Definitions

Oxidation-Reduction Reactions

Questions

1. Indicate whether a reaction will occur or not in each of following. Writing a balanced equation is not necessary.
   (a) Magnesium metal is added to hydrochloric acid.
   (b) Copper metal is added to hydrochloric acid.
   (c) Magnesium metal is added to an aqueous solution of copper (II) chloride.
   (d) Copper metal is added to an aqueous solution of magnesium (II) chloride.
   (e) Lithium metal is added to water.
   (f) Aluminum metal is added to water.
   (g) Fluorine gas is bubbled through an aqueous solution of sodium bromide.
   (h) Liquid bromine is added to an aqueous solution of sodium fluoride.

2. Write a balanced chemical equation for each of the following, each of which results in a reaction occurring. For reactions occurring in water solution, write the balanced net ionic equation. Indicate the phase of each reactant and product.
   (a) Strontium metal is heated with elemental phosphorus.
   (b) Chips of calcium metal are added to hydrochloric acid.
   (c) Turnings of lead metal are added to an aqueous solution of silver nitrate.
   (d) A piece of potassium metal is added to a beaker of water.
   (e) Chlorine gas is bubbled through an aqueous solution of potassium iodide.
   (f) Acetylene (C_2H_2) is burned in air.
   (g) Glucose (C_6H_{12}O_6) is burned in air.

3. For reactions 1(b), 1(c), and 1(e), write the oxidation half reaction, the reduction half reaction, and show how they add to make the overall net ionic equation.

4. Have access to Handout 6 from the Class Web Site.
HOMEWORK 4B

Definitions
Oxidation; Reduction

Questions
1. Write a balanced chemical equation for each of the following, each of which results in a reaction occurring. Indicate the phase of each reactant and product.
   (a) An electric current is passed through molten sodium bromide.
   (b) Solid nickel (II) chlorate is heated.

2. Give the oxidation numbers of all atoms in each of the following:
   (a) $S_8$
   (b) $Te^{2-}$
   (c) $Li_3P$
   (d) $CoCl_3$
   (e) $NaBiO_3$
   (f) $Mg_2P_2O_7$
   (g) $Ca(NO_3)_2$
   (h) $N_2O$
   (i) $N_2H_4$
   (j) $H_2SiO_3$
   (k) $ClO_2^-$
   (l) $UO_2^{2+}$

HOMEWORK 4C

Definitions
Precipitating Reaction; Precipitate; Formula Equation; Complete Ionic Equation; Net Ionic Equation; Bronsted Acid; Bronsted Base

Questions
1. Based upon the solubility rules, predict whether each of the following ionic compounds would be soluble or insoluble in water:
   (a) sodium fluoride
   (b) chromium (III) nitrate
   (c) zinc chloride
   (d) aluminum sulfate
   (e) calcium sulfide
   (f) magnesium carbonate

2. Indicate whether a reaction will occur or not in each of following. Writing a balanced equation is not necessary.
   (a) Solutions of calcium nitrate and aluminum chloride are mixed.
   (b) Solutions of iron (II) acetate and zinc sulfate are mixed.
   (c) Solutions of sodium phosphate and aluminum bromide are mixed.

3. Write the balanced net ionic equation for each of the following, each of which results in a reaction occurring. Indicate the phase of each reactant and product.
   (a) Solutions of barium acetate and nickel (II) sulfate are mixed.
   (b) Sodium hydroxide and nitric acid solutions are mixed.
   (c) Solid magnesium carbonate is added to an acetic acid solution.
   (d) Solutions of ammonium sulfate and sodium hydroxide are mixed.
**HOMEWORK 4D**

*Definitions*

Oxidizing Agent; Reducing Agent

*Questions*

1. For each of the following reactions, (1) specific whether it is an oxidation-reduction reaction or not, and if it is, identify (2) the element oxidized, (3) the element reduced (4) the oxidizing agent, and (5) the reducing agent:
   (a) \( \text{Cu} + 2\text{Ag}^+ \rightarrow 2\text{Ag} + \text{Cu}^{2+} \)
   (b) \( \text{HCl} + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl} \)
   (c) \( \text{SiCl}_4 + 2\text{H}_2\text{O} \rightarrow 4\text{HCl} + \text{SiO}_2 \)
   (d) \( \text{SiCl}_4 + 2\text{Mg} \rightarrow 2\text{MgCl}_2 + \text{Si} \)

2. Predict the products of the following oxidation-reduction reactions, but do not balance:
   (a) Solutions of potassium dichromate and sodium sulfite are mixed.
   (b) Carbon monoxide is bubbled into an acidified solution of potassium permanganate.
   (c) A basic solution of potassium permanganate is mixed with a solution of tin (II) nitrate.
   (d) Concentrated nitric acid is added to a solution of sodium bromide.
   (e) Aluminum metal is added to a solution of hydrogen peroxide.

**HOMEWORK 4E**

*Questions*

1. Write the balanced net ionic equation for each of the following, each of which results in a reaction occurring. Indicate the phase of each reactant and product.
   (a) Solutions of potassium dichromate and hydrochloric acid are mixed.
   (b) A precipitate of cadmium sulfide is treated with concentrated nitric acid.
   (c) An acidified solution of potassium permanganate is added to a solution of sodium nitrite.
   (d) A basic solution of potassium permanganate is added to a solution of lead (II) nitrate.
   (e) Acidic solutions of hydrogen peroxide and sodium oxalate are mixed.
Definitions

Stoichiometric Mixture; Limiting Reactant; Theoretical Yield

Questions

1. Complete the table for each of the following reactions:

(a) \[ \text{N}_2 + \text{O}_2 \rightarrow 2\text{NO} \]
(b) \[ \text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH} \]

<table>
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<th></th>
<th>( \text{N}_2 )</th>
<th>( \text{O}_2 )</th>
<th>( \text{NO} )</th>
<th>( \text{CO} )</th>
<th>( 2\text{H}_2 )</th>
<th>( \text{CH}_3\text{OH} )</th>
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<tr>
<td>final moles</td>
<td>___</td>
<td>___</td>
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</tr>
</tbody>
</table>

2. Hydrogen molecules and fluorine molecules, shown in the reaction chamber to the right, react to form hydrogen fluoride molecules. Draw a picture of the chamber after the reaction.

3. The reaction between iron (III) oxide and aluminum (the thermite reaction) produces so much heat that it has been used for welding railroad rails, in incendiary bombs, and to ignite solid-fuel rocket motors. If 15.0 grams of iron (III) oxide will be used in the thermite reaction, calculate

(a) the mass of aluminum that must react
(b) the mass of aluminum oxide that will be formed
(c) the mass of iron that will be formed

4. Ammonia can be produced by the reaction of nitrogen gas with hydrogen gas.

(a) Calculate the mass of ammonia that will be produced when 750. grams of nitrogen gas reacts with 350. grams of hydrogen gas.
(b) Which of the two reactants is the limiting reagent?
(c) How many grams of the nonlimiting reagent remain after the reaction has ended?
**Definitions**

Stock Solution; Dilution

**Questions**

1. A stock solution containing manganese (II) ions is prepared by dissolving 1.584 g of manganese metal in nitric acid, then diluting the solution to a final volume of 1.000 L.
   (a) Calculate the molarity of the manganese (II) ions in the stock solution.
   (b) If 50.00 mL of the stock solution is pipetted into a 1000 mL volumetric flask and diluted to a final volume of 1000.0 mL, calculate the molarity of the manganese (II) ions in this diluted solution.

2. Calculate the volume of water that must be added to 100.0 mL of 15.6 M ammonia in order to produce a 6.00 M ammonia solution.

3. A 20.0 mL sample of a 0.050 M calcium chloride solution is mixed with a 30.0 mL sample of a 0.040 M silver nitrate solution.
   (a) Calculate the moles of each of the ions present in the solution before any reaction has occurred.
   (b) Calculate the moles of each of the ions present in the solution after any reaction has occurred.
   (c) Calculate the molarities of each of the ions present in the solution after any reaction has occurred.

**Definitions**

Titration; Equivalence Point; Indicator; Endpoint

**Questions**

1. Zinc metal is oxidized by the dichromate ion in an acidic solution. Calculate the mass of zinc that can be oxidized by 26.50 mL of a 0.2022 M dichromate ion solution.

2. Potassium biphthalate, KHC₈H₄O₄, is an acidic salt with a molar mass of 204.22 g/mol, and it can be neutralized by sodium hydroxide according to the following equation:

   \[
   \text{KHC}_8\text{H}_4\text{O}_4 + \text{NaOH} \rightarrow \text{H(OH)} + \text{NaKC}_8\text{H}_4\text{O}_4
   \]

   If 20.46 mL of the sodium hydroxide solution is required to neutralize 0.1082 g of potassium biphthalate, calculate the molarity of the sodium hydroxide solution.

3. Acetylsalicylic acid is a monoprotic acid that is the active ingredient in aspirin. It took 35.17 mL of a 0.5065 M sodium hydroxide solution to react completely with 3.210 g of acetylsalicylic acid. Calculate the molar mass of acetylsalicylic acid.
HOMEWORK 4I

Definitions
Molar Mass

Questions
1. Calculate the percent composition by mass of each element in $C_3H_4O_2$.
2. Calculate the number of atoms of phosphorus present in 5.00 g of tetraphosphorus hexaoxide.
3. A metal oxide with the formula $M_2O_3$ is 68.4% metal by mass. Calculate the molar mass of the metal.

HOMEWORK 4J

Definitions
Empirical Formula; Molecular Formula

Questions
1. Combustion of a hydrocarbon yields 6.78 g of carbon dioxide and 2.78 g of water. If the molar mass of the compound is $85 \pm 5$ g/mol, determine its empirical and molecular formulas.
2. A compound contains only carbon, hydrogen and nitrogen. Combustion of 9.96 g of the compound yields 16.01 g of carbon dioxide and 4.37 g of water. If the molar mass of the compound is $160 \pm 10$ g/mol, determine its empirical and molecular formulas.
3. Elemental analysis of an unknown pure substance indicates that the percent composition by mass is 94.70% carbon and 5.30% hydrogen. A solution that is prepared by dissolving 6.76 grams of the substance in 50.00 grams of chloroform, $CHCl_3$, has a boiling point of 63.35°C. (The normal boiling point of chloroform is 61.20°C and the molal boiling point constant, $K_b$, for chloroform is 3.63°C/kg/mol).
   (a) Determine the empirical formula of the substance.
   (b) Calculate the molar mass of the substance.
   (c) Determine the molecular formula of the substance.
1. When will an elemental metal react with a metal ion in solution?

2. Name the metals that will:
   (a) react with water
   (b) react with acids

3. When will an elemental halogen react with a halide ion in solution?

4. Name the products formed when a compound is burned in air.

5. Name the products formed when a metallic chlorate is heated.

6. Indicate whether a reaction will occur or not in each of following. Writing a balanced equation is not necessary.
   (a) Aluminum metal is added to sulfuric acid.
   (b) Platinum metal is added to sulfuric acid.
   (c) Aluminum metal is added to an aqueous solution of platinum (II) nitrate.
   (d) Platinum metal is added to an aqueous solution of aluminum nitrate.
   (e) Aluminum metal is added to water.
   (f) Platinum metal is added to water.
   (g) Chlorine gas is bubbled through an aqueous solution of potassium fluoride.
   (h) Fluorine gas is bubbled through an aqueous solution of potassium chloride.
   (i) Solutions of magnesium acetate and silver nitrate chloride are mixed.
   (j) Solutions of ammonium oxalate and cobalt (II) chloride are mixed.

(continued on next page)
7. Write a balanced chemical equation for each of the following, each of which results in a reaction occurring. For reactions in solution, give the balanced \textit{net ionic equation}. Indicate the phase of each reactant and product.

(a) Solutions of lead (II) nitrate and potassium bromide are mixed.
(b) Solutions of hydrofluoric acid and lithium hydroxide are mixed.
(c) Solutions of sulfuric acid and ammonium carbonate are mixed.
(d) Solutions of ammonia and potassium monohydrogen phosphate are mixed.
(e) Liquid benzene (C_6H_6) is burned in air.
(f) Magnesium ribbon is added to a solution of copper (II) sulfate.
(g) Iron filings are added to hydrochloric acid.
(h) A piece of lithium metal is added to water.
(i) Fluorine gas is bubbled through a solution of sodium chloride.
(j) Calcium metal is burned in nitrogen gas.
(k) Mercury (II) oxide is heated strongly.
(l) Solid iron (III) chlorate is heated.
(m) The copper (II) oxide on a penny reacts with the acetic acid in Del Taco hot sauce.
(n) Crystals of copper (II) sulfide are added to a hydrochloric acid solution.
(o) Solutions of potassium dichromate and phosphorous acid are mixed.
(p) Liquid mercury metal is added to concentrated nitric acid.
(q) An acidified solution of potassium permanganate is added to a solution of iron (II) nitrate.
(r) An basic solution of potassium permanganate is added to a solution of iron (II) nitrate.

8. A lake may be polluted with Hg\textsubscript{2}\textsuperscript{2+} ions. What precipitation reaction might you use to test for the presence of Hg\textsubscript{2}\textsuperscript{2+}?

9. To four significant figures, calculate the percent composition by mass of each element in the superconductor \textit{YBa}_2\textit{Cu}_3\textit{O}_7.

10. A metal oxide with the formula MO\textsubscript{2} is 59.9% metal by mass. Calculate the molar mass of the metal.

11. Complete combustion of 0.360 g of ethylene glycol (composed of carbon, hydrogen and oxygen) produces 0.510 g of carbon dioxide and 0.313 g of water. If ethylene glycol has a molar mass of about 60 g/mol, determine its molecular formula.

\textit{(continued on next page)}
12. Carbon monoxide and hydrogen molecules, shown in the reaction chamber below to the left, react to form methanol according to the reaction:

$$\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$$

Draw a picture of the chamber after the reaction.

13. Hydrogen and oxygen molecules, shown in the reaction chamber above to the right, react to form water. Draw a picture of the chamber after the reaction.

14. When carbon is heated with copper (II) oxide, metallic copper and carbon dioxide gas are formed.
   (a) Calculate the mass of metallic copper that will be produced when 10.00 g of carbon reacts with 100.0 g of copper (II) oxide.
   (b) Which of the two reactants is the limiting reagent?
   (c) How many grams of the nonlimiting reactant remain after the reaction has ended?

15. A 0.4230 g sample of impure sodium nitrate was heated, converting all of the sodium nitrate to sodium nitrite and oxygen gas. If 0.2864 g of sodium nitrite were collected, calculate the percent by mass of sodium nitrate in the impure sodium nitrate sample.

16. A stock solution is prepared by dissolving 10.8 g of ammonium sulfate crystals in enough water to make 100.0 mL of solution.
   (a) Calculate the molarity of the ammonium sulfate in the stock solution.
   (b) If 10.00 mL of the stock solution is added to 50.00 mL of deionized water, calculate the molarity of the ammonium sulfate in this diluted solution.

17. A 100.0 mL sample of a 0.200 M potassium hydroxide solution is mixed with a 100.0 mL sample of a 0.200 M magnesium nitrate solution.
   (a) Calculate the moles of each of the ions present in the solution before any reaction has occurred.
   (b) Calculate the moles of each of the ions present in the solution after any reaction has occurred.
   (c) Calculate the molarities of each of the ions present in the solution after any reaction has occurred.

*continued on next page*
18. A 25.00 mL sample of a hydrochloric acid solution requires 24.16 mL of a 0.106 M sodium hydroxide solution to be neutralized. Calculate the molarity of the hydrochloric acid solution.

19. A student was given a monoprotic acid which was either acetic acid (CH₃CO₂H), pyruvic acid (CH₃COCO₂H), or propionic acid (C₂H₅CO₂H). A solution is prepared by dissolving 0.102 grams of the acid in 50.0 mL of water, and titrated with 11.56 mL of 0.100 M NaOH. Identify the unknown acid.

20. A 0.506 g sample of ore containing stibnite (Sb₂S₃) was chemically treated with an acid to produce antimony (III) ions in solution. The antimony (III) was oxidized to antimony (V) by titrating it with a standard potassium dichromate solution.
   (a) Write the balanced net ionic equation for the reaction between the antimony (III) ions and the potassium dichromate solution.
   (b) The titration of the antimony (III) ions required 19.30 mL of 0.0233 M dichromate ion solution. Calculate the number of moles of antimony (III) ions that reacted with the dichromate solution.
   (c) Calculate the number of moles of stibnite (Sb₂S₃) in the original sample.
   (d) Calculate the percentage by mass of stibnite (Sb₂S₃) in the ore.

21. Calculate the number of atoms of sulfur present in 5.00 g of iron (III) sulfite.

**HOMEWORK 4R ANSWERS**

1. Atoms of active metals react with ions of less active metals.

2. (a) Alkali metals, Ca, Sr, Ba, and Ra
    (b) All metals but Noble Metals, Coinage Metals, and Hg

3. Atoms of active halogens react with ions of less active halogens.

4. Oxides of each element in the compound

5. Metallic chloride and oxygen

6. (a) yes   (b) no   (c) yes   (d) no   (e) no
    (f) no    (g) no    (h) yes   (i) no    (j) yes

*(continued on next page)*
7. (a) $\text{Pb}^{2+} (aq) + 2\text{Br}^- (aq) \rightarrow \text{PbBr}_2 (s)$
(b) $\text{HF} (aq) + \text{OH}^- (aq) \rightarrow \text{F}^- (aq) + \text{H}_2\text{O} (l)$
(c) $2\text{H}^+ (aq) + \text{CO}_3^{2-} (aq) \rightarrow \text{H}_2\text{O} (l) + \text{CO}_2 (g)$
(d) $\text{NH}_3 (aq) + \text{HPO}_4^{2-} (aq) \rightarrow \text{NH}_4^+ (aq) + \text{PO}_4^{3-} (aq)$
(e) $2\text{C}_6\text{H}_6 (l) + 15\text{O}_2 (g) \rightarrow 12\text{CO}_2 (g) + 6\text{H}_2\text{O} (g)$
(f) $\text{Mg} (s) + \text{Cu}^{2+} (aq) \rightarrow \text{Mg}^{2+} (aq) + \text{Cu} (s)$
(g) $\text{Fe} (s) + 2\text{H}^+ (aq) \rightarrow \text{Fe}^{2+} (aq) + \text{H}_2 (g)$ or
$2\text{Fe} (s) + 6\text{H}^+ (aq) \rightarrow 2\text{Fe}^{3+} (aq) + 3\text{H}_2 (g)$
(h) $2\text{Li} (s) + 2\text{H}_2\text{O} (l) \rightarrow 2\text{Li}^+ (aq) + 2\text{OH}^- (aq) + \text{H}_2 (g)$
(i) $\text{F}_2 (g) + 2\text{Cl}^- (aq) \rightarrow 2\text{F}^- (aq) + \text{Cl}_2 (g)$
(j) $3\text{Ca} (s) + \text{N}_2 (g) \rightarrow \text{Ca}_3\text{N}_2 (s)$
(k) $2\text{HgO} (s) \rightarrow 2\text{Hg} (l) + \text{O}_2 (g)$
(l) $2\text{Fe(ClO}_3)_3 (s) \rightarrow 2\text{FeCl}_3 (s) + 9\text{O}_2 (g)$
(m) $\text{CuO} (s) + 2\text{HC}_2\text{H}_3\text{O}_2 (aq) \rightarrow \text{Cu}^{2+} (aq) + 2\text{C}_2\text{H}_3\text{O}_2^- (aq) + \text{H}_2\text{O} (l)$
(n) $\text{CuS} (s) + 2\text{H}^+ (aq) \rightarrow \text{Cu}^{2+} (aq) + \text{H}_2\text{S} (g)$
(o) $8\text{H}^+ (aq) + \text{Cr}_2\text{O}_7^{2-} (aq) + 3\text{H}_3\text{PO}_4 (aq) \rightarrow 2\text{Cr}^{3+} (aq) + 3\text{H}_3\text{PO}_4 (aq) + 4\text{H}_2\text{O} (l)$
(p) $2\text{Hg} (l) + 4\text{H}^+ (aq) + 2\text{NO}_3^- (aq) \rightarrow \text{Hg}_2^{2+} (aq) + 2\text{NO}_2 (g) + 2\text{H}_2\text{O} (l)$ or
$\text{Hg} (l) + 4\text{H}^+ (aq) + 2\text{NO}_3^- (aq) \rightarrow \text{Hg}^{2+} (aq) + 2\text{NO}_2 (g) + 2\text{H}_2\text{O} (l)$
(q) $8\text{H}^+ (aq) + \text{MnO}_4^- (aq) + 5\text{Fe}^{2+} (aq) \rightarrow \text{Mn}^{2+} (aq) + 5\text{Fe}^{3+} (aq) + 4\text{H}_2\text{O} (l)$
(r) $2\text{H}_2\text{O} (l) + 5\text{OH}^- (aq) + \text{MnO}_4^- (aq) + 3\text{Fe}^{2+} (aq) \rightarrow \text{MnO}_2 (s) + 3\text{Fe(OH)}_3 (s)$

8. $\text{Hg}_2^{2+} (aq) + 2\text{Cl}^- (aq) \rightarrow \text{Hg}_2\text{Cl}_2 (s)$ or
$\text{Hg}_2^{2+} (aq) + 2\text{Br}^- (aq) \rightarrow \text{Hg}_2\text{Br}_2 (s)$ or
$\text{Hg}_2^{2+} (aq) + 2\Gamma^- (aq) \rightarrow \text{Hg}_2\text{I}_2 (s)$

9. 13.35% Y, 41.22% Ba, 28.62% Cu, 16.81% O

10. 47.8 g/mol

11. $\text{C}_2\text{H}_4\text{O}_2$

(continued on next page)
14. (a) 79.89 g Cu
(b) CuO
(c) 2.45 g C

15. 83.40% NaNO₃

16. (a) 0.817 M (NH₄)₂SO₄
(b) 0.136 M (NH₄)₂SO₄

17. (a) 0.0200 mol K⁺, 0.0200 mol OH⁻, 0.0200 mol Mg²⁺, 0.0400 mol NO₃⁻
(b) 0.0200 mol K⁺, 0.0100 mol Mg²⁺, 0.0400 mol NO₃⁻
(c) 0.100 M K⁺, 0.0500 M Mg²⁺, 0.200 M NO₃⁻

18. 0.102 M HCl

19. pyruvic acid

20. (a) 14H⁺ + 3Sb³⁺ + Cr₂O₇²⁻ → 2Cr³⁺ + 3Sb⁵⁺ + 7H₂O
(b) 0.00135 mol Sb³⁺
(c) 0.000675 mol Sb₂S₃
(d) 45.3% Sb₂S₃

21. 2.57 x 10^{22} S atoms