

# **EMAC 351 PHYSICAL CHEMISTRY FOR ENGINEERS FALL 2007**

## **COURSE OBJECTIVES**

To develop understanding of the basic concepts and approaches of Physical Chemistry.  
To acquire practical skills through multiple problem solving.

## **COURSE OUTLINE**

This course is an introduction to the principles of physical chemistry and their application to systems involving physical and chemical transformations. Topics covered in this semester are: the nature of physical chemistry, overview of the laws of thermodynamics, thermochemistry, equilibrium and electrolytes, chemical reaction kinetics, an introduction to quantum mechanics and molecular statistics.

### **Text-book:**

K.J. Laidler, J.H. Meiser, B. C. Sanctuary, Physical Chemistry, 4<sup>th</sup> Edition, Houghton Mifflin Co., Boston, 2003

## **COURSE SYLLABUS**

- **1. The Nature of Physical Chemistry and the Kinetic Theory of Gases**

- 1.1 The Nature of Physical Chemistry
- 1.8 The Equation of State for an Ideal Gas
- 1.12 Real Gases
- 1.13 Equations of State
- 1.14 The Virial Equation

- **2/3. The Laws of Thermodynamics**

- 2.3 Equilibrium States and Reversibility
- 2.4 Energy, Heat, and Work
- 2.5 Thermochemistry
  
- 3.3 Molecular Interpretation of Entropy
- 3.4 The Calculation of Entropy Changes
- 3.6 Conditions for Equilibrium
- 3.7 The Gibbs Energy
- 3.9 The Gibbs-Helmholtz Equation

- **4. Chemical Equilibrium**

- 4.1 Chemical Equilibrium Involving Ideal Gases
- 4.2 Equilibrium in Nonideal Gaseous Systems
- 4.3 Chemical Equilibrium in Solution
- 4.4 Heterogeneous Equilibrium
- 4.5 Tests for Chemical Equilibrium
- 4.6 Shifts of Equilibrium at Constant Temperature
- 4.7 Coupling of Reactions
- 4.8 Temperature Dependence of Equilibrium Constants
- 4.9 Pressure Dependence of Equilibrium Constants

- **TEST 1 (approx. September 27)**

- **7/8. Solutions of Electrolytes, Electrochemical cells**

- 7.1 Faraday's Laws of Electrolysis
- 7.3 Weak Electrolytes: The Arrhenius Theory
- 7.10 Activity Coefficients
- 7.11 Ionic Equilibria
- 7.13 The Donnan Equilibrium

- 8.1 The Daniell Cell
- 8.2 Standard Electrode Potential
- 8.3 Thermodynamics of Electrochemical Cells
- 8.4 Types of Electrochemical Cells

- **9. Chemical Kinetics I. The Basic Ideas**

- 9.1 Rates of Consumption and Formation
- 9.2 Rate of Reaction
- 9.3 Empirical Rate Equations
- 9.4 Analysis of Kinetic Results
- 9.7 The Arrhenius Equation
- 9.8 Potential-Energy Surfaces
- 9.9 The Preexponential Factor

**Mid-term grades: Based on (results of Test 1 + homework)**

- **TEST 2 (approx. October 30)**

- **10. Chemical Kinetics II. Composite Mechanisms**

- 10.1 Evidence for a Composite Mechanism
- 10.2 Types of Composite Reactions
- 10.3 Rate Equations for Composite Mechanisms
- 10.4 Rate Constants, Rate Coefficients, and Equilibrium Constants
- 10.5 Free-Radical Reactions
- 10.6 Photochemical Reactions
- 10.9 Catalysis

- **11. Quantum Mechanics and Atomic Structure**

- 11.1 Electromagnetic Radiation and the Old Quantum Theory
- 11.2 Bohr's Atomic Theory
- 11.3 The Foundations of Quantum Mechanics
- 11.4 Schrödinger's Wave Mechanics
- 11.5 Quantum-Mechanical Postulates
- 11.6 Quantum Mechanics of Some Simple Systems

- **15. Statistical Mechanics**

- 15.1 Forms of Molecular Energy
- 15.2 Principles of Statistical Mechanics
- 15.3 The Partition Function
- 15.4 Thermodynamic Quantities from Partition Functions
- 15.5 The Partition Function for Some Special Cases

**TEST 3 (December 6)**

**Self-study/Group project:** Each test (worth 100 points each) will include one extra question (for 5 points) based on a self-study subject announced 2-3 weeks in advance of the test. At that time a group of 3-5 students may volunteer to study this material, prepare “handouts” (which can be in the form of a wiki-page on the course Blackboard) and present it for the rest of the class. The members of the group will earn as much as 5 points for the question on this subject on the following test (depending on the quality of the presentation, handouts, etc.). Note that this means that the members of the presenting group will not necessarily have to answer the self-study question on the exam. The presenting group will be selected based on a “first-email received” basis. Each student will be allowed to be a member of no more than one presenting group during the semester.

**Homework Assignments:** will be announced in class and posed on the course website: <http://elena.emac.cwru.edu/emac351/> Homework will be graded by the assigned graduate student. Grading time for the homework is not more than 1 week. In special cases (contact your grader for permission) late submission of the homework could be arranged. Late homework cannot be submitted if it has been already graded and returned to other students.

**FINAL GRADE (based on 100):** = (results of test 1 + test 2 + test 3)\*0.25 +  
+ homework\*0.2+  
+ self-study question/group project\*0.05

The average Homework grade will be equivalent to 20 points towards the final grade. The average of the grades for self-study question received on 3 tests (one of which can be substituted by the corresponding group project) will be equivalent to 5 points toward the final grade. Anyone with “A” will be excused from the final exam. **The final exam will count the same as one test, (i.e. 25 points toward the final grade) and can replace the result of one of the tests.**

During the semester there will be occasional opportunities for gaining extra credit points (e.g. for oral presentations by individual students), which can be used towards the following test.

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INSTRUCTOR:

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TEACHING ASSISTANT: TBA

**Class comments and suggestions:**

I welcome your comments, preferably by e-mail. They will be helpful while we proceed with the course, and especially so for future classes.

**How to consult with the instructor:**

During the semester the instructor is prepared to meet individually (by appointment) with any and all students enrolled in this course. I would like especially to meet with students with disabilities who are registered with the Coordinator of Disability Services (368-5230) and who may need individual arrangements. Instructor hours: Tuesday/Thursday 11.30-12.30.