Preview Sheet for Test 4
Entropy, Enthalpy, Gibbs Energy, and the Second Law
Thursday, December 6, 9:00 – 11:00 a.m., OR 101

Hanson/Green: Chapter 2 (pp. 2-3 to 2-8; 2-10 to 2-11), Chapter 7 (skip Sect. 7.9)
Chapter 8 (skip Sect. 8.5, 8.12), Chapter 9, Chapter 10
Lectures from 11/9 to 12/3 (start of class); Problem Sets 10 and 12

<u>Studying strategies:</u>

- Focus on your lecture notes and homework first, then look at the textbook. Anticipate some conceptual questions not based on the homework.
- If a topic was not covered in homework or in lecture, you are not responsible for it! Please ask me if you are unsure about whether a particular topic is "fair game" for the exam.
- Correlating Gibbs energy and energy level diagrams (*i.e.* PS 12 #6) will <u>not</u> be on the test.
- You <u>will</u> be tested on constructing energy level population diagrams (as in Hanson and Green Problems 2.2 and 2.4 from Problem Set 7). As we saw in class on November 9, these diagrams come up again when we talk about entropy.
- Expect a mixture of mathematical problems (~65 points) and short explanation questions (~35 points). You should be able to use equations not only to calculate numbers, but also to make qualitative arguments.

<u>My Office Hours</u>: Monday: After 2:30 p.m.; Tuesday: All day; Wednesday: 1:30 – 3:30 p.m.

[From the test booklet:]

<u>Instructions before starting the test:</u>

1. Write your name in the space above and on the backs of the other pages.
2. This exam is closed-everything.
3. Your exam booklet should have **nine** pages total, with questions on pp. 2-6, equations and constants on p. 7, and a periodic table and other reference data on pp. 8-9. Check to see you have nine pages now. If you do not, ask for another copy of the exam.
4. You may use programmable calculators, but chemical data should not be stored in them.
5. To receive full credit for a mathematical problem, you must show the method by which you obtained the final answer, including dimensional analysis. <u>However, you do not need to justify how you calculated molar masses</u>.
6. A final numerical answer must contain the correct units and number of significant figures to receive full credit.
7. You have <u>**120 minutes**</u> to work on this exam. Do not start until you are instructed to.

<u>What not to memorize (they will be provided in the test booklet)</u>:

(1) The periodic table
(2) Hanson and Green Table 7.1 (Standard Molar Entropies) and Table 9.1 (Standard Molar Enthalpies of Formation)

(3) The information below:

$$N! = N(N-1)(N-2)\cdots 1$$

$$W = \frac{N!}{N_0!N_1!N_2!\cdots} \qquad \frac{N_j}{N_i} = \exp\left(-(E_j - E_i)/kT\right) \qquad \mu = \frac{m_1 m_2}{m_1 + m_2}$$

$$E_{vib} = \left(i + \frac{1}{2}\right)h\nu \quad \text{where} \quad \nu = \frac{1}{2\pi}\sqrt{\frac{k_f}{\mu}} \text{ and } i = 0,1,2,...$$

$$E_{rot} = i(i+1)\frac{h^2}{8\pi^2}\left(\frac{1}{\mu R^2}\right) \quad \text{where} \quad i = 0,1,2,...$$

$$E_{trans} = \left(n_x^2 + n_y^2 + n_z^2\right)\frac{h^2}{8}\left(\frac{1}{mV^{2/3}}\right) \quad \text{where} \quad n = 1,2,3...$$

$$\Delta U = \Delta U_C + \Delta U_T = q + w \qquad \Delta U_T = C\Delta T \qquad q_{sys} + q_{surr} = 0$$

$$w = -p_{surr}\Delta V \qquad pV = nRT \qquad T\text{ (K)} = T\text{ (°C)} + 273.15\text{ K}$$

$$\Delta S_{sys} + \Delta S_{surr} = \Delta S_{univ} \geq 0 \qquad S = k\ln W \qquad \Delta S_{surr} = \frac{q_{surr}}{T} = -\frac{\Delta H}{T}$$

$$\Delta S = nR\ln\frac{V_2}{V_1} \qquad \Delta S = -nR\ln\frac{p_2}{p_1} \qquad \Delta S = -nR\ln\frac{[X]_2}{[X]_1}$$

$$S_x = S_x^o - R\ln P_x/\text{bar} \qquad S_x = S_x^o - R\ln[X]/\text{M} \qquad \Delta_r S = \Delta_r S^o - R\ln Q$$

For the reaction a A(g) + b B(g) $\rightarrow$ d D(g), $Q = \dfrac{p_D^d}{p_A^a p_B^b}$

$$H = U + pV \qquad \Delta H = \Delta U + p\Delta V \qquad p\Delta V = RT\Delta n_{gas}$$

$$G = H - TS \qquad \Delta G = \Delta H - T\Delta S \leq 0$$

$$\ln(vp) = -\frac{\Delta_{vap}H°}{R}\left(\frac{1}{T}\right) + \frac{\Delta_{vap}S°}{R}$$

$N_A = 6.022 \times 10^{23}$ particle mol^{-1} $\qquad k = 1.381 \times 10^{-23}$ J K^{-1} particle^{-1}

1 J = 1 kg m^2 s^{-2} $\qquad$ 1 kJ = 10^3 J

R = 0.08315 L bar mol^{-1} K^{-1} = 8.315 J mol^{-1} K^{-1} $\qquad$ 1 L bar = 100 J