IDX G10 Chem H

Study Guide Issue 4

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Finals Rage: Chapter 11 IMF, Chapter 3 Stoichiometry, Chapter 4 Aqueous Solutions, Chapter 10 Gases (Including Lab information)

10. 1 Characteristics of Gases

- Gaseous elements:
  - He, Ne, Ar, Kr, Xe
  - H_2, N_2, O_2, F_2, Cl_2
- Properties:
  - Gas expands spontaneously to fill its container
  - Highly compressible
  - 2+ gases form a homogenous mixture

10.2 Pressure

- Pressure (P): force acting on a given area
  - $P = \frac{F}{A}$ (solid)
    - F: force
    - A: Area
  - $P = \rho g h$ (liquid)
    - ρ: density of fluid
    - g: gravitational acceleration
    - h: depth below surface
- SI unit: Pascal (Pa); 1 Pa = 1 N/m^2
- 1 bar = 10^5 Pa = 100kPa
- 1 atm = 760. mmHg = 760. torr = 1.01325*10^5 Pa = 101.325 kPa = 1.01325 bar
- Barometer: device used to measure atmospheric pressure
- Manometer: Used to measure the difference in pressure between atmospheric pressure and that of a gas in a vessel
- Standard atmospheric pressure (1 atm): pressure at sea level, pressure sufficient to support column of mercury 760mm high

10.3 The Gas Laws

- Boyle's Law
  - n, T constant
  - $P \propto \frac{1}{V}$; PV = constant
- Charles' Law
  - n, P constant
  - $V \propto T$; $\frac{V}{T}$ = constant
- Avogadro's Law
  - P, T constant
  - $V \propto n$; $\frac{V}{n}$ = constant

- V: volume
- P: pressure
- n: number of moles
- T: temperature (K)
- Standard Temperature and Pressure (STP): 1.0 atm and 273.15 K

10.4 The Ideal-Gas Equation

- Ideal-gas equation
  - Combining $V \propto \frac{1}{P}$, $V \propto T$, $V \propto n$, we get $V \propto \frac{nT}{P}$
  - PV = nRT
  - R: gas constant; 8.314 J/mol·K or 0.0826 L·atm/mol·K
- Hypothetical gas whose pressure, volume, and temperature relationship are described completely by the ideal gas equation
- Assumptions:
  - That the molecules of an ideal gas do not interact with one another
  - That the combined volume of the molecule is much smaller than the volume the gass occupies
- Helium is most similar to the "ideal gas"

10.5 Further Applications of the Ideal Gas Equation

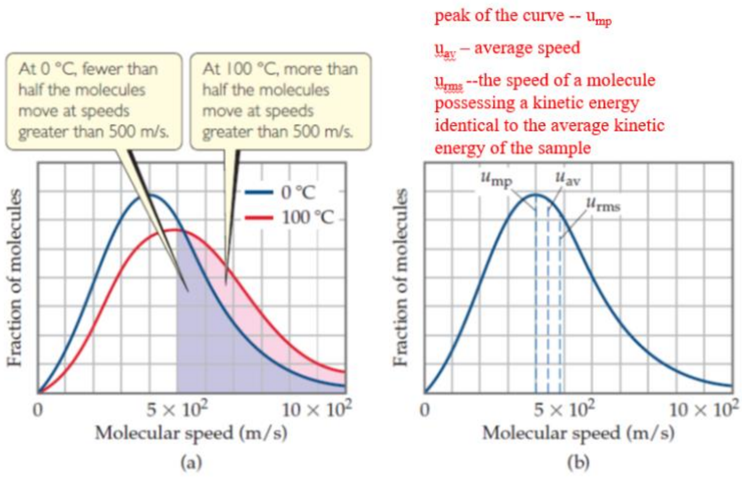
- Gas Densities (Formulas)
  - $\mathrm{d} = \frac{m}{V}$
  - $PV = nRT$
  - $\frac{n}{V} = \frac{P}{RT}$
  - $d = \frac{nM}{V} = \frac{PM}{RT}$
- Molar Mass (Formulas)
  - $M = \frac{dRT}{P}$

10.6 Gas Mixtures and Partial Pressures

- Dalton's law of partial pressures
  - $P_t = P_1 + P_2 + P_3 + \cdots$
  - $P_1 = n_1(\frac{RT}{V})$; $P_2 = n_2(\frac{RT}{V})$; $P_3 = n_3(\frac{RT}{V})$; …
  - $P_t = (n_1 + n_2 + n_3 + \cdots)\left(\frac{RT}{V}\right) = n_t\left(\frac{RT}{V}\right)$
- Partial Pressures and Mole Fractions
  - $\frac{P_1}{P_t} = \frac{n_1 RT/V}{n_t RT/V} = \frac{n_1}{n_t}$
  - Mole fraction: $X_1 = \frac{moles\ of\ compound\ 1}{total\ moles} = \frac{n_1}{n_t}$
- Collecting Gases over Water
- $P_{total} = P_{gas} + P_{H_2O}$
  - P_{gas} = partial pressure of the collected gas, used to calculate n
  - P_{H_2O} = vapor pressure of water
  - $P_{total} = P_{atm}$ – use barometer

10.7 The Kinetic-Molecular Theory of Gases

- The Kinetic-Molecular Theory
  - 1. Gases consist of large numbers of molecules that are in continuous, random motion
  - 2. The combined volume of all the molecules of that gas is negligible relative to the total volume in which the gas is contained
  - 3. Attractive and repulsive forces between gas molecules are negligible
  - 4. Energy can be transferred between molecules during collisions but, as long as temperature remains constant, the *average* kinetic energy of the molecules does not change with time
  - 5. The average kinetic energy of the molecules is proportional to the absolute temperature. At any given temperature the molecules of all gases have the same average kinetic energy
- Distributions of Molecular Speed



(a) The effect of temperature on molecular speed. The relative area under the curve for a range of speeds gives the relative fraction of molecules that have those speed.

(b) Position of most probable (u_{mp}), average (u_{av}), and root-mean-square (u_{rms}) speeds of gas molecules. The data shown here are for nitrogen gas at 0 ° C.

   - Average Kinetic Energy $\propto$ Absolute Temperature

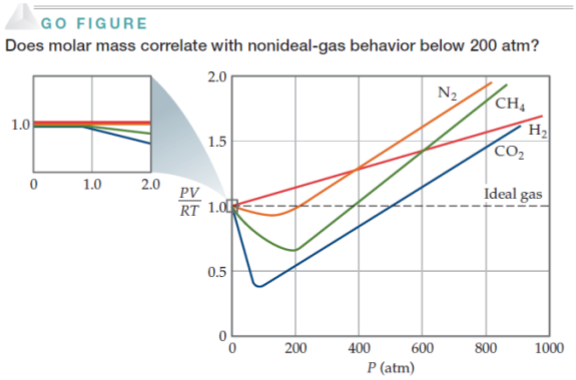
- Application of Kinetic-Molecular Theory to the Gas Laws
   - Volume increase → Pressure decrease (Temperature constant)
   - Temperature increase → Pressure increase (Volume constant)

10.8 Molecular Effusion and Diffusion

- Kinetic Energy $\propto$ Absolute Temperature
   - $KE = \frac{1}{2}mv^2$
   - $u_{rms} = \sqrt{\frac{3RT}{M}}$ (Root-mean-square speed)
   - $u_{mp} = \sqrt{\frac{2RT}{M}}$ (Most probable speed)
- Effusion: the escape of gas molecules through a tiny hole
- Diffusion: the spread of one substance throughout a space or throughout a second substance
- Effusion/Diffusion is faster for lower-mass molecules than higher-mass molecules
- Graham's Law of Effusion
   - For two gases at the same T and P in two containers with identical pinholes
   - $\frac{r_1}{r_2} = \frac{u_{rms1}}{u_{rms2}} = \sqrt{\frac{3RT/M_1}{3RT/M_2}} = \sqrt{\frac{M_2}{M_1}}$
- Diffusion and Mean Free Path

- Diffusion rate of gases throughout a volume of space is much slower than molecular speeds due to molecular collisions (constantly changing directions)
- Mean Free Path: Average distance traveled by a molecule between collisions

10.9 Real Gases: Deviations from Ideal Behavior



- Ideal gas: PV = nRT
  - Real gases conform more closely at high temperature and low pressure
- Real gas (for 1 mol gas): PV/RT – P graph
- Reasons for deviation:
  - Molecules of ideal gas
    - Assumed to occupy no gas
    - Have no attraction for one another
  - Molecules of real gas
    - Do have finite volumes
    - Do attract one another
- Van der Waals Equation
  - $\left(P + \frac{n^2 a}{v^2}\right)(v - nb) = nRT$
  - Attraction force increases as the square of the number of molecules/volume
  - Subtract nb to adjust the volume downward to give the volume that would be available to the molecules in the ideal case