CHEMISTRY:
THE MOLECULAR NATURE OF MATTER & CHANGE

SILBERBERG

QUESTIONS

Limiting Reactants

3.65 Calculate the mass of each product formed when 6.082 g diborane (B_2H_6) reacts with excess water:

$$B_2H_6(g) + H_2O(l) \rightarrow H_3BO_3(s) + H_2(g) \text{ [unbalanced]}$$

3.67 Elemental phosphorus occurs as tetratomic molecules, P_4. What mass of chlorine gas is needed for complete reaction with 251 g phosphorus to form phosphorus pentachloride?

3.69 Solid iodine trichloride is prepared by reaction between solid iodine and gaseous chlorine to form iodine monochloride crystals, followed by treatment with additional chlorine.

a) write a balanced equation for each step
b) write an overall balanced equation for the formation of iodine trichloride
c) how many grams of iodine are needed to prepare 25.8 kg of final product?

3.71 Many metals react with oxygen gas to form the metal oxide. For example, calcium reacts as follows:

$$2Ca(s) + O_2(g) \rightarrow 2CaO(s)$$

You wish to calculate the mass of calcium oxide that can be prepared from 4.20 g Ca and 1.60 g O_2.

a) How many moles of CaO can be produced from the given mass of Ca?
b) How many moles of CaO can be produced from the given mass of O_2?
c) Which is the limiting reactant?
d) How many grams of CaO can be produced?

3.73 Calculate the maximum number of moles and mass of iodic acid (HIO_3) that can form when 735 g iodine trichloride reacts with 107.7 g water:

$$ICl_3 + H_2O \rightarrow ICl + HIO_3 + HCl \text{ [unbalanced]}$$

What mass of the excess reactant remains?

3.75 When 0.100 mol carbon is burned in a closed vessel with 8.00 g oxygen, how many grams of carbon dioxide can form? Which reactant is in excess, and how many grams of it remain after the reaction?

3.77 Aluminium nitrite and ammonium chloride react to form aluminum chloride, nitrogen and water. What mass of each substance is present after 53.0 g aluminum nitrite and 48.9 g ammonium chloride react completely?

Volumetric Reactions

3.96 Calculate each of the following quantities:

a) Molarity of a solution prepared by diluting 37.00 mL of 0.250 *M* potassium chloride to 150.00mL.
b) Molarity of a solution prepared by diluting 25.71 mL of 0.0706 *M* ammonium sulfate to 500.00 mL.
c) Molarity of sodium ion in a solution made by mixing 3.58 mL of 0.288 *M* sodium chloride with 500 mL of 6.51×10^{-3} *M* sodium sulfate (assume volumes are additive).

3.100 How many milliliters of 0.55 *M* HCl are needed to react with 5.7 g $CaCO_3$?

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

3.102 How many grams of solid barium sulfate form when 25.0 mL of 0.160 *M* barium chloride reacts with 68.0 mL of 0.055 *M* sodium sulfate? Aqueous sodium chloride is the other product.

CHEMISTRY

ZUMDAHL, FOURTH EDITION

QUESTIONS

Limiting Reactants and Percent Yield

91. Consider the reaction

$$Mg(s) + I_2(s) \rightarrow MgI_2(s)$$

Identify the limiting reagent in each of the reaction mixtures below:

a) 100 atoms of Mg and 100 molecules of I_2
b) 150 atoms of Mg and 100 molecules of I_2
c) 200 atoms of Mg and 300 molecules of I_2
d) 0.16 mol Mg and 0.25 mol I_2
e) 0.14 mol Mg and 0.14 mol I_2
f) 0.12 mol Mg and 0.08 mol I_2
g) 6.078 g Mg and 63.46 g I_2
h) 1.00 g Mg and 2.00 g I_2
i) 1.00 g Mg and 20.00 g I_2

93. When a mixture of silver metal and sulfur is heated silver sulfide is formed:

$$16Ag(s) + S_8(s) \rightarrow (heat) \qquad 8Ag_2S(s)$$

a) What mass of Ag_2S is produced from a mixture of 2.0 g Ag and 2.0 g S_8?
b) What mass of which reactant is left unreacted?

95. Consider the following unbalanced equation:

$$Ca_3(PO_4)_2(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_3PO_4(aq)$$

What masses of calcium sulfate and phosphoric acid can be produced from the reaction of 1.0 kg calcium phosphate with 1.0 kg concentrated sulfuric acid (98% H_2SO_4 by mass)?

97. When copper is heated with an excess of sulfur, copper(I) sulfide is formed. In a given experiment, 1.50 g copper was heated with excess sulfur to yield 1.76 g copper(I) sulfide. What is the theoretical yield? What is the percent yield?

Acid-Base Reactions

47. A solution is prepared by dissolving 15.0 g NaOH in 150.0 mL of 0.250 *M* nitric acid. Will the final solution be acidic, basic or neutral? Calculate the concentrations of all the ions present in the solution after the reaction has occurred. Assume no volume change on addition of NaOH.

51. A student titrates an unknown amount of potassium hydrogen phthalate ($KHC_8H_4O_4$) often abbreviated KHP with 20.46 mL of a 0.1000 *M* NaOH solution KHP (molar mass = 204.22 g/mol) has one acidic hydrogen. How many grams of KHP were titrated (reacted completely) by the sodium hydroxide solution?

65. Calcium metal will react with water as follows:

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$$

What is the molarity of hydroxide ions in the solution formed when 4.25 g calcium metal is dissolved in enough water to make a final volume of 225 mL?

69. Rust stains can be removed by washing a surfaced with a dilute solution of oxalic acid ($H_2C_2O_4$). The reaction is

$$Fe_2O_3(s) + 6H_2C_2O_4(aq) \rightarrow 2Fe(C_2O_4)_3^{-3}(aq) + 3H_2O(l) + 6H^+(aq)$$

a) What mass of rust can be removed by 1.0 L of a 0.14 *M* solution of oxalic acid?

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3.65 27.18 g H_3BO_3; 2.659 g H_2

3.67 1.44 x 10^3 g

3.69

a) $I_2(s) + Cl_2(g) \rightarrow 2ICl(s)$
   $ICl(s) + Cl_2(g) \rightarrow ICl_3(s)$
b) $I_2(s) + 3Cl_2(g) \rightarrow 2ICl_3(s)$
c) 1.40 x 10^4 g

3.71

a) 0.105 mol
b) 0.100 mol
c) O_2
d) 5.61 g

3.73 1.58 mol; 277 g; 22.3 g H_2O in excess

3.75 4.40 g CO_2; 4.80 g O_2 in excess

3.77 2.7 g Al $(NO_2)_3$; 0 g NH_4Cl; 40.6 g $AlCl_3$; 25.6 g N_2; 32.9 g H_2O

3.96

a) 0.0617 *M*
b) 0.00363 *M*
c) 0.0150 *M*

3.100 2.1 x 10^2 mL

3.102 0.87 g

ZUMDAHL ANSWERS

91.

a) Stoichiometric mixture
b) I_2
c) Mg
d) Mg
e) Stoichiometric mixture
f) I_2
g) Stoichiometric mixture
h) I_2
i) Mg

93.

a) 2.4 g
b) 1.7 g S_8 unreacted

95. 1300 g $CaSO_4$, 630 g H_3PO_4

97. 1.88 g (theoretical) 93.6%

47. Basic as OH^- is left, 0.250 *M* NO_3^-, 2.50 *M* Na^+, 2.25 *M* OH^-

51. 0.4178 g

65. 0.942 *M*

69. (a) 3.7 g Fe_2O_3