Stuff for Tuesday, May 15, 2012

- 1094 session on Wednesday. Read T3 in advance.
- Quiz on Friday on T1, T2, *and* T3.

Recap on calculation of $P = \frac{N}{V}[mv_x^2]_{\text{avg}} = \frac{N}{V}k_B T$:

Assumptions	Corrections
1. N is huge	It *is* huge! 10^{23} is a typical number.
2. gas molecule $\ll$ avg. volume	$V \to V - b\frac{N}{N_A}$ "excluded volume"
3. molecules act like particles	quantum mechanics! (critical at low T)
4. no interactions between particles	$P \to P + a'(N/V)^2$
5. all molecules in gas are identical	$P_s = N_s k_B T$ for species s
6. all collisions with wall are elastic	works on average (but complicated!)
7. motion of molecules is random	good approx. but could simulate

Consider 5 particles with $v_x = -2$ m/s, -1 m/s, 0 m/s, 1 m/s, 2 m/s.

- average velocity: $[v_x]_{\text{avg}} = \frac{1}{5}\sum_{i=1}^{5} v_{x_i} = \frac{1}{5}(-2-1+0+1+2) = 0$ m/s
- average speed: $[|v_x|]_{\text{avg}} = \frac{1}{5}(2+1+0+1+2) = \frac{6}{5}$ m/s = 1.2 m/s
- rms velocity: $\sqrt{[v_x^2]_{\text{avg}}} = \sqrt{\frac{1}{5}(4+1+0+1+4)} = \sqrt{2\,\text{m/s}^2} = \sqrt{2}$ m/s = 1.4 m/s

T1, T2 and T3 Stuff

- Specific heat c: $dU = mc\,dT$ or $c \equiv \frac{1}{m}\frac{dU}{dT}$
- Ideal gas law: $PV = Nk_BT$ with $k_B = 1.38 \times 10^{-23}$ J/K
- Temperature and energy:

$$K_{\rm avg} = \frac{1}{2}[mv^2]_{\rm avg} = \frac{3}{2}k_BT \quad \Longrightarrow \quad v_{\rm rms} \equiv \sqrt{[v^2]_{\rm avg}} = \sqrt{\frac{3k_BT}{m}}$$

- Thermal energy of a gas: $U = \frac{f}{2}Nk_BT$
  - Near room T, $f \approx 3$ (monatomic gas), $f \approx 5$ (diatomic gas), and $f > 6$ (polyatomic gas)
  - f is called the number of molecular "degrees of freedom"
- Gas processes: heat is energy flow from ΔT
  - First Law: $\Delta U = Q + W$
  - Expansion or compression work: $dW = -P\,dV$
  - Adiabatic: $TV^{\gamma-1} = \text{const.}$ $\qquad PV^{\gamma} = \text{const.}$ $\qquad \gamma = 1 + 2/f$