PHY 540: Integrated Physics and Chemistry (Summer 2005)

Robert Culbertson (Robert.culbertson@asu.edu)

Catalog Description: Collaborative inquiry methods for teaching structure of matter and its properties. Emphasis on coordinating concepts of physics and chemistry. Evaluation of curriculum materials and design of coherent instructional units.

Prerequisites: Inservice teacher of chemistry or physics, or instructor approval. CHM 480, PHY 480 (PHS 530) or instructor approval.

Course Objectives: To explore the common conceptual foundations for physics and chemistry and their implications. Emphasis on qualitative modeling and reasoning.

Supplemental Text: *Chemical Bonding Clarified Through Quantum Mechanics* by George C. Pimentel and Richard D. Sprately (1982)

Grading
Each student is expected to spend 45 hours per semester credit hour
Letter grade vs. satisfactory-fail: satisfactory grades may not transfer
A-B-C grades: B means average; a 3.0 GPA is minimum requirement for MNS and other graduate degrees
Incomplete: only for special circumstances
Attendance: Grades are based on attendance, journal, participation, and final project
Journal: a daily log book or notebook of problems solved, labs done, personal notes, notes on readings; journals will be evaluated periodically
Final project: a usable module that integrates physics and chemistry. Presented during last week; electronic copy required

Course Content (Major topics in bold. Suggested topics below each major topic.)

I. Particulate structure of matter:

Macroscopic vs microscopic descriptions. Classification of properties.
Explanation of (observed) macroscopic properties with microscopic models.
Systematic explanation of details with models of increasing complexity.
Macroscopic evidence for microscopic structure.

II. Energy additivity and conservation.

Kinetic energy (translational, vibrational and rotational).
Interaction energy.
- Modeled with potential energy diagrams.
- Hard sphere and Lennard-Jones models.
- Impenetrability and particle size.

Particle energy (internal energy and structure).

Explanations for Gas laws and phase changes.
Visualizable models (macroscopic analogs) for solids, liquids and gases.
Heat and temperature: measurement and explanation.
Mechanisms for energy transfer and storage.

III. Particle composition and basic properties.

Particle hierarchy:
molecules, atoms, nuclei & electrons, protons & neutrons, (quarks?).
Mass additivity and *matter conservation*. Elementary particle masses.
Electric charge additivity and conservation. Quantized charge.

IV. Atomic models.

Nuclei and electrons. Atomic number and mass.
Coulomb interaction.
Electron orbitals as "electron clouds."
Quantized energy levels and energy level diagrams.
Quantum numbers and shells.
Electron binding energy.
Emission and absorption of photons.
Periodic Table of the elements. Classification & explanation for "pure substance."
Mass-energy conversion.

V. Molecular models.

Diagrammatic representations of molecular structure.
3D models of molecular shapes.
Models of molecular (chemical) bonds
Valence models. Electronegativity.
Batteries and electrochemistry.
Covalent models.
Long-range molecular interactions. Van der Waals force.

VI. Molecular collisions and chemical reactions

Conservation laws and balancing chemical equations.
Energy release in inelastic collisions (heat of reaction).
Activation energy and its implication for molecular models.

VII. Thermodynamics.

Equilibrium, irreversibility and entropy.

Selected readings from:

A. E. Lawson & J. P. Birk, Chemistry: A Critical Thinking Approach, ASU (1994).
M. Alonzo & E. Finn, On the notion of internal energy, *Physics Education* **32:** 256-264 (1997).