Gas Laws

Gas Pressure

- ____________ is defined as force per unit area.
- Gas particles exert pressure when they ____________ with the walls of their container.
- Units of Pressure
  - Pascal (Pa)
  - Kilopascal (KPa)
  - Atmosphere (atm)
  - mmHg
  - Torr
- Gas Conversions
  - 1 atm = 101.3 kPa = 760 torr = 760 mmHg

Kinetic Theory

- Gases are composed of tiny particles whose size is ____________ compared to the average distance between them.
- The gas particles move ____________ , in straight lines in all directions and at various speeds.
- The forces of attraction or repulsion between two gas particles are extremely ____________ , except when they collide.
- When particles collide with one another, the collisions are ____________ (no kinetic energy is lost).
- The average kinetic energy of a molecule is ____________ proportional to the Kelvin temperature.

Kinetic Theory

- These assumptions have limitations. For example, gases can be liquefied if cooled enough.
- This means “real” gas particles DO attract one another to some extent; otherwise the particles would never stick to one another and therefore never condense to form a liquid.

How fast do gas particles move?

- v = √(3RT/M)
- v = velocity (m/s) = also called root mean squared velocity (rms)
- R = 8.3145 J/mol K (on sheet)
- T = temp (K)
- M = molecular weight (Kg/mol)

Example

- Find the velocity of an oxygen molecule in a 20°C room.

Boyle's Law: Pressure and Volume

- ____________ states that the pressure and volume of a gas at constant temperature are ____________ proportional.

$$P_1V_1 = P_2V_2$$

Example

- A sample of Helium gas is compressed from 4.0 L to 2.5 L at a constant temperature. If the pressure of the gas in the 4.0 L volume is 210 KPa, what will the pressure be at 2.5 L?

Charles' Law: Volume & Temperature

- He noted that as temperature went up, so did volume when pressure was held constant

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

Temperature conversions

K = 273 + °C

°C = 0.56 (°F – 32)

°F = 1.8 °C + 32

Example

- A sample of gas at 40.0 °C occupies a volume of 2.32 L. If the temperature is raised to 75.0 °C what will the new volume be?

Gay Lussac's Law: Pressure & Temperature

- Gay Lussac studied the relationship between pressure and temperature
- ____________ relationship existed between the Kelvin temperature and volume
- $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Example

- The pressure of a gas in a tank is 3.20 atm at 22.0 °C. If the temperature rises to 60.0 °C, what will the new pressure in the tank be?

Avogadro's Law

- Volume is directly proportional to the number of moles of a gas present
- $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

Combined Gas Law

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

- Instead of memorizing all three equations, you can simply memorize this one
- Just delete what you don' t need

Example

- A gas at 110.0 kPa and 30.0°C fills a flexible container to a volume of 2.00 L. If the temperature was raised to 80.0°C and the pressure was increased to 440.0 kPa, what is the new volume?

Ideal Gas Law

P V = n R T

- P = Pressure (atm)
- V = Volume (L)
- T = Temperature (K)
- n = number of moles
- R is a constant, called the Ideal Gas Constant
- R = 0.0821 L atm / mol K

PV = nRT

- Calculate the number of moles of a gas contained in a 3.0 L vessel at 300.0K with a pressure of 1.50 atm

Permutations of the Ideal Gas Law

$$PV = \frac{mRT}{M}$$

- P = Pressure (atm)
- V = volume (L)
- m = mass of the gas (g)
- R = 0.0821 L atm / mol K
- T = Temperature (K)
- M = molecular mass

Example

- What is the pressure 2.0 g of nitrogen gas in a 5.0 L container at 300.0 K?

Permutations of the Ideal Gas Law

$$P = \frac{DRT}{M}$$

- P = pressure (atm)
- D = density (g/L)
- R = 0.0821 L atm / mol K
- T = temperature (K)
- M = molecular mass

Example

- What is the molar mass of a gas that has a density of 1.40 g/L at STP?

Avogadro's Principle

- ____________ Principle – equal volumes of gases at equal temperature and pressure contain the same number of particles
- ____________– the volume of gas that 1 mole of a substance occupies at STP
- At STP 1 mol of a gas = 22.4 L
- New conversion factor at STP ONLY!

$$\frac{1 \text{ mol}}{22.4 \text{ L}}$$

Example

- Calculate the volume 0.881 mol of a gas will occupy at STP.

Example

- Calculate the volume that 2.000 kg of methane would occupy at STP.

Real versus Ideal Gas

- No gas is ideal, but some are close
- Real gases have attraction to each other & have some volume
- Ideal gases are not attracted to each other & have no volume

Real Gas Equation

- $[P + a(n/V)^2]\ (V-nb) = nRT$
- Just the ideal gas law equation with corrections for attraction (a) & volume (b)
- Has only been on the AP test a time or two
- Just plug in all numbers
- a & b will be given & equation is on formula sheet