Recitation 5

1. Application of gas law: relation between gas density and molar mass (page.193)

To relate gas density and molar mass, the number of moles of gas, n, can be expressed as:

n = grams of gas / molar mass
= mass/molar mass
= m/molar mass

From ideal gas equation,

P = nRT/V = [(m/molar mass) RT] / V
= m (RT)/ V (molar mass)
= dRT/molar mass (since density, d = m/V)

Therefore, molar mass = dRT/P

Sample exercise 5.14
The density of a gas was measured at 1.50 atm and 27 ^{o}C and found to be 1.95 g/L. Calculate the molar mass of the gas.

Solution:

Molar mass = dRT/P
= [1.95 g/L * 0.08206 L.atm $mol^{-1}K^{-1}$ * 300K]/1.5 atm
= 32.0 g/mol

2. Chapter 5: Exercise 42
A person accidentally swallows a drop of liquid oxygen, O_2 (l), which has a density of 1.149 g/mL. Assuming the drop has a volume of 0.050 mL, what volume of gas will be produced in the person's stomach at body temperature (37 ^{0}C) and a pressure of 1.0 atm?

Solution:

For O_2 liquid, d = 1.149 g/mL
V_1 = 0.050 mL
Mass of oxygen liquid drop will be:
$m = d * V_1 = 1.149$ g/ml * 0.050 mL = 0.05745 g

n = m/M = 0.05745 g / 32 g/mol = 1.8×10^{-3} mol

PV = nRT

V = nRT/P
= [1.8×10^{-3} mol * 0.08206 L.atm $mol^{-1} K^{-1}$ * (273 +37) K] / 1.0 atm
= 45.78×10^{-3} mL

3. Kinetic Molecular Theory (KMT): Chapter 5: Exercise 79
Calculate the root mean square velocities of CH_4 and N_2 molecules at 273 K and 546 K?

Solution:
$u_{rms} = (3RT/M)^{1/2}$

R = 8.3145 J $mol^{-1} K^{-1}$
M = molar mass in kg = 1.604×10^{-2} kg/mol for CH_4

For CH_4 at 273 K,
u_{rms} = (3 * 8.314 $Jmol^{-1}K^{-1}$ * 273 K / 1.604×10^{-2} kg/mol$)^{1/2}$ = 652 m/s

For CH_4 at 546 K,
u_{rms} = (3 * 8.314 $Jmol^{-1}K^{-1}$ * 546 K / 1.604×10^{-2} kg/mol$)^{1/2}$ = 921 m/s

For N_2 at 273 K,
u_{rms} = (3 * 8.314 $Jmol^{-1}K^{-1}$ * 273 K / 2.802×10^{-2} kg/mol$)^{1/2}$ = 493 m/s

For N_2 at 546 K,
u_{rms} = (3 * 8.314 $Jmol^{-1}K^{-1}$ * 546 K / 2.802×10^{-2} kg/mol$)^{1/2}$ = 697 m/s

Note: As the temperature increases we observe an increase in u_{rms}

4. Chapter 5: Exercise 81

Consider a 1.0-L container of neon gas at STP. Will the average kinetic energy, average velocity, and frequency of collisions of gas molecules with the walls of the container increase, decrease, or remain the same under each of the following conditions?

a. **The temperature is increases to 100^0C**
b. **The temperature is decreased to - 50^0C**
c. **The volume is decreased to 0.5 L.**
d. **The number of moles of neon is doubled.**

Solution:

(a) When the temperature is increased to 100 ^{o}C, the average kinetic energy increases, average velocity increases and frequency of collisions of gas molecules with the walls of the container increases.

(b) When the temperature is decreased to - 50 ^{o}C, the average kinetic energy decreases, average velocity decreases and frequency of collisions of gas molecules with the walls of the container decreases.

(c) When the volume is decreased to 0.5 L the average kinetic energy will be the same (KE proportional to T), average velocity will be the same (1/2 mv^2 = KE proportional to T) and frequency of collisions of gas molecules with the walls of the container will increase.

(d) When the number of moles of neon is doubled, the average kinetic energy will be the same, the average velocity will be the same and frequency of collisions of gas molecules with the walls of the container will increase.