Syllabus - CHE 411 / CHE 5411 - Advanced Inorganic Chemistry

Spring Semester — 3 semester hours credit
Class: MCC 402 — TR 9:25 - 10:40 AM

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Instructional Materials:
The required text is *Inorganic Chemistry 3rd Edition* by Gary L. Miessler and Donald A. Tarr. A suggested accompanying text is *A Guide to Modern Inorganic Chemistry* by Steven M. Owen and Alan T. Brooker. In addition to this text you will need a scientific calculator. Many of the class notes will be distributed.

Prerequisites: CHE 211, CHE 317, and CHE 318. The latter may be taken as a co-requisite. In addition to these specific prerequisites, students enrolled in CHE 5411 must have previously completed at least eighteen hours of chemistry.

Disclaimer: Although I expect to conduct the course according to the following, I reserve the right to make modifications if circumstances dictate.

Course Description: A study of modern inorganic chemistry with emphasis on the principles and trends in the chemistry of the elements and on the essentials of structure, bonding, and reactivity of inorganic systems

Rationale: If organic chemistry is defined as the chemistry of hydrocarbon compounds and their derivatives, inorganic chemistry can be described broadly as the chemistry of “everything else.” Many students recognize the importance of organic chemistry because of its relationship to biochemistry, but inorganic chemistry also plays important roles in today’s world. From organometallic chemistry which bridges the gap between organic and inorganic chemistry to semiconductors involved in computer and information technology, inorganic chemistry continues to be a large, important, and rapidly growing field in which all students of chemistry should be knowledgeable.

Attendance: Your attendance at all class meetings is expected. Please refer to the *Mississippi College Undergraduate Bulletin* or to the *Mississippi College Graduate Catalog* for a discussion of the university’s attendance policy. If a regular class meeting is missed, it is the student’s responsibility to obtain any assignments or instructions that were given by the instructor. Missing a class is **not** an excuse for not preparing for the next class meeting or not having an assignment ready on time. Don’t miss a scheduled test! In the event of an extreme emergency and an excused absence, a make-up test will be given. The test must be made up prior to the graded tests being returned to the class. Make-up tests are usually different from the regular test and may be more difficult. If the student cannot return to class until after the tests have been returned, the grade on the final exam may be substituted for the missing grade.

Methods of Instruction: Class will consist primarily of lectures and working problems. Occasionally, students enrolled in CHE 5411 will be required to present oral reports to the rest of the class.

Required Practices: You are expected to read the appropriate sections of your text and work any problems assigned before coming to class. Finally, as previously mentioned, all students will need a good scientific calculator and be fairly proficient with it.

Grading: Three tests will be given during the semester, each with a value of 100 points. Unannounced pop tests are given periodically, the total number of pop test points and points from homework assignments will be approximately 50. Pop tests that are missed are not made up. The final exam is comprehensive and is worth 150 to 200 points. Your overall grade is determined by dividing your grand total by the total possible points. Occasionally there are opportunities for extra credit points by attending a special seminar or a visiting lecture.

CHE 411: Final letter grades are determined on a 10-point scale. Please refer to the *Mississippi College Undergraduate Bulletin* for a discussion of the university's grading system and how quality points are assigned.

CHE 5411: In addition to the above, approximately 50 points may be earned from the periodic reports and oral presentations mentioned above. Final letter grades are determined on the following scale:

90 -100 % = A	68 - 74 = C+	45 - 54 = D
84 - 89 % = B+	55 - 67 = C	below 45 = F
75 - 83 % = B		

Please refer to the *Mississippi College Graduate Catalog* for a discussion of the university's graduate grading system and how grade points are assigned.

Academic integrity: Mississippi College students are expected to be honest. Please refer to the *Mississippi College Undergraduate Bulletin* or to the *Mississippi College Graduate Catalog* for a discussion of plagiarism and cheating. Also refer to the *Mississippi College Tomahawk* or to University Policy 2.19.

Course Overview: The course covers material presented in chapters 1-7, chapter 9, and chapters 11-16 of the textbook. Chapter 1 presents an introduction to inorganic chemistry. Chapter 2 covers atomic structure and trends in the periodic chart. Chapters 4-6 cover bonding theories while chapter 3 presents symmetry and group theory. Acid-base chemistry is covered in chapter 9, and an introduction to solid-state chemistry is presented in chapter 7. Some descriptive chemistry is covered in chapter 14, and coordination chemistry is covered in chapters 11-13. Chapter 15 presents an introduction to organometallic chemistry and inorganic chains, rings, cages, and clusters are discussed in chapter 16.

Course Outline:

I. Introduction to Inorganic Chemistry

II. Nucleogenesis

- A. Cosmic distribution
- B. Terrestrial distribution

III. Atomic Structure

- A. Review of the hydrogen atom and its wavefunctions
- B. Polyatomic atoms
    - 1. Electron spin and the Pauli Exclusion Principle
    - 2. Aufbau Principle
    - 3. Electronic configurations and the Periodic Chart
    - 4. Atomic term symbols and Hund's Rules

IV. Periodic Trends

- A. Shielding and Slater's Rules
- B. Atomic size
- C. Ionization potentials
- D. Electron Affinity
- E. Electronegativity

V. Symmetry and Group Theory

- A. Symmetry elements
- B. Schoenflies point groups
- C. Irreducible representations and character tables
- D. Uses of symmetry
    - 1. Wavefunction classification
    - 2. Optical activity
    - 3. Dipole moments
    - 4. Spectroscopic selection rules

VI. Bonding Models

- A. Ionic compounds
    - 1. Crystal systems
    - 2. Structures of crystal lattices
    - 3. Lattice energy and the Born-Haber Cycle
    - 4. Atomic size revisited - ionic radii
- B. Covalent compounds
    - 1. Valence bond theory
        - a. Lewis structures
            - (1) resonance
            - (2) formal charges
        - b. Hybridization
        - c. VSEPR theory
    - 2. Molecular orbital theory
        - a. Linear combination of atomic orbitals
            - (1) delocalization
            - (2) antibonding orbitals
        - b. Symmetry and overlap
        - c. Homonuclear diatomic molecules
        - d. Heteronuclear diatomic molecules
        - e. Bond order and bond strength

- f. Polyatomic molecules
  - (1) B_2H_6
  - (2) SF_6
  - (3) O_3

VII. Complex Ions and Coordination Compounds
- A. Nomenclature
- B. Theories of bonding
  - 1. Valence bond theory
  - 2. Crystal field theory
  - 3. Ligand Field theory

VIII. Solid State
- A. Band Theory
- B. Metals
- C. Alloys
- D. Semiconductors
  - 1. Intrinsic
  - 2 Extrinsic
    - a. *p*-type
    - b. *n*-type
- E. Superconductors
  - 1. Low temperature
  - 2. High temperature

IX. Nuclear Isomers of Hydrogen

X. Acid-Base Chemistry

XI. Environmental Chemistry

XII. Organometallic Chemistry
- A. The 18-electron rule
- B. Nomenclature

XIII. Interesting Inorganic Structures
- A. Chains
- B. Rings
- C. General cages
- D. Boron Cage Compounds
- E. Metal Clusters

Learning Objectives: (This is not an exhaustive list.)

1) Learn the theory of nucleogenesis, what nuclear reactions take place in the stars, why different stars have different colors, why iron is the end product of stellar fusion, and how elements heavier than iron are formed.
2) Learn the cosmic and terrestrial distributions of the elements and understand why they are different.
3) Learn the different parts of the hydrogenic wavefunctions and how nodes relate to relative energies.
4) Learn that electron spin is actually intrinsic angular momentum.
5) Learn how to determine atomic term symbols from a given electronic configuration and how to use Hund's Rules to predict the electronic ground state.

6) Learn how to explain trends in the periodic chart and hot to rationalize exceptions to these periodic trends.
7) Learn how to assign molecules and geometrical objects to their proper symmetry point group.
8) Learn how to use symmetry to determine if a molecule is polar or not.
9) Learn how to use symmetry to determine if a molecule is chiral or achiral.
10) Learn how to assign wavefunctions and motions of molecules to the proper irreducible representations of the point groups to which the molecules belong.
11) Learn how to compute direct products of irreducible representations and how these direct products may be used to determine spectroscopic selection rules..
12) Learn the seven crystal systems and the fourteen different Bravais lattices.
13) Learn some of the differences and similarities of valence bond theory and molecular orbital theory.
14) Learn how to draw Lewis structures, including those for some open-shell systems.
15) Learn how to use formal charges to predict the relative weight of different canonical structures to the resonance hybrid.
16) Learn that hybridization does not predict geometry, but rather geometry predicts hybridization.
17) Learn how to predict molecular geometries using VSEPR theory.
18) Learn how molecular orbitals are constructed from the linear combination of atomic orbitals.
19) Learn about nonbonding, antibonding, and virtual molecular orbitals.
20) Learn how to compute the bond order in a molecule from the molecular orbital energy diagram.
21) Learn how molecular orbital theory handles hypervalency and electron-deficient molecules.
22) Learn how to name complex Ions and coordination compounds.
23) Learn the strengths and weaknesses of valence bond theory, crystal field theory, and molecular orbital theory in describing the bonding in and color of coordination compounds and complex ions.
24) Learn how molecular orbital theory can explain why metal carbonyls are often colorless while a complex like $[CoF_6]^{3-}$ is brightly colored.
25) Learn how band theory can explain bonding in metals and semiconductors.
26) Learn the composition of some common alloys.
27) Learn the difference between substitutional and interstitial alloys.
28) Learn the difference between intrinsic and extrinsic semiconductors.
29) Learn the difference between *n*-type and *p*-type extrinsic semiconductors.
30) Learn the difference between low-temperature and high-temperature superconductors.
31) Learn about the different isotopes of hydrogen.
32) Learn about the different nuclear spin isomers of molecular hydrogen.
33) Learn the different models of acids and bases.
34) Learn how the acidity of binary hydrogen compounds vary.
35) Learn how to determine the relative strengths of oxyacids.
36) Learn what causes the ozone hole.
37) Learn the major sources of acid rain.
38) Learn what causes the “Greenhouse Effect.”