Chemistry of the Solar System: PTYS510B

Syllabus

Class format: The class consists of lectures, homework assignments, and two exams. This is a small class and should be highly interactive.

Textbook: Physical Chemistry by Atkins. This is a classic text, used in physical chemistry classes throughout the world. There is far more material than we can cover and there are very few physical chemistry topics that are not covered in this book. It will be a good reference for almost any topic in planetary science, outside of orbital dynamics.

Homework: Problem sets will be passed out every two weeks. On the day that the problem set is due, the entire class will be devoted to discussion of the problems and solutions. Completion of the problem set is the primary means by which students learn the course material.

There will be 2 exams, a mid-term and a final.

Grading: The final grade will be the weighted average of the homework grades (40%), the exam grades (40%) and the class participation (20%).

Topics

1) Review of Quantum Mechanics
   a) Schrodinger's Equation
   b) Rotating Systems and Angular Momentum
   c) Vibrating Systems
   d) Parity and Angular Momentum

2) Review of Molecular Structure
   a) Hamiltonian, Schroödinger Equation, Wave Functions
   b) Rotational Energy Levels
   c) Vibrational Energy Levels
   d) Electronic Energy Levels
   e) Important molecules in this solar system and others

3) Molecular Bonding
   a) Covalent bonds
   b) Hydrogen bonds
   c) Bond energies

4) Building Large Organic Molecules
    a) Large hydrocarbons
    b)

5) Spectroscopy
    a) Rotational Transitions
    b) Vibrational Transitions
    c) Electronic transitions
        (1) selection rules
        (2) intensities
    d) Rotational Structure of Vibrational Bands
    e) Vibrational Structure of Electronic bands
    f) Polyatomic Molecules

6) Photo-processes
        i) photo-ionization
        ii) photo-dissociation
            (a) mechanisms
            (b) fragment distributions

7) Gas Phase Equilibrium Chemistry
    a) Reaction Energetics
    b) Thermodynamics: H, G, and S
    c) Law of Mass Action
    d) Planetary Atmospheres Examples

8) Kinetics
        i) Intermolecular forces
        ii) two body collision dynamics
        iii) Ion-Neutral Collisions
            (a) Langevin rates
        iv) Electron-ion recombination
        v) Neutral-Neutral Collisions
            (a) Energy barriers
            (b) Detailed balancing
            (c) Unimolecular (recombination) reactions
            (d) Bimolecular reactions
            (e) Trimolecular reactions
            (f) RRKM approximation
            (g) Troe formula
9) Ices
    a) Overview of likely ices
    b) Clathrate hydrates
        i) Water ice phase diagram
        ii) Thermodynamics
            (1) Clausius Clapyeron

(2) Helmholtz energy
(3) Gibbs energy
(4) Chemical potential
(5) Entropy of mixing
(6) Partition function

iii) Methane clathrates

10) Phase diagrams and equilibrium processes
   a) Gibbs phase rule
   b) Phase diagrams
      i) Binary
      ii) Eutectics, peritectics
      iii) Ternary
   c) Applications
      i) Ammonia-water
      ii) CH4-N2
   d) Equilibrium Melting
   e) Fractional melting