Name _____ Date _____ Class _____

20 OXIDATION-REDUCTION REACTIONS

Practice Problems

In your notebook, solve the following problems.

SECTION 20.1 THE MEANING OF OXIDATION AND REDUCTION

Determine what is oxidized and what is reduced in each reaction. Identify the oxidizing agent and the reducing agent.

1. $2Sr + O_2 \rightarrow 2SrO$
2. $2Li + S \rightarrow 2Li_2S$
3. $2Cs + Br_2 \rightarrow 2CsBr$
4. $3Mg + N_2 \rightarrow Mg_3N_2$
5. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
6. $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$
7. $Si + 2F_2 \rightarrow SiF_4$
8. $2Ca + O_2 \rightarrow 2CaO$
9. $Mg + 2HCl \rightarrow MgCl_2 + H_2$
10. $2Na + 2H_2O \rightarrow 2NaOH + H_2$

SECTION 20.2 OXIDATION NUMBERS

1. Give the oxidation number of each kind of atom or ion.
   - **a.** Sn
   - **b.** K^+
   - **c.** S^{2-}
   - **d.** Fe^{3+}
   - **e.** Se
   - **f.** Mg^{2+}
   - **g.** Sn^{4+}
   - **h.** Br^-
2. Calculate the oxidation number of chromium in each of the following formulas.
   - **a.** Cr_2O_3
   - **b.** $H_2Cr_2O_7$
   - **c.** $CrSO_4$
   - **d.** CrO_4^{2-}
3. Use the changes in oxidation number to determine which elements are oxidized and which are reduced in these reactions. (Note: It is not necessary to use balanced reactions.)
   - **a.** $C + H_2SO_4 \rightarrow CO_2 + SO_2 + H_2O$
   - **b.** $HNO_3 + HI \rightarrow NO + I_2 + H_2O$
   - **c.** $KMnO_4 + HCl \rightarrow MnCl_2 + Cl_2 + H_2O + KCl$
   - **d.** $Sb + HNO_3 \rightarrow Sb_2O_5 + NO + H_2O$
4. For each reaction in problem 3 above, identify the oxidizing agent and reducing agent.

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SECTION 20.3 BALANCING REDOX EQUATIONS

1. Balance these equations using the oxidation-number-change method.
   - **a.** $C + H_2SO_4 \rightarrow CO_2 + SO_2 + H_2O$
   - **b.** $H_2S + HNO_3 \rightarrow S + NO + H_2O$
   - **c.** $HNO_3 + HI \rightarrow NO + I_2 + H_2O$
   - **d.** $Sb + HNO_3 \rightarrow Sb_2O_5 + NO + H_2O$
   - **e.** $KMnO_4 + HCl \rightarrow MnCl_2 + Cl_2 + H_2O + KCl$
   - **f.** $KIO_4 + KI + HCl \rightarrow KCl + I_2 + H_2O$
   - **g.** $Zn + Cr_2O_7^{2-} + H^+ \rightarrow Zn^{2+} + Cr^{3+} + H_2O$
2. Write half-reactions for the oxidation and reduction processes for each of the following reactions.
   - **a.** $Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$ (acidic solution)
   - **b.** $Sn^{2+} + IO_3^- \rightarrow Sn^{4+} + I^-$ (acidic solution)
   - **c.** $S^{2-} + NO_3^- \rightarrow S + NO$ (acidic solution)
   - **d.** $Mn^{2+} + H_2O_2 \rightarrow MnO_2 + H_2O$ (basic solution)
3. Balance these reactions using the half-reaction method.
   - **a.** $Zn + HgO \rightarrow ZnO_2^{2-} + Hg$ (basic solution)
   - **b.** $Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$ (acidic solution)
   - **c.** $Sn^{2+} + IO_3^- \rightarrow Sn^{4-} + I^-$ (acidic solution)
   - **d.** $S^{2-} + NO_3^- \rightarrow S + NO$ (acidic solution)
   - **e.** $Mn^{2+} + H_2O_2 \rightarrow MnO_2 + H_2O$ (basic solution)
   - **f.** $CrO_2 + ClO^- \rightarrow CrO_4^{2-} + Cl^-$ (basic solution)

Section 20.1

1. Sr: oxidized (reducing agent)
   O_2: reduced (oxidizing agent)
2. Li: oxidized (reducing agent)
   S: reduced (oxidizing agent)
3. Cs: oxidized (reducing agent)
   Br_2: reduced (oxidizing agent)
4. Mg: oxidized (reducing agent)
   N_2: reduced (oxidizing agent)
5. Fe: oxidized (reducing agent)
   O_2: reduced (oxidizing agent)
6. Br^-: oxidized (reducing agent)
   Cl_2: reduced (oxidizing agent)
7. Si: oxidized (reducing agent)
   F_2 reduced (oxidizing agent)
8. Ca: oxidized (reducing agent)
   O_2 reduced (oxidizing agent)
9. Mg: oxidized (reducing agent)
   H^+: reduced (oxidizing agent)
10. Na: oxidized (reducing agent)
    H_2O: reduced (oxidizing agent)

Section 20.2

1. **a.** Sn is tin in an uncombined state. The oxidation number is 0.
   b. The ionic charge on potassium is 1+, thus the oxidation number is +1.
   c. The ionic charge on sulfur is 2−, thus the oxidation number is −2.
   d. The ionic charge on iron is 3+, thus the oxidation number is +3.
   e. Se is selenium in an uncombined state. The oxidation number is 0
   f. The ionic charge on magnesium is 2+, thus the oxidation number is +2.
   g. The ionic charge on tin is 4+, thus the oxidation number is +4.
   f. Increase in oxidation number of iodine ion = +1; decrease in oxidation number of iodine = −7.
   $KIO_4 + 7KI + 8HCl \rightarrow 8KCl + 4I_2 + 4H_2O$
   g. Increase in oxidation number of zinc = +2; decrease in oxidation number of chromium = −3.
   $3Zn + 2Cr_2O_7^{2-} + 28H^+ \rightarrow 3Zn^{2+} + 4Cr^{3+} + 14H_2O$
2. **a.** $Fe^{2+} \rightarrow Fe^{3+} + e^-$
   $5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$
   b. $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$
   $6H^+ + 6e^- + IO_3^- \rightarrow I^- + 3H_2O$
   c. $S^{2-} \rightarrow S + 2e^-$
   $3e^- + 4H^+ + NO_3^- \rightarrow NO + 2H_2O$
3. **a.** $2OH^- + Zn + HgO \rightarrow ZnO_2^{2-} + Hg + H_2O$
   b. $8H^+ + 5Fe^{2+} + MnO_4^- \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$
   c. $6H^+ + 3Sn^{2+} + IO_3^- \rightarrow 3Sn^{4-} + I^- + 3H_2O$
   d. $8H^+ + 3S^{2-} + 2NO_3^- \rightarrow 3S + 2NO + 4H_2O$
   e. $2OH^- + Mn^{2+} + H_2O_2 \rightarrow MnO_2 + 2H_2O$
   f. $2OH^- + CrO_2 + ClO^- \rightarrow CrO_4^{2-} + Cl^- + H_2O$
   h. The ionic charge on bromine is 1−, thus the oxidation number is −1.
2. **a.** +3 **c.** +2
   b. +6 **d.** +6
3. **a.** $\overset{0}{C} + \overset{+1\ +6-2}{H_2SO_4} \rightarrow \overset{+4-2}{CO_2} + \overset{+4-2}{SO_2} + \overset{+1\ -2}{H_2O}$
   Carbon is oxidized (0 → +4).
   Sulfur is reduced (+6 → +4).
   b. $\overset{+1+5-2}{HNO_3} + \overset{+1-1}{HI} \rightarrow \overset{+2-2}{NO} + \overset{0}{I_2} + \overset{+1\ -2}{H_2O}$
   Nitrogen is reduced (+5 → +2).
   Iodide ion is oxidized (−1 → 0).
   c. $\overset{+1\ +7\ -2}{KMnO_4} + \overset{+1-1}{HCl} \rightarrow \overset{+2\ -1}{MnCl_2} + \overset{0}{Cl_2} + \overset{+1\ -2}{H_2O} + \overset{+1-1}{KCl}$
   Manganese is reduced (+7 → +2).
   Chloride ion is oxidized (−1 → 0).
   d. $\overset{0}{Sb} + \overset{+1+5-2}{HNO_3} \rightarrow \overset{+5\ -2}{Sb_2O_5} + \overset{+2-2}{NO} + \overset{+1\ -2}{H_2O}$
   Antimony is oxidized (0 → +5).
   Nitrogen is reduced (+5 → +2).
4. **a.** Oxidizing agent is sulfur;
   Reducing agent is carbon.
   b. Oxidizing agent is nitrogen;
   Reducing agent is iodine.
   c. Oxidizing agent is manganese;
   Reducing agent is chlorine.
   d. Oxidizing agent is nitrogen;
   Reducing agent is antimony.

Section 20.3

1. **a.** Increase in oxidation number of carbon = +4; decrease in oxidation number of sulfur = −2.
   $C + 2H_2SO_4 \rightarrow CO_2 + 2SO_2 + 2H_2O$
   b. Increase in oxidation number of sulfur = +2; decrease in oxidation number of nitrogen = −3.
   $3H_2S + 2HNO_3 \rightarrow 3S + 2NO + 4H_2O$
   c. Increase in oxidation number of iodine ion = +1; decrease in oxidation number of nitrogen = −3.
   $2HNO_3 + 6HI \rightarrow 2NO + 3I_2 + 4H_2O$
   d. Increase in oxidation number of antimony = +5; decrease in oxidation number of nitrogen = −3.
   $6Sb + 10HNO_3 \rightarrow 3Sb_2O_5 + 10NO + 5H_2O$
   e. Increase in oxidation number of chlorine ion = +1; decrease in oxidation number of manganese = −5.
   $2KMnO_4 + 16HCl \rightarrow 2MnCl_2 + 5Cl_2 + 8H_2O + 2KCl$