University of Washington
Department of Chemistry
Chemistry 355
Spring Quarter 2005

Midterm Exam Announcements

The Midterm Examination will be held on Friday, 6 May

- Covering:
  - Chapters 1-4 in the text + sections 5.1, 5.2, 5.3.
  - Lectures 1-19
  - All Problems in Homework Assignments 1-5(-ATP problem)
- Bring
  - Calculator (any type)
  - Pencil/Pen
  - Straight Edge (for drawing graphs)
  - Blue/Green Book
  - 1 page of notes (double-sided, see below)
- Format:
  - Closed Book.
  - Open Notes.
    - One page, double-sided,
    - Attached to or entered into the blue/green book
    - Turned in with the exam blue/green book
- Grading: Grading of the examination will be based on the standards stated in the Chemistry 355 course syllabus. Please review the standards section of the syllabus. Important points to keep in mind:

    - Partial credit is USUALLY given in units of 3-5 points.
    - Obtaining the correct numerical answer is counted in partial credit grading. An answer that is within 10% of the correct answer will be fully credited.
    - Calculations must include physical units and a proper dimensional analysis must be included in the calculation.
    - Students are expected to understand how to use their calculators properly. Students will NOT be forgiven for mistakes resulting from calculator errors.
    - When you are asked to explain an answer or are asked to define a term, a worded statement *in complete sentences* is required.
    - If you are given the option to choose from a list of problems (e.g. answer three of the following five questions) you will NOT be credited for answering more than the requested number. For example, if you are allowed to select three problems out of five for answering…and you answer all five… the graders will NOT credit you for the highest three scoring problems out of five. The first three problems presented on the blue book will be graded.

Examination Study Guidelines: Here is a general outline of the examination that will be presented to you on 21 April. Sample questions and answers are presented.

Problem 1 (20 points total) Define four terms or phrases provided (fives points per definition).

- Example of one of four terms or phrases that might be presented.
  Define Chemical Equilibrium
  - Acceptable Answer: The condition of a chemical system, composed of reactants and products, in which all tendency for net conversion of reactants into products or products into reactants, has ceased, and no further net change will occur spontaneously.

Problem 2 (20 points total) Qualitative Answers to Questions. Answer two out of four (10 points per answer).

Example. Two identical cannons are loaded with identical gun powder charges, but one cannon is not loaded with a cannon ball while the other cannon is loaded with a cannon ball. Both cannons are fired. A consequence of the First Law of Thermodynamics is that as a result of the firing, the loaded cannon will be heated to a higher temperature than the unloaded cannon. Do you agree or disagree? Explain.

- Solution: Disagree. From the First Law $\Delta E=q+w$. The energy released as a result of the firing (explosion of the gun powder) is manifested as heat and work done in moving the cannon ball. Much less work is performed in the unloaded cannon because the heavy cannon ball does not have to be propelled out of the cannon barrel, so the unloaded cannon heats up more.

- Other things to study:
  - Statement and Meaning of the First, Second and Third Laws of Thermodynamics
  - Relationship between mechanical degrees of freedom and thermodynamic quantities like heat capacity and entropy.
  - Assumptions and results of the kinetic theory of gases.
  - When quantization is important in describing physical motions.
  - Ideal and Henry's Law solution models. Why are electrolyte solutions not ideal?
  - Microscopic interpretations of thermodynamic state functions, work, and heat.
  - Thermodynamic reversibility and efficiency.

Problem 3: (20 points) Short calculations. In these problems you are usually asked to calculate one quantity or read and interpret a graph. A single equation is usually involved. Typically you are asked to answer two problems out of four, or three out of five, depending on the degree of difficulty of the problems.

Example: 1 kJoule of heat is transferred at constant pressure to 2 moles of a monatomic ideal gas, which is initially at 1 atm pressure and has a temperature of 300K. Calculate the final temperature.

Solution: Because the heat is transferred at constant pressure

$q_P = \Delta H = n\overline{C}_P \Delta T$

where n is the number of moles

$\overline{C}_P$ *is the molar heat capacity at constant pressure* $= \frac{5R}{2}$

Solving $q_P = \Delta H = n\overline{C}_P \Delta T \Rightarrow 1000J = (2moles)\frac{(5)(8.31J/mole \cdot K)(T_2 - 300K)}{2}$

$T_2 = \frac{1000J}{(5)(8.31J/K)} + 300K \approx 324K$

Note: Any answer within 10% of 324K will be fully credited.

- Other relationships to study:
  - Other equations relating changes in thermodynamic state functions (ΔE, ΔH, and ΔS), work, and heat to changes in state variables (ΔT, ΔV, ΔP).
  - Equation and graph of the Maxwell-Boltzmann speed distribution function from kinetic theory of gases.
  - Ideal gas and van der Waals equations of state.
  - How to calculate ΔH^0 for chemical reactions from standard heats of formation
  - How to calculate ΔH for chemical reactions at different temperatures using heat capacity data (see section 2-9 in the Barrows text).
  - Understand how to calculate work for reversible and irreversible expansions/compressions of gases.
  - Ideal and Henry's Law Solutions
  - Electrolyte solutions and activity coefficients

Problem 4 (40 points total) This will be a multi-step calculation where you may have to use several equations and calculate several things. The relationships you should study are the same as listed above for problem 3. This problem will be styled after the supplementary homework problems or after some of the multi-step calculations given in the Lecture Notes. You will probably be able to chose from 2 problems.

Example: 5 moles of an ideal monatomic gas expand at a constant temperature from a pressure of P=10.0 atm. to a pressure of 1.0 atm. at a constant temperature of T=298K. Assume the expansion occurs reversibly. Calculate ΔE, ΔH, ΔS, w, and q.

Solution: The process is an isothermal, reversible expansion of an ideal gas. Therefore:

$\Delta H = n\overline{C}_P \Delta T = 0$ *and* $\Delta E = n\overline{C}_V \Delta T = 0$

$\Delta E = q_{rev} + w_{rev} = 0 \Rightarrow q_{rev} + w_{rev} = 0$ *or* $q_{rev} = -w_{rev}$

$$q_{rev} = -w_{rev} = \int_{V_1}^{V_2} PdV = nRT\int_{V_1}^{V_2} \frac{dV}{V} = nRT\ln\left(\frac{V_2}{V_1}\right)$$

$$but\ PV = nRT\ and\ so V = \frac{nRT}{P}. It\ follows\ that\ \frac{V_2}{V_1} = \frac{P_1}{P_2}\ at\ cons\tan t\ T.$$

$$Then\ q_{rev} = -w_{rev} = nRT\ln\left(\frac{P_1}{P_2}\right) = (5moles)(8.31J/mole\cdot K)(298K)\ln\left(\frac{1atm}{10atm}\right) = 28{,}500J$$

Finally

$$\Delta S = \frac{q_{rev}}{T} = \frac{28{,}500J}{298K} = 95.6J/K.$$