

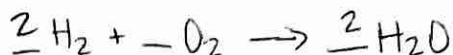
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Gas Stoichiometry

Practice Sheet #32

1. Hydrogen is combined with oxygen to form water.

a. Write a balanced chemical equation for this reaction.



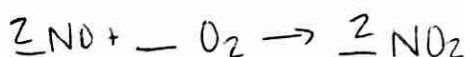
b. What volume and mass of hydrogen and oxygen (at STP) would be required to produce 27.0 g of water?

$$27.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol H}_2}{2 \text{ mol H}_2\text{O}} \times \frac{2.016 \text{ g H}_2}{1 \text{ mol H}_2} = 3.02 \text{ g H}_2 \times \frac{1 \text{ mol}}{2.016 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 33.6 \text{ L H}_2$$

$$27.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{1 \text{ mol O}_2}{2 \text{ mol H}_2\text{O}} \times \frac{32 \text{ g O}_2}{1 \text{ mol O}_2} = 24.0 \text{ g O}_2 \times \frac{1 \text{ mol}}{32 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 16.8 \text{ L O}_2$$

2. Nitrogen monoxide reacts with oxygen to produce nitrogen dioxide.

a. Write a balanced chemical equation for this reaction.



b. If 140 L of oxygen react at STP, what volume of and mass of nitrogen monoxide is required? What volume and mass of nitrogen dioxide (at STP) would be produced?

$$140 \text{ L O}_2 \times \frac{1 \text{ mol O}_2}{22.4 \text{ L}} \times \frac{2 \text{ mol NO}}{1 \text{ mol O}_2} = 12.5 \text{ mol NO} \times \frac{46 \text{ g NO}}{1 \text{ mol}} = 575 \text{ g NO}_2$$

$$12.5 \text{ mol NO} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 280 \text{ L NO}_2$$

$$140 \text{ L O}_2 \times \frac{1 \text{ mol O}_2}{22.4 \text{ L}} \times \frac{2 \text{ mol NO}}{1 \text{ mol O}_2} = 12.5 \text{ mol NO} \times \frac{30 \text{ g NO}}{1 \text{ mol}} = 375 \text{ g NO}$$

$$12.5 \text{ mol NO} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 280 \text{ L NO}$$

c. If 15.0 g of nitrogen monoxide react, what volume of and mass of oxygen (at STP) is required? What volume and mass of nitrogen dioxide (at STP) would be produced?

$$15.0 \text{ g NO} \times \frac{1 \text{ mol NO}}{30 \text{ g NO}} \times \frac{2 \text{ mol NO}_2}{2 \text{ mol NO}} = 0.500 \text{ mol NO}_2 \times \frac{46 \text{ g NO}_2}{1 \text{ mol}} = 23.0 \text{ g NO}_2$$

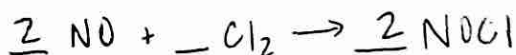
$$0.500 \text{ mol NO}_2 \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 11.2 \text{ L NO}_2$$

$$15.0 \text{ g NO} \times \frac{1 \text{ mol NO}}{30 \text{ g NO}} \times \frac{1 \text{ mol O}_2}{2 \text{ mol NO}} = 0.250 \text{ mol O}_2 \times \frac{32 \text{ g O}_2}{1 \text{ mol}} = 8.00 \text{ g O}_2$$

$$0.250 \text{ mol O}_2 \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 5.60 \text{ L O}_2$$

3. Nitrogen monoxide reacts with chlorine to form nitrosyl chloride (NOCl) at STP.

a. Write a balanced chemical equation for this reaction.



b. If 448 mL of nitrogen monoxide react with 336 mL of chlorine, which reactant is limiting and which is in excess?

$$0.448 \text{ L} \times \frac{1 \text{ mol NO}}{22.4 \text{ L}} \times \frac{2 \text{ mol NOCl}}{2 \text{ mol NO}} = 0.0200 \text{ mol NOCl}$$

$$0.336 \text{ L} \times \frac{1 \text{ mol Cl}_2}{22.4 \text{ L}} \times \frac{2 \text{ mol NOCl}}{1 \text{ mol Cl}_2} = 0.0300 \text{ mol NOCl}$$

LR = NO

Excess = Cl₂

c. What volume and mass of nitrosyl chloride will be produced (at STP)?

$$0.0200 \text{ mol NOCl} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 0.448 \text{ L NOCl}$$

$$0.0200 \text{ mol NOCl} \times \frac{65.45 \text{ g NOCl}}{1 \text{ mol}} = 1.31 \text{ g NOCl}$$

Name: _____ per _____

4. Propyne (C_3H_4) undergoes combustion with oxygen to produce carbon dioxide and water.

a. Write a balanced chemical equation for this reaction.



b. If 52.0 L of propyne at 1.24 atm and 2870 °C, what volume and mass of oxygen is required?

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(1.24 \text{ atm})(52.0 \text{ L})}{(0.0821 \frac{\text{Latm}}{\text{molK}})(3143 \text{ K})} = 0.250 \text{ mol } C_3H_4$$

$$n = 0.250 \text{ mol } C_3H_4 \times \frac{4 \text{ mol } O_2}{1 \text{ mol } C_3H_4} = 1.00 \text{ mol } O_2$$

$$1 \text{ mol } O_2 \times \frac{32 \text{ g}}{1 \text{ mol } O_2} = 32.0 \text{ g } O_2$$

$$V = \frac{nRT}{P} = \frac{(1.00 \text{ mol})(0.0821)(3143 \text{ K})}{1.24 \text{ atm}} = 208 \text{ L}$$

c. What volume and mass of carbon dioxide water will be produced?

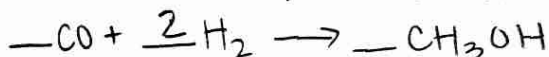
$$0.250 \text{ mol } C_3H_4 \times \frac{3 \text{ mol } CO_2}{1 \text{ mol } C_3H_4} = 0.750 \text{ mol } CO_2$$

$$0.750 \text{ mol } CO_2 \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 33.0 \text{ g } CO_2$$

$$V = \frac{nRT}{P} = \frac{(0.750 \text{ mol})(0.0821)(3143 \text{ K})}{1.24 \text{ atm}} = 15.6 \text{ L } CO_2$$

5. Carbon monoxide is combined with hydrogen to produce methanol (CH_3OH) at 5.25×10^6 Pa and 250 °C.

a. Write a balanced chemical equation for this reaction.



b. If 450 mL of carbon monoxide react with 800 mL of hydrogen, which reactant is limiting and which is excess?

$$n_{CO} = \frac{PV}{RT} = \frac{(5.25 \times 10^6 \text{ Pa})(0.450 \text{ L})}{(8314 \frac{\text{LPa}}{\text{molK}})(523 \text{ K})} = 0.543 \text{ mol } CO$$

$$n_{H_2} = \frac{PV}{RT} = \frac{(5.25 \times 10^6 \text{ Pa})(0.800 \text{ L})}{(8314 \frac{\text{LPa}}{\text{molK}})(523 \text{ K})} = 0.966 \text{ mol } H_2$$

$$0.543 \text{ mol } CO \times \frac{1 \text{ mol } CH_3OH}{1 \text{ mol } CO} = 0.543 \text{ mol } CH_3OH$$

$$0.966 \text{ mol } H_2 \times \frac{1 \text{ mol } CH_3OH}{2 \text{ mol } H_2} = 0.483 \text{ mol } CH_3OH$$

$H_2 = \text{L.R.}$
 $CO = \text{EXCESS}$

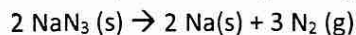
c. What volume and mass of methanol will be produced? If the percent yield for the reaction is 90.0%, what mass of methanol will actually be produced?

$$0.483 \text{ mol } CH_3OH \times \frac{32 \text{ g } CH_3OH}{1 \text{ mol } CO} = 15.5 \text{ g } CH_3OH \text{ theoretical}$$

$$V = \frac{nRT}{P} = \frac{(0.483 \text{ mol})(8314 \frac{\text{LPa}}{\text{molK}})(523 \text{ K})}{(5.25 \times 10^6 \text{ Pa})} = 0.400 \text{ L}$$

$$0.90 = \frac{X}{15.5} \text{ actual} = 14.0 \text{ g } CH_3OH \text{ actual}$$

6. Automobile air bags inflate following a serious impact. The impact triggers the chemical reactions:



a. If an automobile air bag has a volume of 11.8 L, how much NaN_3 in grams is required to fully inflate the air bag upon impact? Assume STP conditions.

$$11.8 \text{ L } N_2 \times \frac{1 \text{ mol } N_2}{22.4 \text{ L } N_2} \times \frac{2 \text{ mol } NaN_3}{3 \text{ mol } N_2} \times \frac{64.99 \text{ g } NaN_3}{1 \text{ mol } NaN_3} = 22.8 \text{ g } NaN_3$$