_2O_2
element reduced	element oxidized	the oxidizing agent	the reducing agent

p. $\overset{0}{Zn}$ + $\overset{4+}{M}\overset{2-}{nO_2}$ + $\overset{3-}{N}\overset{+}{H_4}\overset{-}{Cl}$ → $\overset{2+}{Zn}\overset{-}{Cl_2}$ + $\overset{3+}{M}\overset{2-}{n_2O_3}$ + $\overset{3-}{N}\overset{+}{H_3}$ + $\overset{+}{H_2}\overset{2-}{O}$

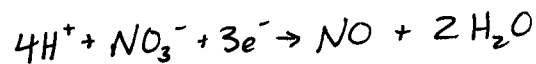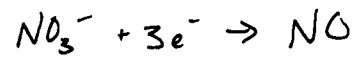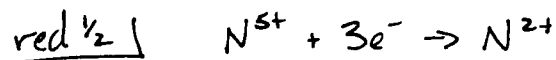| Mn^{4+}	Zn^0	MnO_2	Zn
element reduced	element oxidized	the oxidizing agent	the reducing agent

3. Balance the following equations using half reactions. Identify the oxidation half reactions and the reduction half reactions.
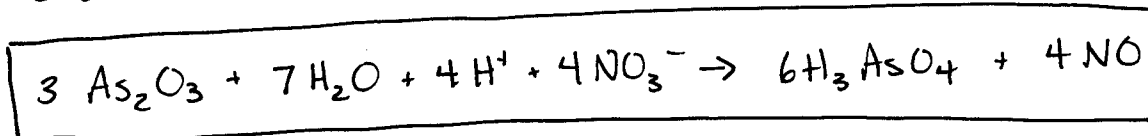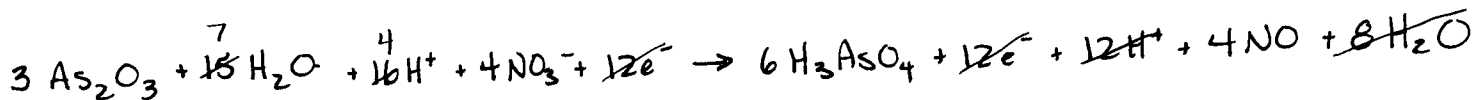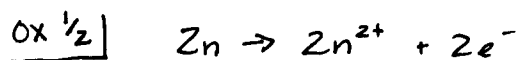
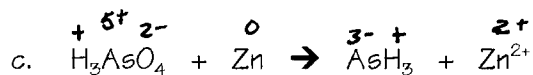a. $\overset{6+}{C}\overset{2-}{r_2}\overset{}{O_7^{2-}}$ + $\overset{+}{H^+}$ + $\overset{-}{I^-}$ → $\overset{3+}{Cr^{3+}}$ + $\overset{0}{I_2}$ + $\overset{+}{H_2}\overset{2-}{O}$

ox ½ | $2I^- → I_2 + 2e^-$

red ½ |
$Cr^{6+} + 3e^- → Cr^{3+}$
$Cr_2O_7^{2-} + 6e^- → 2Cr^{3+}$
$Cr_2O_7^{2-} + 6e^- + 14H^+ → 2Cr^{3+} + 7H_2O$

× 3

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

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

b. $\overset{3+}{A}\overset{2-}{s_2O_3}$ + $\overset{+}{H^+}$ + $\overset{5+}{N}\overset{2-}{O_3^-}$ + $\overset{+}{H_2}\overset{2-}{O}$ → $\overset{+}{H_3}\overset{5+}{A}\overset{2-}{sO_4}$ + $\overset{2+}{N}\overset{2-}{O}$

ox ½ |
$As^{3+} → As^{5+} + 2e^-$
$As_2O_3 → 2H_3AsO_4 + 4e^-$
$As_2O_3 + 5H_2O → 2H_3AsO_4 + 4e^- + 4H^+$
× 3

red ½ |
$N^{5+} + 3e^- → N^{2+}$
$NO_3^- + 3e^- → NO$
$4H^+ + NO_3^- + 3e^- → NO + 2H_2O$
× 4

$3As_2O_3 + \overset{7}{\cancel{15}}H_2O + \overset{4}{\cancel{16}}H^+ + 4NO_3^- + \cancel{12e^-} → 6H_3AsO_4 + \cancel{12e^-} + \cancel{12H^+} + 4NO + \cancel{8H_2O}$

$$\boxed{3As_2O_3 + 7H_2O + 4H^+ + 4NO_3^- → 6H_3AsO_4 + 4NO}$$

c. $\overset{+\ 5+\ 2-}{H_3AsO_4} + \overset{0}{Zn} \rightarrow \overset{3-\ +}{AsH_3} + \overset{2+}{Zn^{2+}}$

$\underline{\text{ox } \frac{1}{2}}$ $Zn \rightarrow Zn^{2+} + 2e^-$ $\underline{\text{red } \frac{1}{2}}$ $As^{5+} + 8e^- \rightarrow As^{3-}$

                                                                 $H_3AsO_4 + 8e^- \rightarrow AsH_3$

                $\times 4$ $8H^+ + H_3AsO_4 + 8e^- \rightarrow AsH_3 + 4H_2O$

$4Zn + 8H^+ + H_3AsO_4 + 8\cancel{e^-} \rightarrow 4Zn^{2+} + 8\cancel{e^-} + AsH_3 + 4H_2O$

$$\boxed{4Zn + 8H^+ + H_3AsO_4 \rightarrow 4Zn^{2+} + AsH_3 + 4H_2O}$$

d. $\overset{6+\ 2-}{MnO_4{}^{2-}} + \overset{+}{H^+} \rightarrow \overset{7+\ 2-}{MnO_4^-} + \overset{4+\ 2-}{MnO_2}$

$\underline{\text{ox } \frac{1}{2}}$ $Mn^{6+} \rightarrow Mn^{7+} + e^-$ $\underline{\text{red } \frac{1}{2}}$ $Mn^{6+} + 2e^- \rightarrow Mn^{4+}$

      $MnO_4{}^{2-} \rightarrow MnO_4^- + e^-$ $MnO_4{}^{2-} + 2e^- \rightarrow MnO_2$

               $\times 2$ $4H^+ + MnO_4{}^{2-} + 2e^- \rightarrow MnO_2 + 2H_2O$

$\overset{3}{\cancel{2}}MnO_4{}^{2-} + 4H^+ + Mn\cancel{O_4}{}^{2-} + \cancel{2e^-} \rightarrow 2MnO_4^- + \cancel{2e^-} + MnO_2 + 2H_2O$

$$\boxed{3MnO_4{}^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O}$$

e. $\overset{7+\ 2-}{MnO_4^-} + \overset{4+\ 2-}{SO_2} \rightarrow \overset{2+}{Mn^{2+}} + \overset{6+\ 2-}{SO_4{}^{2-}} + \overset{+}{H^+}$

$\underline{\text{ox } \frac{1}{2}}$ $S^{4+} \rightarrow S^{6+} + 2e^-$ $\underline{\text{red } \frac{1}{2}}$ $Mn^{7+} + 5e^- \rightarrow Mn^{2+}$

      $SO_2 \rightarrow SO_4{}^{2-} + 2e^-$ $MnO_4^- + 5e^- \rightarrow Mn^{2+}$

$SO_2 + 2H_2O \rightarrow SO_4{}^{2-} + 2e^- + 4H^+$ $8H^+ + MnO_4^- + 5e^- \rightarrow Mn^{2+} + 4H_2O$

                $\times 5$ $\times 2$

$5SO_2 + \overset{2}{\cancel{10}}H_2O + \cancel{16}H^+ + 2MnO_4^- + \cancel{10e^-} \rightarrow 5SO_4{}^{2-} + \cancel{10e^-} + \overset{4}{\cancel{20}}H^+ + 2Mn^{2+} + \cancel{8H_2O}$

$$\boxed{5SO_2 + 2H_2O + 2MnO_4^- \rightarrow 5SO_4{}^{2-} + 4H^+ + 2Mn^{2+}}$$

f. $\overset{7+ \; 2-}{MnO_4^-} + \overset{+ \; 4+ \; 2-}{H_2SO_3} + \overset{+}{H^+} \rightarrow \overset{2+}{Mn^{2+}} + \overset{+ \; 6+ \; 2-}{HSO_4^-} + \overset{+ \; 2-}{H_2O}$

$\underline{ox \; \tfrac{1}{2}}$ $S^{4+} \rightarrow S^{6+} + 2e^-$

$H_2SO_3 \rightarrow HSO_4^- + 2e^-$

$H_2SO_3 + H_2O \rightarrow HSO_4^- + 2e^- + 3H^+$

$\times 5$

$\underline{red \; \tfrac{1}{2}}$ $Mn^{7+} + 5e^- \rightarrow Mn^{2+}$

$MnO_4^- + 5e^- \rightarrow Mn^{2+}$

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

$\times 2$

$5H_2SO_3 + 5H_2O + \overset{1}{\cancel{16}}H^+ + 2MnO_4^- + \cancel{10e^-} \rightarrow 5HSO_4^- + \cancel{10e^-} + \cancel{15}H^+ + 2Mn^{2+} + \overset{3}{\cancel{8}}H_2O$

$\boxed{5H_2SO_3 + H^+ + 2MnO_4^- \rightarrow 5HSO_4^- + 2Mn^{2+} + 3H_2O}$

g. $\overset{0}{I_2} + \overset{+ \; 4+ \; 2-}{H_2SO_3} + \overset{+ \; 2-}{H_2O} \rightarrow \overset{-}{I^-} + \overset{+ \; 6+ \; 2-}{HSO_4^-} + \overset{+}{H^+}$

$\underline{ox \; \tfrac{1}{2}}$ $S^{4+} \rightarrow S^{6+} + 2e^-$

$H_2SO_3 \rightarrow HSO_4^- + 2e^-$

$H_2SO_3 + H_2O \rightarrow HSO_4^- + 2e^- + 3H^+$

$\underline{red \; \tfrac{1}{2}}$ $I^0 + e^- \rightarrow I^-$

$I_2 + 2e^- \rightarrow 2I^-$

$H_2SO_3 + H_2O + I_2 + 2e^- \rightarrow HSO_4^- + 2e^- + 3H^+ + 2I^-$

$\boxed{H_2SO_3 + H_2O + I_2 \rightarrow HSO_4^- + 3H^+ + 2I^-}$

h. $\overset{2+ \; 2-}{HgS} + \overset{-}{Cl^-} + \overset{5+ \; 2-}{NO_3^-} \rightarrow \overset{2+ \; -}{HgCl_4^{2-}} + \overset{0}{S} + \overset{2+ \; 2-}{NO}$

$\underline{ox \; \tfrac{1}{2}}$ $S^{2-} \rightarrow S^0 + 2e^-$

$HgS \rightarrow S + 2e^-$

$4Cl^- + HgS \rightarrow S + 2e^- + HgCl_4^{2-}$

$\times 3$

$\underline{red \; \tfrac{1}{2}}$ $N^{5+} + 3e^- \rightarrow N^{2+}$

$NO_3^- + 3e^- \rightarrow NO$

$4H^+ + NO_3^- + 3e^- \rightarrow NO + 2H_2O$

$\times 2$

$12Cl^- + 3HgS + 8H^+ + 2NO_3^- + \cancel{6e^-} \rightarrow 3S + \cancel{6e^-} + 3HgCl_4^{2-} + 2NO + \overset{}{\cancel{4}}H_2O$

$\boxed{12Cl^- + 3HgS + 8H^+ + 2NO_3^- \rightarrow 3S + 3HgCl_4^{2-} + 2NO + \cancel{4}H_2O}$

i. $\overset{4+ \ 2-}{NO_2} + \overset{2- \ +}{OH^-} \rightarrow \overset{3+ \ 2-}{NO_2^-} + \overset{5+ \ 2-}{NO_3^-}$

$\underline{ox \ \frac{1}{2}}$ $N^{4+} \rightarrow N^{5+} + e^-$

$NO_2 \rightarrow NO_3^- + e^-$

$NO_2 + 2OH^- \rightarrow NO_3^- + e^- + H_2O$

$\underline{red \ \frac{1}{2}}$ $N^{4+} + e^- \rightarrow N^{3+}$

$NO_2 + e^- \rightarrow NO_2^-$

$2NO_2 + 2OH^- + NO_2 + e^- \rightarrow NO_3^- + e^- + H_2O + NO_2^-$

$$\boxed{2NO_2 + 2OH^- \rightarrow NO_3^- + H_2O + NO_2^-}$$

j. $\overset{0}{S} + \overset{+}{H^+} + \overset{5+ \ 2-}{NO_3^-} \rightarrow \overset{4+ \ 2-}{SO_2} + \overset{2+ \ 2-}{NO} + \overset{+ \ 2-}{H_2O}$

$ox \ \frac{1}{2}$ $S^0 \rightarrow S^{4+} + 4e^-$

$S \rightarrow SO_2 + 4e^-$

$S + 2H_2O \rightarrow SO_2 + 4e^- + 4H^+$

$\underline{red \ \frac{1}{2}}$ $N^{5+} + 3e^- \rightarrow N^{2+}$

$NO_3^- + 3e^- \rightarrow NO$

$4H^+ + NO_3^- + 3e^- \rightarrow NO + 2H_2O$

$\times 3$ (ox) $\times 4$ (red)

$3S + 6H_2O + 16H^+ + 4NO_3^- + 12e^- \rightarrow 3SO_2 + 12e^- + 12H^+ + 4NO + 8H_2O$

$$\boxed{3S + 4H^+ + 4NO_3^- \rightarrow 3SO_2 + 4NO + 2H_2O}$$

4. Balance the following equations after putting them in ionic form.

a. $\overset{0}{Cu}(s) + \overset{+ \ 5+2-}{HNO_3}(aq) \rightarrow \overset{2+ \ 5+2-}{Cu(NO_3)_2}(aq) + \overset{2+ \ 2-}{NO}(g) + \overset{+ \ 2-}{H_2O}(l)$

$Cu + H^+ + NO_3^- \rightarrow Cu^{2+} + NO_3^- + NO + H_2O$

$\underline{ox \ \frac{1}{2}}$ $Cu \rightarrow Cu^{2+} + 2e^-$

$\underline{red \ \frac{1}{2}}$ $N^{5+} + 3e^- \rightarrow N^{2+}$

$NO_3^- + 3e^- \rightarrow NO$

$4H^+ + NO_3^- + 3e^- \rightarrow NO + 2H_2O$

$\times 3$ $\times 2$

$3Cu + 8H^+ + 2NO_3^- + 6e^- \rightarrow 3Cu^{2+} + 6e^- + 2NO + 4H_2O$

$$\boxed{3Cu + 8H^+ + 2NO_3^- \rightarrow 3Cu^{2+} + 2NO + 4H_2O}$$

b. $\overset{2+\ 5+\ 2-}{Fe(NO_3)_2(aq)} + \overset{+\ 5+\ 2-}{HNO_3(aq)} \rightarrow \overset{3+\ 5+\ 2-}{Fe(NO_3)_3(aq)} + \overset{2+\ 2-}{NO(g)} + \overset{+\ 2-}{H_2O(l)}$

$Fe^{2+} + NO_3^- + H^+ + NO_3^- \rightarrow Fe^{3+} + NO_3^- + NO + H_2O$

ox ½ | $Fe^{2+} \rightarrow Fe^{3+} + e^-$ red ½ | $N^{5+} + 3e^- \rightarrow N^{2+}$

$NO_3^- + 3e^- \rightarrow NO$

$4H^+ + NO_3^- + 3e^- \rightarrow NO + 2H_2O$

× 3

$3Fe^{2+} + 4H^+ + NO_3^- + 3e^- \rightarrow 3Fe^{3+} + 3e^- + NO + 2H_2O$

$\boxed{3Fe^{2+} + 4H^+ + NO_3^- \rightarrow 3Fe^{3+} + NO + 2H_2O}$

c. $\overset{0}{Zn(s)} + \overset{+\ 5+\ 2-}{HNO_3(aq)} \rightarrow \overset{2+\ 5+\ 2-}{Zn(NO_3)_2(aq)} + \overset{4+\ 2-}{NO_2(g)} + \overset{+\ 2-}{H_2O(l)}$

$Zn + H^+ + NO_3^- \rightarrow Zn^{2+} + NO_3^- + NO_2 + H_2O$

ox ½ | $Zn \rightarrow Zn^{2+} + 2e^-$ red ½ | $N^{5+} + e^- \rightarrow N^{4+}$

$NO_3^- + e^- \rightarrow NO_2$

$2H^+ + NO_3^- + e^- \rightarrow NO_2 + H_2O$

× 2

$Zn + 4H^+ + 2NO_3^- + 2e^- \rightarrow Zn^{2+} + 2e^- + 2NO_2 + 2H_2O$

$\boxed{Zn + 4H^+ + 2NO_3^- \rightarrow Zn^{2+} + 2NO_2 + 2H_2O}$

d. $\overset{0}{Sb(s)} + \overset{+\ 6+\ 2-}{H_2SO_4(aq)} \rightarrow \overset{3+\ 6+\ 2-}{Sb_2(SO_4)_3(aq)} + \overset{4+\ 2-}{SO_2(g)} + \overset{+\ 2-}{H_2O(l)}$

$Sb + H^+ + HSO_4^- \rightarrow Sb^{3+} + SO_4^{2-} + SO_2 + H_2O$

ox ½ | $Sb \rightarrow Sb^{3+} + 3e^-$ red ½ | $S^{6+} + 2e^- \rightarrow S^{4+}$

$HSO_4^- + 2e^- \rightarrow SO_2$

$3H^+ + HSO_4^- + 2e^- \rightarrow SO_2 + 2H_2O$

× 2   × 3

$2Sb + 9H^+ + 3HSO_4^- + 6e^- \rightarrow 2Sb^{3+} + 6e^- + 3SO_2 + 6H_2O$

$\boxed{2Sb + 9H^+ + 3HSO_4^- \rightarrow 2Sb^{3+} + 3SO_2 + 6H_2O}$

e. $\overset{+\ 2-}{H_2S}(g) + \overset{+\ 4+\ 2-}{H_2SO_3}(aq) \rightarrow \overset{0}{S}(s) + \overset{+\ 2-}{H_2O}(l)$

ox $\frac{1}{2}$ | $S^{2-} \rightarrow S^0 + 2e^-$

$H_2S \rightarrow S + 2e^- + 2H^+$ $\times 2$

red $\frac{1}{2}$ | $S^{4+} + 4e^- \rightarrow S^0$

$4H^+ + H_2SO_3 + 4e^- \rightarrow S + 3H_2O$

$2H_2S + 4H^+ + H_2SO_3 + 4e^- \rightarrow 2S + 4e^- + 4H^+ + S + 3H_2O$

$$\boxed{2H_2S + H_2SO_3 \rightarrow 3S + 3H_2O}$$

f. $HCl(aq) + HNO_3(aq) \rightarrow HClO(aq) + NO(g)$

$H^+ + Cl^- + H^+ + \overset{5+\ 2-}{NO_3^-} \rightarrow \overset{+\ +\ 2-}{HClO} + \overset{2+\ 2-}{NO}$

ox $\frac{1}{2}$ | $Cl^- \rightarrow Cl^+ + 2e^-$

$2H_2O + Cl^- \rightarrow HClO + 2e^- + H^+$ $\times 3$

red $\frac{1}{2}$ | $N^{5+} + 3e^- \rightarrow N^{2+}$

$4H^+ + NO_3^- + 3e^- \rightarrow NO + 2H_2O$ $\times 2$

$3H_2O + 3Cl^- + 8H^+ + 2NO_3^- + 6e^- \rightarrow 3HClO + 6e^- + 3H^+ + 2NO + 4H_2O$

$$\boxed{3Cl^- + 5H^+ + 2NO_3^- \rightarrow 3HClO + 2NO + H_2O}$$

g. $Ag(s) + HClO_3(aq) + HCl(aq) \rightarrow AgCl(s) + H_2O(l)$

$\overset{0}{Ag} + \overset{+\ 5+\ 2-}{HClO_3} + H^+ + Cl^- \rightarrow \overset{+\ -}{AgCl} + \overset{+\ 2-}{H_2O}$

ox $\frac{1}{2}$ | $Ag \rightarrow Ag^+ + e^-$

$Ag \rightarrow AgCl + e^-$

$Ag + Cl^- \rightarrow AgCl + e^-$ $\times 5$

red $\frac{1}{2}$ | $Cl^{5+} + 6e^- \rightarrow Cl^-$

$HClO_3 + 6e^- \rightarrow AgCl$

$5H^+ + Ag + HClO_3 + 6e^- \rightarrow AgCl + e^- + 3H_2O$

$5Ag + 5Cl^- + 5H^+ + Ag + HClO_3 + 6e^- \rightarrow 5AgCl + 5e^- + AgCl + e^- + 3H_2O$

$$\boxed{6Ag + 5Cl^- + 5H^+ + HClO_3 \rightarrow 6AgCl + 3H_2O}$$

h. $KI(aq) + O_2(g) \rightarrow KI_3(aq) + H_2O(l)$

$$K^+ + \overset{-}{I} + \overset{0}{O_2} \rightarrow K^+ + \overset{-\frac{1}{3}}{I_3^-} + \overset{+\ 2-}{H_2O}$$

ox ½⟩
$$\overset{-}{I} \rightarrow \overset{-\frac{1}{3}}{I} + \tfrac{2}{3}e^-$$
$$3I^- \rightarrow I_3^- + 2e^-$$
⎫ x 2

red ½⟩
$$O^0 + 2e^- \rightarrow O^{2-}$$
$$4H^+ + O_2 + 4e^- \rightarrow 2H_2O$$

$$6I^- + 4H^+ + O_2 + \cancel{4e^-} \rightarrow 2I_3^- + \cancel{4e^-} + 2H_2O$$

$$\boxed{6I^- + 4H^+ + O_2 \rightarrow 2I_3^- + 2H_2O}$$

i. $HNO_3(aq) + H_2SO_4(aq) + Hg(l) \rightarrow Hg_2SO_4(s) + NO(g) + H_2O(l)$

$$H^+ + \overset{5+\ 2-}{NO_3^-} + \overset{+}{H^+} + \overset{+\ 6+\ 2-}{HSO_4^-} + \overset{0}{Hg} \rightarrow \overset{+\ 6+\ 2-}{Hg_2SO_4} + \overset{2+\ 2-}{NO} + \overset{+\ 2-}{H_2O}$$

ox ½⟩
$$Hg^0 \rightarrow Hg^+ + e^-$$
$$2Hg \rightarrow Hg_2SO_4 + 2e^-$$
$$HSO_4^- + 2Hg \rightarrow Hg_2SO_4 + 2e^- + H^+$$
⎫ x 3

red ½⟩
$$N^{5+} + 3e^- \rightarrow N^{2+}$$
$$NO_3^- + 3e^- \rightarrow NO$$
$$4H^+ + NO_3^- + 3e^- \rightarrow NO + 2H_2O$$
⎫ x 2

$$3HSO_4^- + 6Hg + 8H^+ + 2NO_3^- + \cancel{6e^-} \rightarrow 3Hg_2SO_4 + \cancel{6e^-} + 3H^+ + 2NO + 4H_2O$$

$$\boxed{3HSO_4^- + 6Hg + 5H^+ + 2NO_3^- \rightarrow 3Hg_2SO_4 + 2NO + 4H_2O}$$

j. $\overset{2+\ 2-}{CO}(g) + \overset{5+\ 2-}{I_2O_5}(g) \rightarrow \overset{4+\ 2-}{CO_2}(g) + \overset{0}{I_2}(g)$

ox ½⟩
$$C^{2+} \rightarrow C^{4+} + 2e^-$$
$$H_2O + CO \rightarrow CO_2 + 2e^- + 2H^+$$
⎫ x 5

red ½⟩
$$I^{5+} + 5e^- \rightarrow I^0$$
$$I_2O_5 + 10e^- \rightarrow I_2$$
$$10H^+ + I_2O_5 + 10e^- \rightarrow I_2 + 5H_2O$$

$$5\cancel{H_2O} + 5CO + \cancel{10H^+} + I_2O_5 + \cancel{10e^-} \rightarrow 5CO_2 + \cancel{10e^-} + \cancel{10H^+} + I_2 + 5\cancel{H_2O}$$

$$\boxed{5CO + I_2O_5 \rightarrow 5CO_2 + I_2}$$