NS D.2 (pg 1 of 1) Ideal Gas Law and the Gas Constant

Name________________________

Up until this point all of the problems that have used the Combined Gas Law have only worked with four variables that describe gas:

i. pressure
ii. volume
iii. temperature
iv. number of moles.

The Combined Gas Law

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

All of the problems that we have considered thus far have been "before and after" problems. Very often the container has been sealed, and we have had no concern with how much gas was in the container.

This mathematical relationship holds for ideal gases, and ideal behavior depends on certain conditions (normal temperatures and pressures – we will later analyze how and when real gas behavior deviates from ideal gas behavior).

Avogadro's Hypothesis

In 1811 Amedeo Avogadro proposed this hypothesis:

> At the same temperature and pressure, equal volumes of different gases will contain equal numbers of particles.

This makes sense if you remember that one of our postulates of the Kinetic Molecular Theory (as applied to gases) states that the distance between the particles in a gas is very great compared to the size of the particles themselves and thus the size of the particle itself is insignificant. Under these conditions, the volume of a gas is determined by the number of particles present, and not the type and/or the size of the individual particles present.

Molar Volume

Remember the "Beach Ball" facts about all gases: 1 mole of any gas at 1 atm (760 mmHg) pressure and 0ºC (273 K) temperature will always occupy 22.4 L. This 22.4 L/mole is known as the molar volume.

The conditions of 1 atm (760 mmHg = 760 torr) and 0ºC (273 K) are known as STP – standard temperature and pressure.

Since many of the problems you will be working on, are not "before and after" type problems, it is best to insert the "Beach Ball" facts into one side of the modified Combined Gas Law equation and come up with a gas constant.

$$\frac{PV}{nT} = \frac{(1atm)(22.4L)}{(1mol)(273K)} \quad \text{or} \quad \frac{PV}{nT} = \frac{(760mmHg)(22.4L)}{(1mol)(273K)} \quad \text{or} \quad \frac{PV}{nT} = \frac{(101.3kPa)(22.4L)}{(1mol)(273K)}$$

Solving the left side of this equation will give the gas constant "R" $0.0821\frac{atmL}{molK}$ or $62.4\frac{mmHgL}{molK}$ or $8.31\frac{kPaL}{molK}$

$\frac{PV}{nT} = R$ apply algebra to rewrite this equation, and the ideal gas law is usually written P V = n R T

Which units should be used?

Notice that on the gas constant, R, is the combination of four concepts: $\frac{\Pr essure(P) \times Volume(V)}{Amount(n) \times Temperature(T)}$

Each value of the gas constants comes with a particular set of units. Whatever units are on the gas constant value that you choose, must be the same units that you use for each of the four variables in the remainder of the ideal gas equation.

- Temperature (T)
  - the temperature units must always be in Kelvin
- Amount (n)
  - the amount units must always be in moles
- Volume (V)
  - volume must always be in Liters
- Pressure (P)
  - pressure must be in mmHg when using 62.4 mmHg•L•mol^{-1}•K^{-1}
  - pressure must be in atm when using 0.0821 atm•L•mol^{-1}•K^{-1}