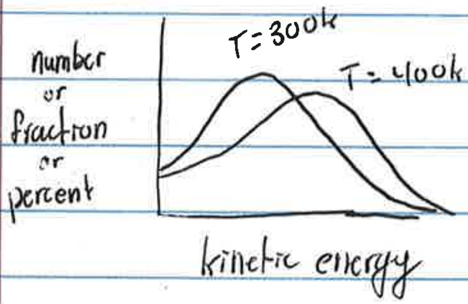
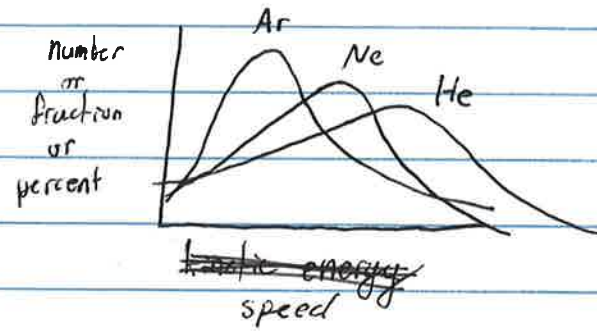
Today 11/26: last few details from chap 10, Graham's law
chap 9, sections 9.12 and 9.13
chap 11, 11.1 - 11.3

Tuesday 11/27: last lab expt., problem club with Ali: 7-8:30

Wednesday 11/28: 11.4, 11.6, 11.7

$$E_k = \frac{1}{2}mu^2 = \frac{3RT}{2N_A} = kT \qquad E_k \propto T$$





· At constant temp,

$$\frac{1}{2}m_A u_A^2 = \frac{1}{2}m_B u_B^2$$

$$\frac{u_A^2}{u_B^2} = \frac{m_B}{m_A} \rightarrow \frac{u_A}{u_B} = \sqrt{\frac{MM_B}{MM_A}}$$

} Graham's law
- diffusion
- effusion

A = fast, light molecule
B = slow, heavy molecule

· What is the relative speed of $NH_3(g)$ (fast) to $HCl(g)$ (slow)?

$$\frac{u_{NH_3}}{u_{HCl}} = \sqrt{\frac{36.5}{17.0}} = 1.47$$

$$u_{NH_3} = 1.47 u_{HCl}$$

· speed is also proportional to speed

$$\frac{distance_{fast}}{distance_{slow}} = \frac{\mathcal{M}_{fast}}{\mathcal{M}_{slow}} = \frac{time_{slow}}{time_{fast}}$$

Intro to entropy

$\Delta H_{rxn} = +80.3$ kJ

~~$Ba(OH)_2 \cdot 6H_2O(s) + 2NH_4Cl(s) \longrightarrow BaCl_2(aq) + 2NH_3(g) + 8H_2O$~~

$\Delta H < 0$ exothermic (enthalpy favored)

$\Delta H > 0$ endothermic (enthalpy not favored)

entropy, S (entropies are absolute and always positive)

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $\boxed{\Delta S = -188\ J/K}$

	$2SO_2(g)$	$O_2(g)$	$2SO_3(g)$	
S	248.1	205	256.6	units = J/mol·K
	x-2mol	x-1mol	x2mol	
	-496.2	-205.0	513.2	units = J/K

$= \Delta S = -188\ J/K$

$\Delta S > 0$ (entropy favored)

$\Delta S < 0$ (entropy not favored)

"Is there an increase in disorder?" yes = entropy favored

"Did we make more gas than we used up?"

$H_2O(l) \rightarrow H_2O(g)$ $\Delta S_{vap} = +$ $\Delta H_{vap} = +$

$H_2O(s) \rightarrow H_2O(l)$ $\Delta S_{fus} = +$ $\Delta H_{fus} = +$

phase changes: ΔH and ΔS have the same sign

$S°$ any gas >> $S°$ any liquid > $S°$ any solid

$2C_2H_5OH_{(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(g)}$ $\Delta H < 0$ $\Delta S > 0$

$4Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$ $\Delta H = ?$ $\Delta S < 0$

$Ba(OH)_2 \cdot 6H_2O_{(s)} + 2NH_4Cl_{(s)} \rightarrow BaCl_{2(aq)} + 2NH_{3(g)} + 8H_2O_{(l)}$ $\Delta S = +428\ J/k$

Gibbs-Helmholtz equation:

$\Delta G = \Delta H - T\Delta S$ $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ (T = 298k)

free energy

$\Delta G < 0$: rxn is spontaneous ← yes { "Does it happen?" or "Can it happen?"

$\Delta G > 0$: rxn is not spontaneous

· at very low temperatures: $\Delta G \rightarrow \Delta H$

· at very high temperatures: $T\Delta S$ takes over

$H_2O_{(l)} \rightarrow H_2O_{(g)}$ $\Delta H > 0$ $\Delta S > 0$

$\Delta G^{25°C} \geq 0$ $\Delta G^{110°C} < 0$

$\Delta G = 0$ at all phase change temperatures (T_b, T_m)

$\Delta G = \Delta H - T\Delta S$

$0 = \Delta H - T\Delta S$

$T = \frac{\Delta H}{\Delta S}$ at phase change temp.

$H_2O_{(l)} \rightarrow H_2O_{(g)}$ $\Delta H^\circ_{vap} = +44\ kJ$ $\Delta S = 118.8\ J/K$

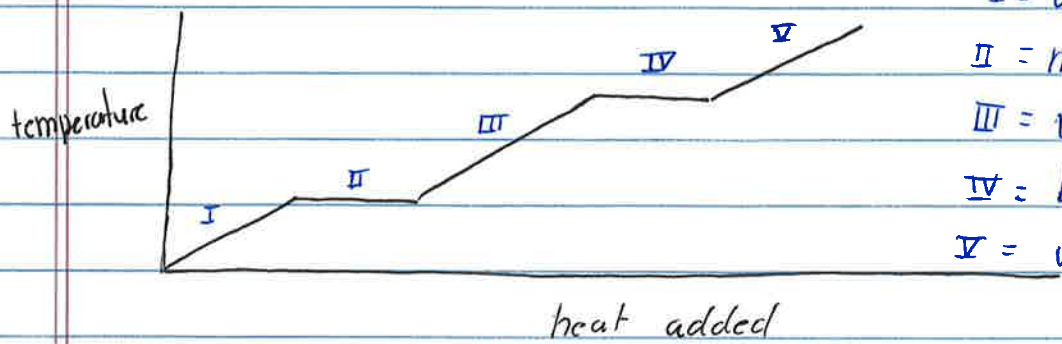
$= 0.1188\ kJ/k$

$T = \frac{44\ kJ \cdot k}{0.1188\ kJ} = 370k = 97°C$

Viscosity and surface tension

Viscosity = resistance to movement through liquid

surface tension = resistance to spreading out



I = warming solid

II = melting solid

III = warming liquid

IV = boiling liquid

V = warming gas

Warming ice to room temp:

$$q_{tot} = q_{I} + q_{II} + q_{III}$$

warming water to boiling point:

$$q_{tot} = q_{III} + q_{IV}$$