Name:____________________ Date:________

H. Chemistry

Ch. 12.1-12.4 Lecture Guide

- Review
  - Characteristics of a gas
    - Atoms are very spread out
    - Only state of matter that is compresible
- 12.1 Pressure
  - Pressure has several commonly used units of measurement.
    - height of mercury in a thermometer → mm Hg (milimeters of mercury) also called torr
    - atm (standard atmosphere)
    - SI unit → Pa (pascal)
    - psi (pounds per square inch)
  - Converting from one unit to another.
    - 1 standard atmosphere = 1.000 atm = 760.0 mm Hg → = 760.0 torr
    - 1 atm = 101,325 Pa
    - 1 atm = 14.69 psi
  - Practice Problems
    - The pressure of the air in a tire is measured to be 28 psi. Represent this pressure in atm, torr, and Pa.

Conversions

→ 1.000 atm = 14.69 psi

$$28 \text{ psi} \times \frac{1.000 \text{ atm}}{14.69 \text{ psi}} = 1.9 \text{ atm}$$

→ 1.000 atm = 760.0 torr

$$1.9 \text{ atm} \times \frac{760.0 \text{ torr}}{1.000 \text{ atm}} = 1.4 \times 10^3 \text{ torr}$$

→ 1.000 atm = 101,325 Pa

$$1.9 \text{ atm} \times \frac{101,325 \text{ Pa}}{1.000 \text{ atm}} = 1.9 \times 10^5 \text{ Pa}$$

- 12.2 Pressure and Volume: Boyle's Law
  - Robert Boyle (1627-1691)
    - Experiment: Found that as pressure increased, volume of gas decreased.

- Boyle's Law
  - Pressure (P) X Volume (V) = k (a constant)
  - So… If $P_1V_1 = k$ AND $P_2V_2 = k$, THEN $P_1V_1 = P_2V_2$
- Calculating **volume** using Boyle's Law.
  - Consider a 1.5-L sample of gaseous Freon-12, CCl_2F_2, at a pressure of 56 torr. If pressure is changed to 150 torr at a constant temperature, will the volume of the gas increase or decrease? What will be the new volume of the gas?

What do we know?

$P_1 = 56$ torr

$V_1 = 1.5$ L

$P_2 = 150$ torr

$V_2 = X?$

$$P_1V_1 = P_2V_2$$

$$\frac{P_1V_1}{P_2} = V_2$$

$$V_2 = \frac{(56\ \text{torr})(1.5\ \text{L})}{(150\ \text{torr})}$$

$$V_2 = 0.56\ \text{L}$$

Volume will decrease because pressure increased.

- Calculate **pressure** using Boyle's Law
  - In an automobile engine the gaseous fuel-air mixture enters the cylinder and is compressed by a moving piston before it is ignited. In a certain engine, the initial cylinder volume is 0.725 L. After the piston moves up, the volume is 0.075 L. The fuel-air mixture initially has a pressure of 1.00 atm. Calculate the pressure of the compressed fuel-air mixture, assuming that both the temperature and the amount of gas remain constant.

What do we know?

$P_1 = 1.00$ atm

$V_1 = 0.725$ L

$P_2 = X?$

$V_2 = 0.075$ L

$$P_1V_1 = P_2V_2$$

$$\frac{P_1V_1}{V_2} = P_2$$

$$P_2 = \frac{(1.00\ \text{atm})(0.725\ \text{L})}{(0.075\ \text{L})}$$

$$P_2 = 9.7\ \text{atm}$$

12.3: Volume and Temperature: Charles's Law

- Jacques Charles (1746-1823)
  - Experiment: Found that as temperature increased, volume of gas also increased.
  - Absolute zero: Extrapolated known data and found that any gas at 0 volume will have a temp. of -273°C, or 0 kelvin.
- Charles's Law
  - $$\frac{\text{Volume } (V)}{\text{Temperature } (T)} = b \text{ (a constant)}$$

    (IN KELVINS!!!)

- So... if $\frac{V_1}{T_1} = b$ AND $\frac{V_2}{T_2} = b$ THEN $\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$

- Calculating **volume** using Charles's Law
  - A sample of gas at 15 °C (at 1 atm) has a volume of 2.58 L. The temperature is then raised to 38 °C (at 1 atm). Does the volume of gas increase or decrease? Calculate the new volume.

What do we know?

$V_1 = 2.58 L$

$T_1 = 15°C = 288 K$ ← remember to change temp. to kelvins if it is not already!

$V_2 = x?$

$T_2 = 38°C = 311 K$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{V_1 T_2}{T_1} = V_2$$

Volume will increase because temperature increased.

$$V_2 = \frac{(2.58 L)(311 K)}{(288 K)}$$

$$V_2 = \boxed{2.79 L}$$

- Calculating **temperature** using Charles's Law
  - Consider a gas that has a volume of 0.675 L at 35 °C and 1 atm pressure. What is the temperature (in units of °C) of a room where this gas has a volume of 0.535 L at 1 atm pressure?

What do we know?

$V_1 = 0.675 L$

$T_1 = 35°C = 308 K$

$V_2 = 0.535 L$

$T_2 = x?$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{V_1}{T_1 V_2} = \frac{1}{T_2}$$

$$\frac{T_1 V_2}{V_1} = T_2$$

$$T_2 = \frac{(308 K)(0.535 L)}{(0.675 L)}$$

$$T_2 = 244 K = \boxed{-29 °C}$$

- 12.4 Volume and Moles: Avagadro's Law
  - Amadeo Avagadro
    - Experiment: Found that for a gas at a constant temperature and pressure, the volume increases as the number of moles increases.
  - Avagadro's Law
    - $\frac{\text{Volume (V)}}{\text{number of moles (n)}} = a$ (a constant)
    - So... If $\frac{V_1}{n_1} = a$ AND $\frac{V_2}{n_2} = a$ THEN $\boxed{\frac{V_1}{n_1} = \frac{V_2}{n_2}}$
  - Using Avagadro's Law in calculations
    - Suppose we have a 12.2-L sample containing .50 mol of oxygen gas, O_2, at a pressure of 1 atm and a temperature of 25 °C. If all of this O_2 is converted to ozone, O_3, at the same temperature and pressure, what will be the volume of the ozone formed?

What do we know?

$V_1 = 12.2\ L$

$n_1 = .50\ mol\ O_2$

$V_2 = X\ ?$

$n_2 = [.33\ mol\ O_3]$

$O_2(g) \rightarrow O_3(g)$

$3O_2(g) \rightarrow 2O_3(g)$

$.50\ mol\ O_2 \times \frac{2\ mol\ O_3}{3\ mol\ O_2} =$

$= .33\ mol\ O_3$

$\frac{V_1}{n_1} = \frac{V_2}{n_2}$

$\frac{V_1 n_2}{n_1} = V_2$

$V_2 = \frac{(12.2L)(.33\ mol\ O_3)}{(.50\ mol\ O_2)}$

$V_2 = \boxed{8.1\ L\ O_3}$