Note Title 1/16/2008

CE 326 Lab # 1 Material Balance Calculation

$PV = nRT$

P = absolute pressure, Pa

V = volume of ideal gas, m^3

T = absolute temperature, K

n = number of moles of gas

$R = 8.3143 \frac{J}{K \cdot mole} = \frac{Pa \cdot m^3}{K \cdot mole}$

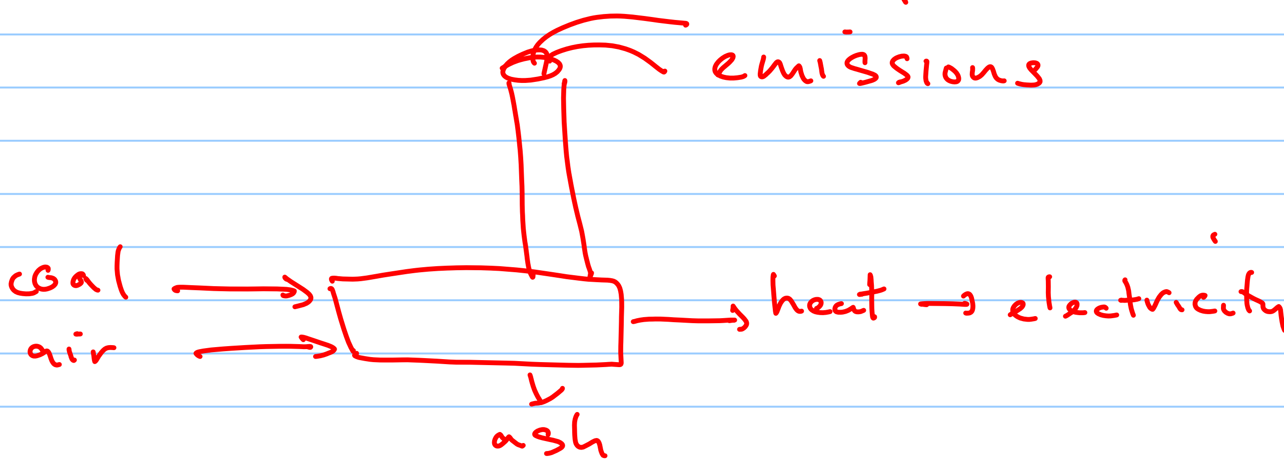
$V = \frac{nRT}{P} \Rightarrow \frac{V}{n} = \frac{RT}{P} = \boxed{\frac{MW}{\rho} = \frac{RT}{P}}$

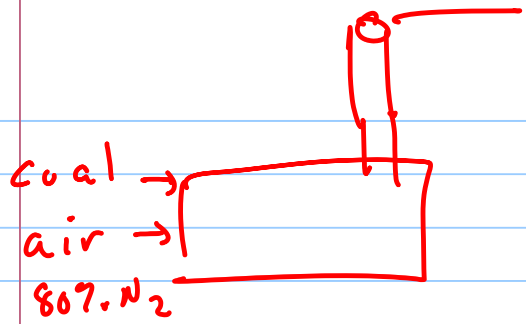
find density of oxygen @ 273 K, 98,000 Pa

$$\rho = \frac{mw \cdot P}{RT} = \frac{32 g/mole \cdot 98{,}000 Pa}{8.3143 \frac{Pa \cdot m^3}{K \cdot mole} \cdot 273 K} = 1381.6 g/m^3$$

$1.38 kg/m^3$

Consider a coal fired power plant





emissions
water vapor
particulates
CO_2
SO_2, SO_x
NO_x
other elements mercury, lead, Chlorine

in our problem - want to look at SO_2 mass balance

Example Problem

Suppose a power plant burns coal with a 6% sulfur content, want to determine how much SO_2 is produced, how much oxygen is required, how much air is required, and what is SO_2 conc in stack gas.

Given: 6% S 94% C

3% of S ends up in bottom ash (97% out stack)

plant uses 20% excess air

5 steps:

1. assume a basis
2. write balanced equations
3. calculate moles
4. calculate volumes
5. calculate concentration

1. Assume basis of 1000 g $\begin{cases} 60\text{ g S} & (\text{at } 6\%) \\ 940\text{ g C} \end{cases}$

60 g S × 0.03 = 1.8 g S in ash

58.2 g S in stack gas

2. $S + O_2 = SO_2$ $MW_S = 32$ g/mole

$C + O_2 = CO_2$ $O_2 = 32$ g/mole

$SO_2 = 64$ g/mole

3. $\frac{58.2 \text{ g S}}{32 \text{ g/mole}} = 1.82$ mole S in stack

1.82 mole S + 1.82 mole O_2 = 1.82 mole SO_2

4. volume of SO_2 = 1.82 mole × $\frac{22.4 \text{ L}}{\text{mole}}$ = 40.7 L SO_2

C: $\frac{940\ g\ C}{12\ g/mole} = 78.3$ mole C

78.3 mole C + 78.3 mole O_2 → 78.3 mole CO_2

O_2 req'd

78.3 mole + 1.82 mole = 80.15 mole O_2 × $\frac{22.4 L}{mole}$ = 1795 L O_2

Excess air 20%

O_2 in air 21%

$\frac{1795\ L\ O_2}{0.21\ (O_2 \text{ in air})} \times (1.20) = 10{,}260$ L air required

(1.20 ← for 20% excess)

$= 10.26\ m^3$ air

5. calc conc of SO_2 = 1.82 mole SO_2 × 64 g/mole = 116.4 g SO_2

$\frac{116.4\ g\ SO_2}{10.26\ m^3}$ = **11.3 g/m³** (mass conc)

$10^6 \cdot \frac{40.7\ L\ SO_2}{10{,}260\ L\ air}$ = **3967 ppm** (volume conc.)

(10^6 ← for ppm)