

# Announcements

To join clicker to class today  
(Clickers with LCD display  
join automatically):

- Turn on the Clicker (the red LED comes on).
- Push "Join" button followed by "20" followed by the "Send" button (switches to flashing green LED if successful).

- Exam next Monday.
- Please wait to be let in to class room.

## Review

- Henry's Law:  $c_{\text{gas}} = k_{\text{H}} P_{\text{gas}}$ ,  $c_{\text{gas}}$  = concentration in solution,  $k_{\text{H}}$  = Henry's law constant for particular gas, solvent and temperature,  $P_{\text{gas}}$  = partial pressure of gas.
- Kinetic Molecular Theory of Gases

# Kinetic Molecular Theory of Gases

- Molecules assumed to be very small (essentially points with no volume)
  - They are constantly moving and exchanging kinetic energy through elastic collisions => they are changing direction and speed randomly, but total kinetic energy constant.
  - Pressure = sum of the force of many collisions with the walls of the container divided by area.
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- Key result:  $u_{\text{rms}} = (3RT/M)^{1/2}$ 
  - Higher temperature => higher average speeds.
  - Distribution of speeds.
- Explains: Diffusion & Effusion
  - $r_1/r_2 = u_{\text{rms}}(1)/u_{\text{rms}}(2) = (3RT/M_1)^{1/2}/(3RT/M_2)^{1/2} = (M_2/M_1)^{1/2}$

# $PV/[nRT]$ for ideal and non-ideal gases

Chang Fig 5.19

$PV/[nRT]$

# Van der Waals gas equation

$$P = nRT/(V-nb) - a(n/V)^2$$

- P, V, n, R, T same as ideal gas law
- b = volume taken up by 1 mole of molecules (increases P)
- a = attraction factor (decreases P)

## Implications

- If V is small ( $\approx nb$ ) P will be much higher than expected.
- If a is larger P will be lower than expected.
- Ex: O<sub>2</sub> at 10 atm of pressure in 1.00 L at 298 K (25 °C): Ideal gas law  $\Rightarrow$  0.409 moles of gas. Using the van der Waals get 0.413 moles of gas.

# Using Van der Waals gas equation

$$P = nRT/(V-nb) - a(n/V)^2$$

You must be able to:

- use equation to calculate the actual pressure observed given all other values.
- look at  $a$  and  $b$  to compare molecules and determine which is more affected by attraction or volume of the molecules.

Example: For  $2.560 \times 10^{-4}$  mol  $\text{H}_2\text{O}$  in 200.0 mL at 298.0 K ideal gas law gives a pressure of  $3.130 \times 10^{-2}$  atm. Use VDW calculate  $P$ .

$$a(\text{H}_2\text{O}) = 5.460 \text{ L}^2\text{atm/mol}^2 \quad b(\text{H}_2\text{O}) = 0.03050 \text{ L/mol}$$

# Review

- Greenhouse effect from absorption of IR radiation by gases in the atmosphere
  - only gases with polar bonds can absorb IR
  - not all effective because of where they absorb.
  - Change in  $^{14}\text{C}:^{12}\text{C}$  ratios in atmosphere indicate that most of the growth in  $\text{CO}_2$  is due to combustion of fossil fuels.
  - Predictions are 1-5 °C change in average temperature => significant sea level rise and changes in weather.
  - Science is not definite, what we do is a political decision.
- IR spectroscopy observes energy absorption which excites molecular vibrations.
  - can be used to identify molecules since particular bonds absorb at particular energies.
    - Trend: triple stronger than double stronger than single
    - shorter wavelength suggests stronger bond => single bond absorbs at longest wavelength.
  - Homonuclear diatomics have nonpolar bonds and do not absorb IR.

# Review

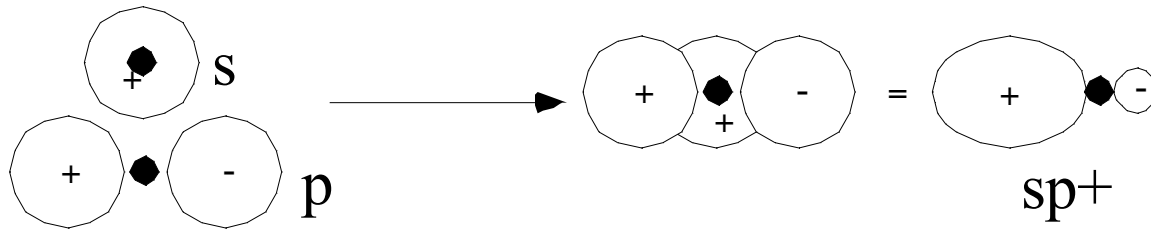
- IR spectroscopy observes energy absorption which excites molecular vibrations.
  - Not all motions of molecules with polar bonds lead to IR absorption.
    - The overall dipole of the molecule must change.
    - Examples: symmetric stretch of  $\text{CO}_2$  and “breathing” of  $\text{CH}_4$  do not absorb IR.
- VSEPR shapes determined by the number of electron groups around the central atom. **YOU MUST KNOW NAMES FOR EACH OF THE SUB-SHAPES.**

Chang Table 10.2 summarizes VSEPR, also see Dr. Gutow's VSEPR web site, reachable from the class web site.



# Review

- Valence bond theory describes bonding in terms of overlap of hybridized atomic orbitals. Example:  $sp$ -hybrid.



- Multiple bonds (double and triple) consist of a sigma( $\sigma$ )-bond and one or two pi( $\pi$ )-bonds.

# $\sigma$ -bond & $\pi$ -bonds in $\text{H}_2\text{CO}$

Chang figure 10.19, see also  
10.15-10.18

# Review

- $PV = nRT$ , solved for  $P$ ,  $V$ ,  $n$  or  $T$
- Used as intermediate values in multistep calculations, including finding density and molar mass or going between the two.
- Partial pressures
  - $P_{\text{tot}} = P_1 + P_2 + \dots = (n_1 + n_2 + \dots)RT/V$
  - $P_i = X_i P_{\text{tot}}$
  - $\sum_i X_i = 1$  or  $X_1 + X_2 + X_3 + \dots = 1$