

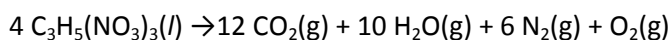
## Mixed Stoichiometry Problems

1. Calculate the theoretical yield of hydrogen (in moles) when 200.0 g of aluminum metal is added to 4.31 L 6.00 M HCl(aq).  $2 \text{ Al(s)} + 6 \text{ HCl(aq)} \rightarrow 2 \text{ AlCl}_3\text{(aq)} + 3 \text{ H}_2\text{(g)}$
2. A sealed room has 80.0 cubic feet of air with density 1.195 g/mL and containing 0.760 %  $\text{CO}_2\text{(g)}$  by weight. How many grams of lithium hydroxide are needed to remove all the carbon dioxide gas from the room?  $2 \text{ LiOH(s)} + \text{CO}_2\text{(g)} \rightarrow \text{Li}_2\text{CO}_3\text{(s)} + \text{H}_2\text{O(l)}$
3. Determine the molarity of the nitric acid solution prepared by reacting 168.0 g of  $\text{NO}_2\text{(g)}$  with 800.0 mL of water. Assume the volume does not change.  $3 \text{ NO}_2\text{(g)} + \text{H}_2\text{O(l)} \rightarrow 2 \text{ HNO}_3\text{(aq)} + \text{NO(g)}$

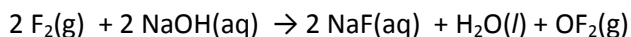
4. The reaction:  $2 \text{ KClO}_3\text{(s)} \rightarrow 2 \text{ KCl(s)} + 3 \text{ O}_2\text{(g)}$  is used to supply emergency oxygen on airplanes.

(a) How many moles of oxygen are required to fill 24.0 cubic meters of air at 745 torr and 72.0 °F so that it is 21.0 %  $\text{O}_2\text{(g)}$  by volume? (b) How many kilograms of  $\text{KClO}_3\text{(s)}$  are required to produce that much oxygen gas?

5. Nitroglycerine is explosive because it decomposes directly to gases according to:



- a. What volume of gas at 100°C would be generated by the decomposition of 20.0 g of nitroglycerine at 1.00 atm?
  - b. This reaction also generates enough heat to heat the gases to about 5000°C. Liquid nitroglycerine has a density of 1.594 g/mL. Determine the pressure exerted by the explosion of 20.0 g of trinitroglycerine in the space taken up by 20.0 g of liquid nitroglycerine.
6. Oxygen difluoride is produced by bubbling fluorine gas through aqueous sodium hydroxide:



How many grams of  $\text{OF}_2$  can be produced by bubbling 40.0 liters of  $\text{F}_2\text{(g)}$  at 2.30 atm and 32.0°C through 5.00 L of 2.10 M  $\text{NaOH(aq)}$ ?

7. A 247.0-L tank of  $\text{SF}_6$  contains 70.0 lb of gas. (a) What is the pressure in the tank at 22.0°C?  
(b)  $\text{SF}_6\text{(g)}$  can be prepared according to:  $\text{S(s)} + 3 \text{ F}_2\text{(g)} \rightarrow \text{SF}_6\text{(g)}$  How many tanks of  $\text{SF}_6\text{(g)}$  can be made from **five** 26.2 L-tanks of  $\text{F}_2\text{(g)}$  at 2.10 MPa at 22.0°C .

**Answers:** 1. Al is limiting, 11.12 mol  $\text{H}_2$  2. 468. mol  $\text{CO}_2$ , so 22.4 kg LiOH

3. 2.43 mol  $\text{HNO}_3$  per 800 mL is 3.04 M  $\text{HNO}_3$  4. a. 203.4 mol  $\text{O}_2$  b. 16.64 kg  $\text{KClO}_3$

5. a. 2.55 mol gas = 78.2 L b.  $8.76 \times 10^4$  atm = 1.29 million psi 6. 99.2 g  $\text{OF}_2$

7. a. 21.30 atm b. 1.67 tanks  $\text{SF}_6$

Solutions:

$$1. \text{ ? mol rxn} = 200.0 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} \times \frac{1 \text{ mol rxn}}{2 \text{ mol Al}} = 3.706 \text{ mol rxn} \text{ so limiting}$$

$$\text{? mol rxn} = 4.31 \text{ L soln} \times \frac{6 \text{ mol HCl}}{1 \text{ L soln}} \times \frac{1 \text{ mol rxn}}{6 \text{ mol HCl}} = 4.31 \text{ mol rxn}$$

$$\text{? mol H}_2 = 3.706 \text{ mol rxn} \times \frac{3 \text{ mol H}_2}{1 \text{ mol rxn}} = 11.12 \text{ mol H}_2$$

$$2. \text{ a. } 80.0 \text{ ft}^3 \times \left(\frac{12 \text{ in}}{1 \text{ ft}}\right)^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} \times \frac{1.195 \text{ g}}{\text{mL}} \times \frac{0.760 \text{ g CO}_2}{100 \text{ g air}} \times \frac{1 \text{ mol CO}_2}{44.0 \text{ g CO}_2} = 468. \text{ mol CO}_2$$

$$\text{b. ? kg LiOH} = 468 \text{ mol CO}_2 \times \frac{2 \text{ mol LiOH}}{1 \text{ mol CO}_2} \times \frac{23.95 \text{ g LiOH}}{1 \text{ mol LiOH}} \times \frac{1 \text{ kg LiOH}}{1000 \text{ g LiOH}} = 22.4 \text{ kg LiOH}$$

$$3. \text{ ? mol HNO}_3 = 168 \text{ g NO}_2 \times \frac{1 \text{ mol NO}_2}{46.0 \text{ g NO}_2} \times \frac{2 \text{ mol HNO}_3}{3 \text{ mol NO}_2} = 2.43 \text{ mol HNO}_3$$

$$2.43 \text{ mol HNO}_3 \text{ in } 800 \text{ mL is } \frac{2.43 \text{ mol HNO}_3}{800 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 3.04 \text{ M HNO}_3$$

$$4. \text{ a. } V = 24.0 \text{ m}^3 \times \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 \times \frac{1 \text{ L}}{1000 \text{ cm}^3} \times \frac{21.0 \text{ L O}_2}{100 \text{ L}} = 5040 \text{ L O}_2$$

$$n = \frac{PV}{RT} = \frac{745 \text{ torr} \cdot 5040 \text{ L}}{0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \cdot 295.4 \text{ K}} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 203.8 \text{ mol}$$

$$\text{b. ? kg KClO}_3 = 203.8 \text{ mol} \times \frac{2 \text{ mol KClO}_3}{3 \text{ mol O}_2} \times \frac{122.5 \text{ g KClO}_3}{1 \text{ mol KClO}_3} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 16.6 \text{ kg KClO}_3$$

$$5. \text{ a. ? mol gas} = 20.0 \text{ g nitroG} \times \frac{1 \text{ mol nitroG}}{227.1 \text{ g nitroG}} \times \frac{29 \text{ mol gas}}{4 \text{ mol nitroG}} = 0.6385 \text{ mol gas}$$

$$V = \frac{nRT}{P} = \frac{0.6385 \text{ mol} \cdot 0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \cdot 373.15 \text{ K}}{1 \text{ atm}} = 19.6 \text{ L}$$

$$\text{b. } 20.0 \text{ g nitroG} \times \frac{1 \text{ mL}}{1.594 \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.0126 \text{ L} \text{ then use } PV = nRT \text{ to calculate new pressure}$$

$$P = = \frac{0.6385 \text{ mol} \times 0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times 5273 \text{ K}}{0.0126 \text{ L}} = 2.19 \times 10^4 \text{ atm} \times \frac{14.7 \text{ psi}}{1 \text{ atm}} = 322 \text{ thousand lb/in}^2 !$$

$$6. \text{ ? mol F}_2 = n = \frac{PV}{RT} = \frac{2.30 \text{ atm} \cdot 40.0 \text{ L}}{0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 305.15 \text{ K}} = 3.67 \text{ mol F}_2 \times \frac{1 \text{ mol rxn}}{2 \text{ mol F}_2} = 1.837 \text{ mol rxn (limiting)}$$

$$\text{? mol rxn} = 5.00 \text{ L} \times \frac{2.10 \text{ mol NaOH}}{1 \text{ L}} \times \frac{1 \text{ mol rxn}}{2 \text{ mol NaOH}} = 5.25 \text{ mol rxn}$$

$$1.837 \text{ mol rxn} \times \frac{1 \text{ mol OF}_2}{1 \text{ mol rxn}} \times \frac{54.0 \text{ g OF}_2}{1 \text{ mol OF}_2} = 99.2 \text{ g OF}_2$$

$$7. \text{ a. 1 tank SF}_6 = 70.0 \text{ lb} \times \frac{453.6 \text{ g}}{1 \text{ lb}} \times \frac{1 \text{ mol SF}_6}{146.1 \text{ g SF}_6} = 217.3 \text{ mol SF}_6$$

$$\text{so } P = \frac{nRT}{V} = \frac{217.3 \text{ mol} \cdot 0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 295.15 \text{ K}}{247.0 \text{ L}} = 21.3 \text{ atm}$$

$$\text{b. 1 tank F}_2 = \text{? mol F}_2 = \frac{PV}{RT} = \frac{2.10 \text{ MPa} \cdot 26.2 \text{ L}}{0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 295.15 \text{ K}} \times \frac{1 \text{ MPa}}{10^6 \text{ Pa}} \times \frac{10^3 \text{ Pa}}{1 \text{ kPa}} \times \frac{1 \text{ atm}}{101.3 \text{ kPa}} = 224.3 \text{ mol}$$

F<sub>2</sub>

$$\text{? tanks SF}_6 = 5 \text{ tanks F}_2 \times \frac{224.3 \text{ mol F}_2}{1 \text{ tank F}_2} \times \frac{1 \text{ mol SF}_6}{3 \text{ mol F}_2} \times \frac{1 \text{ tank SF}_6}{217.3 \text{ mol SF}_6} = 1.72 \text{ tanks SF}_6$$