**The Temperature-Volume Relationship: Charles’s and Gay-Lussac’s Law**

***Charles’s Law*** *– the volume of a fixed amount of gas maintained at a constant pressure is directly proportional to the absolute temperature of the gas.*

Change in temperature alters the volume and pressure of a gas.

If you ***lower the temperature*** of gas at a constant pressure, ***volume decreases*** (contracts)

If you ***raise the temperature*** of a gas at a constant pressure, ***volume increases***(expands)

In theory, any given pressure, change in temperature/change in volume yields a linear equation, with the intercept at -273.15○C (Absolute Zero). Ergo, it is a constant.

**In practice, all gasses condense at low temperatures to become liquids.**

Lord Kelvin used this knowledge to form the Absolute Temperature Scale.

1○ K is equal in magnitude to 1○ C; and the starting point (0○ K) is -273.15○C.

In Chemistry, 273○K is sufficient for use in equations

V ∝ T (volume is proportional to temperature)

V = kT

V/T = k where k is the proportional constant (at this level of study, that constant is pressure)

**This is Charles’s Law**. Another form of Charles’s Law shows that at a *constant* amount of gas and volume, the pressure of the gas is proportional to temperature. (If you raise temperature, pressure increases; if you decrease temperature, pressure decreases)

P ∝ T therefore V1/T1 = V2/T2

**EXAMPLES ON THE FOLLOWING PAGES**

EXAMPLE:

A 452 mL sample of F gas is heated from 22○ C to 187○ C at constant pressure. What is its final volume?

Because the equation involves *constant pressure* we use Charles’ law to solve it: V1/T1 = V2/T2

Where V = volume (in mL) and T = temperature (in Kelvins)

V1 = 452 mL V2 =?

T1 = 22○ C T2 = 187○ C

First, convert the temperature to Kelvin, by adding 273 to each temperature:

V1 = 452 mL V2 =?

T1 = 295○ C T2 = 460○ C

Then, insert the numbers into the equation V1/T1 = V2/T2

452/295 = x/460 Solve for “x” by rearranging the equation (algebraically)

V2 = (V1)(T2)/ T1

x = (452 mL)(460 K)/(295K) Notice that “K” crosses out since it is in both the top and bottom of the equation

x = 704.81 mL or **705 mL (USE THE CORRECT AMOUNT OF SIG FIGS!)**

Now try one without the step-by-step instructions written out! (Review prior notes on Charles’ law for hints)

EXAMPLE 2:

A sample of CO occupies 3.20 L at 125○ C. Calculate the temperature at which the gas will occupy 1.54 L if the pressure remains constant.

V1 = 3.20 L V2 = 1.54L T1 = 125 ○ C (which is 398 ○ K) T2 = x

3.20/398 = 1.54/x

.008 = 1.54/x

.008x = 1.54

1000(.008x) = 1540

8x = 1540

**x = 192.5○ K**

**The Volume-Amount Relationship: Avogadro’s Law**

***Avogadro’s Law*** *– at constant pressure and temperature, the volume of a gas is directly proportional to the number of moles of the gas present.*

V ∝ n

V = kn where *n* is the # of moles and k is the proportionality constant

k = RT/P where R is the gas constant (.00821 atm • L/K • mol) **🡨 you really need to memorize the formula for “R”!**

According to Avogadro’s Law, when two gases react with each other their reacting volumes have a simple ratio to each other. Example:

3H2 + N2 🡪 2NH3

As the volumes of the gas are directly proportionate, the equation can be written

3H2 (g) + N2 (g) 🡪 2NH3 (g)

3 volumes 1 volume 2 volumes

**In other words, gasses react in the same way that liquids react. Their equations must be balanced.**