Preparation for the exam 1

Chem112L, Spring 2012 **Exam dates: Monday, May 15, and Tuesday, May 15**

This exam focuses on structure determination via computational chemistry and NMR, kinetics of chemical and enzymatic reactions, and study of protein folding by circular dichroism. I intend to have a mix of knowledge-showing essay-type, problem-solving, and multiple-choice questions. Knowledge of the following helps you in preparing for the exam:

1. Physical principles behind each of the molecular process
    a. Forces and interactions determining conformations of small molecules
    b. Forces and interactions determining folding of macromolecules
    c. Role of entropy in protein folding
    d. Enzyme catalysis and inhibition

2. Physical principles behind each of the observation/detection methods
    a. Interaction of matter with electromagnetic radiation: general principles
    b. Polarimetry and circular dichroism
    c. Measurement of reaction rates by UV-Vis spectrophotometry
    d. Nuclear magnetic resonance detection of nuclei: chemical shift
    e. Nuclear magnetic resonance detection of nuclei: coupling constants
    f. Data acquisition in modern Fourier-transform 1D and 2D NMR
    g. NMR as a tool to study molecular structures: HSQC, TOCSY, NOE
    h. Molecular modeling with computers: minimization methods
    i. Molecular modeling with computers: conformational analysis
    j. Molecular modeling with computers: Monte Carlo simulations

3. Theoretical description of equilibrium and kinetics of chemical reactions
    a. Dissociation constant in relation to equilibrium concentrations
    b. Rate constants in relation to equilibrium constant
    a. Kinetics of first-order irreversible reactions; rate equation and half-life
    b. Kinetics of consecutive reactions: general principles
    c. Steady state approximation for consecutive reactions
    d. Steady state and equilibrium approximations in enzyme kinetics
    e. Rationale behind the initial velocity approach to enzyme kinetics
    f. Kinetics of two-substrate enzymatic reactions
    g. Kinetics of competitive and uncompetitive inhibition

4. Theoretical description of equilibrium and kinetics of chemical reactions
    a. Transition state stabilization concept in enzyme catalysis
    b. Description of reactions via intersecting potential energy surfaces
    c. The energy levels and wave functions of the quantum harmonic oscillator
    d. Kinetic isotope effect and tunneling in chemical reactions (independent study!)
    e. Temperature dependence of reaction enthalpy and entropy
    f. Heat capacity in relation to protein folding thermodynamics
    g. Theoretical models of protein folding; use of MD simulations

4. Structural and functions concepts pertaining to molecular structure, protein folding, and kinetics
   a. Structure of peptides and proteins
   b. Chiral and achiral molecules
   c. Protein folding diseases: prions
   d. Chemistry of NAD-dependent dehydrogenases

5. Instrumentation
   a. Basic design and operation of a spectropolarimeter
   b. Basic design and operation of a UV-Vis spectrophotometer
   c. Basic design and operation of a FT-NMR spectrometer
   d. Basic design and operation of traditional and ASIC-based computers

6. Broader applications of methods covered; other approaches to study these phenomena
   a. Experimental methods to determine the structure of small molecules
   b. Application of minimization algorithms in chemistry and biochemistry
   c. Application of the Monte Carlo method in chemistry and biochemistry
   d. Using circular dichroism to monitor structural changes in protein
   e. pH- and temperature-dependence of enzymatic reaction rates
   f. Other methods to study protein folding
   g. Other methods to study enzyme catalysis

7. Practical aspects of each of the experiments
   a. Why such wavelengths and cuvettes
   b. Why such concentrations, pH, salts, buffers, etc
   c. Why such acquisition and delay times in 1D proton NMR
   d. Locking and shimming in NMR

8. Data analysis.
   a. Understand why we used such model equations for fitting
   b. Understand the meaning of each of the fitting parameters
   c. Understand the measures of quality of data and fitting
   d. Understand the workflow of scientific data analysis programs such as *Mathematica*
   e. The statistical analysis of enzyme kinetics data; importance of V/K

9. Miscellaneous
   a. How to estimate fitting parameters visually based on the data
   b. Basics of statistics, regression analysis, and error propagation formulas
   c. How to make solutions: you may need a calculator
   d. How to derive one and two-substrate enzyme kinetic equations
   e. How to derive kinetic equations with one substrate and inhibitor
   f. How to derive equations for protein unfolding equilibrium
   g. Distinction between quantum mechanical and molecular mechanical approaches

Answers to many of the questions require substantial thinking. Memorizing all the material may not be the best way to study for this exam.