LECTURE SUPPLEMENT #16 \textbf{COMMENTS/EXAMPLES}

\textbf{IDEAL GAS LAW AND KINETIC MOLECULAR THEORY}

\textbf{1. Comment:} For the proportionality discussed in class, this is a quick way to solve problems when you go from one state to another.

\textbf{Example.} Suppose "n" and "T" are constant and you have an ideal gas that changes from state (1) at \( p_1 = 5 \text{ atm} \) and \( V_1 = 20 \text{ L} \) to a state (2) where \( p_2 = 15 \text{ L} \). Find \( V_2 \).

\textbf{Sol'n:} \( pV = nRT \) \hspace{1cm} \( p_1 V_1 = p_2 V_2 \)

\textbf{or} \( pV = \text{constant} \) \hspace{1cm} \( V_2 = \frac{p_1 V_1}{p_2} = \frac{5 \text{ atm} \cdot 20 \text{ L}}{15 \text{ atm}} = 6.7 \text{ L} \)

So you don't have to know "n" or "T" only that they are constant.

\textbf{2. Comment:} You can solve the kinetic molecular theory problems either from the "microscopic" or "macroscopic" viewpoints.

\textbf{EXAMPLES}

A. Suppose you have 5 moles of He (monatomic) gas at 27°C

\textbf{1. Find the Kinetic Energy.}

\textbf{Sol'n:} \( U = \frac{3}{2} nRT = \frac{3}{2} (5 \text{ mole})(8.31 \text{ J/mol } K)(300 \text{ K}) = 18,700 \text{ J} \)

\textbf{2. Find the # of molecules.}

\textbf{Sol'n:} \( N = n N_A = (5 \text{ mole})(6.02 \times 10^{23} \text{ molecules/mol}) = 3.01 \times 10^{24} \text{ molecules} \)

\textbf{3. Find the kinetic energy per molecule from \( \frac{U}{N} = \frac{3}{2} kT \).}

\textbf{Sol'n:} \( \frac{U}{N} = \frac{3}{2} kT = \frac{3}{2} (1.38 \times 10^{-23} \text{ J/mol K})(300 \text{ K}) = 6.21 \times 10^{-21} \text{ J/molecule} \)

\textbf{4. Find the Kinetic Energy of the He from questions 2 and 3 above.}

\textbf{Sol'n:} \( U = \frac{U}{N} \cdot N = \left( \frac{6.21 \times 10^{-21} \text{ J/molecule}}{3.01 \times 10^{24} \text{ molecules}} \right) = 18,700 \text{ J} \)

\textbf{5. Find the mass of a single He molecule.}\n
\textbf{Sol'n:} \( \frac{m}{N_A} = \frac{4.003 \text{ g/mole}}{6.02 \times 10^{23} \text{ molecules/mole}} = 6.65 \times 10^{-24} \text{ g/molecule} \)

\textbf{6. Find \( V_{\text{rms}} \) for a single He molecule.}

\textbf{Sol'n:} \( \frac{1}{2} m V_{\text{rms}}^2 = \frac{3}{2} kT \) \hspace{1cm} \( V_{\text{rms}} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3(1.38 \times 10^{-23} \text{ J/mol K})(300 \text{ K})}{4.003 \text{ g/molecule}}} = 136 \text{ m/s} \)

B. If you have 5 moles of \( \text{O}_2 \) (diatomic) then \( U = \frac{5}{2} nRT \) etc. But \( V_{\text{rms}} = \sqrt{\frac{3kT}{m}} \) as before! Caution!