Key

HC Stoichiometry, Limiting Reactant & % Yield

SUPPLEMENTAL PRACTICE PROBLEMS

General Stoichiometry

1. Several brands of antacid tablets use aluminum hydroxide to neutralize excess acid.

$$Al(OH)_3(s) + 3\ HCl(aq) \rightarrow AlCl_3(aq) + 3\ H_2O(l)$$

[Molar masses: 78.01 36.46 133.4 18.02]

If 0.750 g of $Al(OH)_3$ is completely reacted:

a) What mass of HCl (aq) is required?

$g\ Al(OH)_3 \rightarrow mol\ Al(OH)_3 \rightarrow mol\ HCl \rightarrow g\ HCl$

$$0.750\ g\ \cancel{Al(OH)_3} \times \frac{1\ mol\ \cancel{Al(OH)_3}}{78.01\ g\ \cancel{Al(OH)_3}} \times \underbrace{\frac{3\ mol\ \cancel{HCl}}{1\ mol\ \cancel{Al(OH)_3}}}_{\text{mole ratio from equation}} \times \frac{36.46\ g\ HCl}{1\ mol\ \cancel{HCl}} = \boxed{1.05\ g\ HCl}$$

b) What mass of water is produced?

$g\ Al(OH)_3 \rightarrow mol\ Al(OH)_3 \rightarrow mol\ H_2O \rightarrow g\ HCl$

$$0.750\ g\ \cancel{Al(OH)_3} \times \frac{1\ mol\ \cancel{Al(OH)_3}}{78.01\ g\ \cancel{Al(OH)_3}} \times \frac{3\ mol\ \cancel{H_2O}}{1\ mol\ \cancel{Al(OH)_3}} \times \frac{18.02\ g\ H_2O}{1\ mol\ \cancel{H_2O}} = \boxed{0.520\ g\ H_2O}$$

2. The equation for one of the reactions in the process of reducing iron ore to the metal is

$$Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2(g)$$

[Molar masses: 159.7 28.01 55.85 44.01]

a) What is the maximum mass of iron, in grams, that can be obtained from 454 g of iron(III) oxide?

$g\ Fe_2O_3 \rightarrow mol\ Fe_2O_3 \rightarrow mol\ Fe \rightarrow g\ Fe$

$$454\ g\ \cancel{Fe_2O_3} \times \frac{1\ mol\ \cancel{Fe_2O_3}}{159.7\ g\ \cancel{Fe_2O_3}} \times \frac{2\ mol\ \cancel{Fe}}{1\ mol\ \cancel{Fe_2O_3}} \times \frac{55.85\ g\ Fe}{1\ mol\ \cancel{Fe}} = \boxed{318\ g\ Fe}$$

b) What volume of CO_2 (g) can be produced when 454 g of iron(III) oxide react completely?

$g\ Fe_2O_3 \rightarrow mol\ Fe_2O_3 \rightarrow mol\ CO_2 \rightarrow L\ CO_2$

$$454\ g\ \cancel{Fe_2O_3} \times \frac{1\ mol\ \cancel{Fe_2O_3}}{159.7\ g\ \cancel{Fe_2O_3}} \times \frac{3\ mol\ \cancel{CO_2}}{1\ mol\ \cancel{Fe_2O_3}} \times \frac{22.4\ L\ CO_2}{1\ mol\ \cancel{CO_2}} = \boxed{191\ L\ CO_2}$$

Limiting Reactants

3. The reaction of methane and water is one way to prepare hydrogen:

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3\,H_2(g)$$

[Molar masses: 16.04 18.02 28.01 2.02]

If you begin with 995 g of CH_4 and 2510 g of water, what is the maximum mass of H_2 that can be produced?

w/ 995g CH_4: g CH_4 → mol CH_4 → mol H_2 → g H_2

$$995\text{ g }\cancel{CH_4} \times \frac{1\text{ mol }\cancel{CH_4}}{16.04\text{ g }\cancel{CH_4}} \times \frac{3\text{ mol }\cancel{H_2}}{1\text{ mol }\cancel{CH_4}} \times \frac{2.02\text{ g }H_2}{1\text{ mol }\cancel{H_2}} = 376\text{ g }H_2$$

Max. mass that can be produced. CH_4 is the limiting reactant

w/ 2510g H_2O: g H_2O → mol H_2O → mol H_2 → g H_2

$$2510\text{ g }\cancel{H_2O} \times \frac{1\text{ mol }\cancel{H_2O}}{18.02\text{ g }\cancel{H_2O}} \times \frac{3\text{ mol }\cancel{H_2}}{1\text{ mol }\cancel{H_2O}} \times \frac{2.02\text{ g }H_2}{1\text{ mol }\cancel{H_2}} = 844\text{ g }H_2$$

4. Disulfur dichloride, S_2Cl_2, is used to vulcanize rubber. It can be made by treating molten sulfur with gaseous chlorine:

$$S_8(l) + 4\,Cl_2(g) \rightarrow 4\,S_2Cl_2(l)$$

[Molar masses: 256.6 70.91 135.0]

Starting with a mixture of 32.0 g of sulfur and 71.0 g of Cl_2, which is the limiting reactant? What is the maximum mass of S_2Cl_2 that can be produced?

• w/ 32.0g S: g S_8 → mol S_8 → mol S_2Cl_2 → g S_2Cl_2

$$32.0\text{ g }\cancel{S_8} \times \frac{1\text{ mol }\cancel{S_8}}{256.6\text{ g }\cancel{S_8}} \times \frac{4\text{ mol }\cancel{S_2Cl_2}}{1\text{ mol }\cancel{S_8}} \times \frac{135.0\text{ g }S_2Cl_2}{1\text{ mol }\cancel{S_2Cl_2}} = 67.3\text{ g }S_2Cl_2$$

Max mass of S_2Cl_2. S_8 is LR.

• w/ 71.0 g Cl_2: g Cl_2 → mol Cl_2 → mol S_2Cl_2 → g S_2Cl_2

$$71.0\text{ g }\cancel{Cl_2} \times \frac{1\text{ mol }\cancel{Cl_2}}{70.91\text{ g }\cancel{Cl_2}} \times \frac{4\text{ mol }\cancel{S_2Cl_2}}{4\text{ mol }\cancel{Cl_2}} \times \frac{135.0\text{ g }S_2Cl_2}{1\text{ mol }\cancel{S_2Cl_2}} = 135\text{ g }S_2Cl_2$$

Percent Yield

29. Diborane, B_2H_6, is a valuable compound in the synthesis of new organic compounds. One of several ways this born compound can be made is by the reaction

$$2\ NaBH_4(s) + I_2(s) \rightarrow B_2H_6(g) + 2\ NaI(s) + H_2(g)$$

[Molar masses: 37.84 253.8 27.67 149.9 2.02]

actual mass B_2H_6

Suppose you use 1.203 g of $NaBH_4$ with an excess of iodine and obtain $\boxed{0.295\ g\ of\ B_2H_6}$. What is the percent yield of B_2H_6?

$$\%\ \text{yield} = \frac{\text{actual mass}}{\text{theoretical mass}} \times 100\% = \frac{0.295\,g}{0.440\,g} \times 100\% = \boxed{67.0\%}$$

need to find theoretical mass B_2H_6:

g $NaBH_4$ → mol $NaBH_4$ → mol B_2H_6 → g B_2H_6

$$1.203\,g\ \cancel{NaBH_4} \times \frac{1\ mol\ NaBH_4}{37.84\,g\ NaBH_4} \times \frac{1\ mol\ \cancel{B_2H_6}}{2\ mol\ \cancel{NaBH_4}} \times \frac{27.67\,g\ B_2H_6}{1\ mol\ \cancel{B_2H_6}} = 0.440\,g$$

Theoretical: 0.440 g

31. Disulfur dichloride, which has a revolting smell, can be prepared by directly combining S_8 and Cl_2, but it can also be made by the following reaction:

$$3\ SCl_2(l) + 4\ NaF(s) \rightarrow SF_4(g) + S_2Cl_2(l) + 4\ NaCl(s)$$

[Molar masses: 103.0 41.99 108.1 135.0 58.46]

a) Assume you begin with 5.23 g of SCl_2 and excess NaF. What is the theoretical yield of S_2Cl_2?

g SCl_2 → mol SCl_2 → mol S_2Cl_2 → g S_2Cl_2

$$5.23\,g\ \cancel{SCl_2} \times \frac{1\ mol\ \cancel{SCl_2}}{103.0\,g\ \cancel{SCl_2}} \times \frac{1\ mol\ \cancel{S_2Cl_2}}{3\ mol\ \cancel{SCl_2}} \times \frac{135.0\,g\ S_2Cl_2}{1\ mol\ \cancel{S_2Cl_2}} = \boxed{2.28\,g\ S_2Cl_2}$$

actual

b) If only $\boxed{1.19\ g\ of\ S_2Cl_2}$ is obtained, what is the percent yield of the compound?

$$\%\ \text{yield} = \frac{\text{actual}}{\text{theoretical}} \times 100\% = \frac{1.19\,g}{2.28\,g} \times 100\% = \boxed{52.2\%}$$