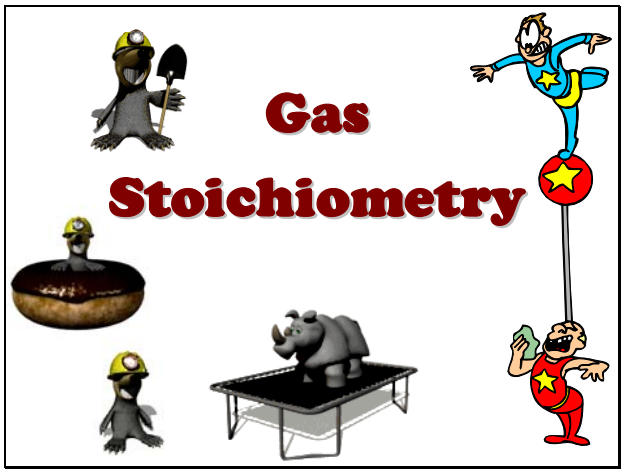

Gas Stoichiometry

- We have looked at stoichiometry: 1) using masses & molar masses, & 2) concentrations.
- We can use stoichiometry for gas reactions.
- As before, we need to consider mole ratios when examining reactions quantitatively.

molar mass of x ↓ | mole ratio from balanced equation ↓ | molar mass of y ↓

grams (x) ↔ moles (x) ↔ moles (y) ↔ grams (y)

↕ ← PV = nRT → ↕

P, V, T (x) P, V, T (y)

- At times you will be able to use 22.4 L/mol at STP and 24.8 L/mol at SATP as shortcuts.

Sample problem 1

CH_4 burns in O_2, producing CO_2 and $H_2O(g)$. A 1.22 L CH_4 cylinder, at 15°C, registers a pressure of 328 kPa.

a) What volume of O_2 at SATP will be required to react completely with all of the CH_4?

First: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

PV = nRT P = 328 kPa, V = 1.22 L, T = 288 K

$$\frac{(328\text{ kPa})(1.22\text{ L})}{(8.31\text{ kPa•L/K•mol})(288\text{ K})} = n = 0.167\text{ mol}$$

$$\#\text{ mol } O_2 = 0.167\text{ mol } CH_4 \times \frac{2\text{ mol } O_2}{1\text{ mol } CH_4} = 0.334\text{ mol}$$

PV = nRT P= 100 kPa, n= 0.334 mol, T= 298 K

$$\frac{(0.334\text{ mol})(8.31\text{ kPa•L/K•mol})(298\text{ K})}{(100\text{ kPa})} = V = 8.28\text{ L}$$

or # L = 0.334 mol x 24.8 L/mol = 8.28 L

Sample problem 1 continued

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

b) How many grams of $H_2O(g)$ are produced?

$$\#\text{ g } H_2O = 0.167\text{ mol } CH_4 \times \frac{2\text{ mol } H_2O}{1\text{ mol } CH_4} \times \frac{18.02\text{ g } H_2O}{1\text{ mol } H_2O} = 6.02\text{ g } H_2O$$

c) What volume of CO_2 (at STP) is produced if only 2.15 g of the CH_4 was burned?

$$\#\text{ mol } CO_2 = 2.15\text{ g } CH_4 \times \frac{1\text{ mol } CH_4}{16.05\text{ g } CH_4} \times \frac{1\text{ mol } CO_2}{1\text{ mol } CH_4} = 0.134\text{ mol } CO_2$$

PV = nRT P = 101.3 kPa, n = 0.134 mol, T = 273 K

$$\frac{(0.134\text{ mol})(8.31\text{ kPa•L/K•mol})(273\text{ K})}{(101.3\text{ KPa})} = V = 3.00\text{ L } CO_2$$

or # L = 0.134 mol x 22.4 L/mol = 3.00 L

Sample problem 2

Ammonia (NH_3) gas can be synthesized from nitrogen gas + hydrogen gas. What volume of ammonia at 450 kPa and 80°C can be obtained from the complete reaction of 7.5 kg hydrogen?

Sample problem 3

Hydrogen gas (and NaOH) is produced when sodium metal is added to water. What mass of Na is needed to produce 20.0 L of H_2 at STP?

Assignment

1. What volume of oxygen at STP is needed to completely burn 15 g of methanol (CH_3OH) in a fondue burner? (CO_2 + H_2O are products)
2. When sodium chloride is heated to 800°C it can be electrolytically decomposed into Na metal & chlorine (Cl_2) gas. What volume of chlorine gas is produced (at 800°C and 100 kPa) if 105 g of Na is also produced?
3. What mass of propane (C_3H_8) can be burned using 100 L of air at SATP? Note: 1) air is 20% O_2, so 100 L of air holds 20 L O_2, 2) CO_2 and H_2O are the products of this reaction.
4. A 5.0 L tank holds 13 atm of propane (C_3H_8) at 10°C. What volume of O_2 at 10°C & 103 kPa will be required to react with all of the propane?
5. Nitroglycerin explodes according to:
   $4\ C_3H_5(NO_3)_3(l) \rightarrow 12\ CO_2(g) + 6\ N_2(g) + 10\ H_2O(g) + O_2(g)$

a) Calculate the volume, at STP, of each product formed by the reaction of 100 g of $C_3H_5(NO_3)_3$.

b) 200 g of $C_3H_5(NO_3)_3$ is ignited (and completely decomposes) in an otherwise empty 50 L gas cylinder. What will the pressure in the cylinder be if the temperature stabilizes at 220°C?