**Chemistry 361  
Inorganic Chemistry**

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| |  |  |  | | --- | --- | --- | | **INSTRUCTOR** | **Office** | **E-Mail** | | Lori Watson | Office: SH 239  Phone: 983-1856 | [watsolo@earlham.edu](mailto:watsolo@earlham.edu) | | |
| **TEXTS** | REQUIRED: Inorganic Chemistry, 5th ed.  by Shriver and Atkins, et. al. |
| **CLASS MEETINGS** | MWF (lecture) 11:00-11:50 (CST 224)  M (lab) 1:00-4:00 (SH 263) |

**COURSE DESCRIPTION**

Inorganic chemists study the entire periodic table (even carbon—as long as it’s bound to a metal!) and are interested in the structure and reactivity of a wide variety of complexes. We will spend the first third of the course learning some “tools” and then will apply them to a variety of current topics in inorganic chemistry (bioinorganic chemistry, solid state materials, catalysis, nuclear chemistry, and more!).

**LEARNING GOALS**

* Students will be able to articulate principles of atomic structure, spectra and orbitals, ionization energy, electron affinity, shielding and effective nuclear charge.
* Students will be able to discuss approaches to modeling bonding interactions of covalent molecular substances including geometries (symmetry point groups), valence bond theory (hybridization, σ, π, δ bonds), molecular orbital theory (homo and hetero-nuclear diatomics, multi-centered MO, electron-deficient molecules, π -donor and acceptor ligands).
* Students will be able to explain elements of transition metal and coordination chemistry and their effects on bonding, reactivity, and spectroscopy. Topics covered will include ligands, coordination number, stereochemistry, bonding motifs, nomenclature; ligand field and molecular orbital theories, Jahn-Teller effects, magnetic properties, electronic spectroscopy (term symbols and spectrochemical series), thermodynamic aspects (formation constants, hydration enthalpies, chelate effect), kinetic aspects (ligand substitution, electron transfer, fluxional behavior), lanthanides and actinides.
* Students will be able to compare and contrast the bonding and reactivity of organometallic complexes with traditional coordination chemistry and organic compounds. Topics will include metal carbonyls, hydrocarbon and carbocyclic ligands, 18-electron rule (saturation and unsaturation), synthesis and properties, patterns of reactivity (substitution, oxidative-addition and reductive-elimination, insertion and de-insertion, nucleophilic attack on ligands, isomerization, stereochemical nonrigidity).
* Students will understand the basic structure of solid state materials including close packing in metals and metal compounds, metallic bonding, band theory, magnetic properties, conductivity, semiconductors, insulators, and defects.
* Students will use their knowledge of inorganic chemistry in two applied fields, catalysis and bioinorganic chemistry, applying principles of bonding and reactivity in inorganic chemistry to molecules and processes important in these applications.

**GRADING**

3 Exams: 300 points

Final: 150 points

Homework: 100 points

Descriptive Chemistry Project: 30 points

Laboratory: 120 points

**MORE ON HOMEWORK AND OTHER ASSIGNMENTS**

There will be 12 problem sets, generally due most weeks; the top 10 problem sets will be counted. You will have approximately 1 week to do each one. You are welcome to work on them in a group, as long as all members contribute, but each person must write up and submit their own answers. **NO late homework will be accepted.**

The most important thing to remember here is: DON’T PANIC!!! Problem sets are meant to challenge you and to help you begin to apply the basic principles we learn and practice in class to problems like those you will encounter in the “real” world of chemistry. The solutions might not be immediately obvious—they require some thought! But I promise—they *are* solvable with the concepts you have learned. And I will be available to help if you have questions!

To help you to practice basic concepts, from time to time I will also provide ungraded practice sheets (with answer keys). You should use these to gain confidence and to study for the exams!

There will also be an individual project on a topic of descriptive chemistry. More information about this assignment will be given in class.

Success in this course absolutely relies on excellent attendance.

**EXAMS**

**There will three exams and a final in this course. Each may be a combination of a take-home and an in-class portion. If there is a take home portion, you may use your book and any notes but you may NOT work together or discuss the exam with anyone except me or do additional research on the web or in the library to answer the questions. The in-class portion will be given during the regular class period. The final exam will be comprehensive, though there will be more questions on material since the 3rd exam. The final exam is scheduled for Monday, April 30, 10:30 a.m.**

**LABORATORY**

You will need to have a notebook and safety glasses for each laboratory period. As many of the reagents we will be working with can be harmful, you should wear gloves at all times. Wearing pants (or a long skirt) and closed toed shoes is also highly encouraged! Additional safety information and a list of the experiments are provided later in this manual.

**MODEL SET**

Each student will need a model set appropriate for inorganic chemistry (it should have parts with the center atoms capable of forming 5 or 6 bonds). We will use it in class and in lab, and you will also be allowed to use it on exams. If you do not own one, you can rent one from the chemistry department for $5.00 for the whole semester. You need to pay a deposit of $25.00 and you will get $20.00 back when you return it. You can also purchase it for the original cost of $25.00.

**ACADEMIC INTEGRITY**

We expect that all material turned in by you is your own work, even though studying and reviewing in groups is strongly encouraged. To quote the *Earlham College Community Principles and Practices*: "*The College trusts students who enroll at Earlham to be honest seekers of truth and knowledge…. Students must be mindful that, although Earlham encourages cooperative and collaborative, rather than competitive, modes of learning, one's work must still be one's own, unless explicitly assigned to a group. Giving or receiving aid inappropriately on assignments and tests, or plagiarizing by using another person’s words or ideas without credit, constitutes a serious breach of our trust in one another and in the integrity of the search for truth*".

In this class, in class exams are to be done without reference to books, notes or other external sources; for the take-home portion of the exams you may use your book and any notes you have taken, but you may not talk to others about the exam or do additional research (i.e. on the web, SciFinder, etc.) on the problems. Laboratory reports and problem sets must be written individually and be your own work, though you are encouraged to discuss the interpretation of your results with your lab partner or groups of students in the class. Your descriptive project and any other class activity is to be your own work, with appropriate citation of information, words, ideas, and figures to the sources from which you have obtained them.

If you are aware of a violation of academic integrity, it is your responsibility to take action. Again, from the *Community Principles and Practices*, “Those who believe they have witnessed violations of academic honor should feel obligated to speak about this to the potential offender. The witness should also feel obligated to report the potential offender to the instructor if the person fails to offer a satisfactory explanation and refuses to report him or herself.” The honor code is both a privilege and a responsibility, and we expect you to take it seriously.

**ACCOMADATIONS FOR DOCUMETNED SPECIAL NEEDS**

Any student with a documented disability (e.g., physical, learning, psychiatric, vision, hearing, etc.) who needs to arrange reasonable accommodations must contact Academic Support Services and the instructor at the beginning of each semester. Accommodation arrangements must be made during the first-two weeks of the semester.

Please see <http://www.earlham.edu/policies/learning-disabilities.html> for details.

**Tentative Lecture Schedule**

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| --- | --- | --- | --- |
| Week | Dates | Readings | Topic |
| 1 | Jan 10 | 1.1-1.2 | Syllabus/Intro |
| Jan 12 | 1.3-1.5 | It’s a wave!  It’s a particle! Structure of orbitals |
| 2 | Jan 15 | 1.6-1.10; 9.1-9.5 | Effective nuclear charge and atomic properties; Review Lewis structures/VSEPR; *PS 1 due* |
| Jan 17 | 2.1-2.6 | Simple valence-bond theory |
| Jan 19 | 6.1-6.2 | Symmetry elements and Point Groups |
| 3 | Jan 22 | 6.3-6.5 | Applications of symmetry; *PS 2 due* |
| Jan 24 | 2.7-2.10 | MO theory of diatomics |
| Jan 26 | N/A | Information Literacy/Descriptive Project (Jose Ignacio) |
| 4 | Jan 29 | 2.11-12; 6.6-10 | MO of polyatomic molecules; *PS 3 due* |
| Jan 31 | 2.13-2.16 | MO of polyatomics continued |
| Feb 2 | 7.1-7.6 | Coordination Compounds: nomenclature and geometry |
| 5 | Feb 5 | 7.7-7.15 | Coordination Compounds: Isomerism and thermodynamics; *PS 4 Due* |
| Feb 7 | 19.1-19.2 | d-block chemistry—general considerations |
| Feb 9 | N/A | Exam 1: Chapters 1-2, 6, 9 |
| 6 | Feb 12 | Box 19.2 | Metal-Metal bonding and other bonding types; project topic due |
| Feb 14 | 20.1 | Crystal field theory |
| Feb 16 | N/A | Midterm break: No class |
| 7 | Feb 19 | 20.2 | Ligand field theory |
| Feb 21 | 20.3-20.7 | Electronic spectra of complexes; *PS 5 Due* |
| Feb 23 | P264, 20.8-20.9 | Magnetism |
| 8 | Feb 26 | 21.1-21.6 | Ligand substitutions |
| Feb 28 | 3.1-3.8 | Closest Packed Structures, metals and alloys; *PS 6 due* |
| Mar 2 | 3.9-3.15 | Ionic Solids and Lattice enthalpies |
| 9 | Mar 5 | 3.16-3.20 | Band gaps and solid solutions |
| Mar 7 | Sections in Ch24 TBA | Material properties (diodes and thermoelectric devices) |
| Mar 9 | N/A | Exam 2: Sections of Chapters 7, 19, 20, 21 |
| 10 | Mar 12 | N/A | Spring break |
| Mar 14 | N/A | Spring break |
| Mar 16 | N/A | Spring break |
| 11 | Mar 19 | N/A | ACS meeting; No Class. Time to work on Descriptive Project |
| Mar 21 | 8.1-8.2 | X-ray diffraction |
| Mar 23 | 22.1-22.4 | Organometallic chemistry—bonding; *PS 7 due* |
| 12 | Mar 26 | 22.5-22.20 | Organometallic chemistry—ligands |
| Mar 28 | 22.21-22.26 | Organometallic chemistry—reactions |
| Mar 30 | 25.1-25.9 | Homogeneous catalysis; *PS 8 due* |
| 13 | Apr 2 | 24.13-24.17 | Metal oxides and applications; Hydrogen storage materials and pigments |
| Apr 4 | 24.22-24.30 | Nanomaterials |
| Apr 6 | 25.10-25.17 | Heterogeneous catalysis; *PS 9 due* |
| 14 | Apr 9 | 26.1-26.5 | Bioinorganic—intro and Na/K/Ca/Zn |
| Apr 11 | 26.6-26.8 | Bioinorganic—transport and storage of Fe and O2 |
| Apr 13 | 26.9-26.12 | Bioinorganic—enzymes; *PS 10 due* |
| 15 | Apr 16 | N/A | Exam 3: Sections of Chapters 3, 22, 24, 25, 26 |
| Apr 18 | N/A | No Class: Celebration of Learning |
| Apr 20 | 26.13-26.14 | Bioinorganic—Nitrogenases and hydrogenases; *PS 11 due* |
| 16 | Apr 23 | 27.1-27.10 | Metals in medicine |
| Apr 25 | 27.1-27.10 | Metals in medicine, cont. |
| Apr 27 | N/A | review for final exam; *PS 12 due; Final descriptive chem project must be posted and all lab reports turned in* |

**LABORATORY INFORMATION**

*Schedule*

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| Date |  |
| Jan 15 | VSEPR and Computational Modeling |
| Jan 22 | The wonderful world of symmetry |
| Jan 29 | Molecular Orbital Theory and its Applications |
| Feb 5 | Ag Antimicrobial Complexes pt 1 |
| Feb 12 | Ag Antimicrobial Complexes pt 2 |
| Feb 19 | Anomalous Paramagnetism/ Ag Antimicrobial Complexes pt 3 |
| Feb 26 | Anomalous Paramagnetism/ Ag Antimicrobial Complexes pt 4 |
| Mar 5 | Solid State Models. |
| Mar 12 | No Lab: Spring Break |
| Mar 19 | No Lab: Work on Descriptive Projects |
| Mar 26 | Ferrocene + BuLi |
| Apr 2 | Ferrocene + BuLi, cont. |
| Apr 9 | Cobaloximes |
| Apr 16 | Cobaloximes, cont. |
| Apr 23 | Check out/ Finish all spectra |

*Laboratory Reports*

You will write a laboratory report 4 experiments using the *communication* (not article)template provided at: http://pubs.acs.org/page/inocaj/submission/templates.html

Each report should be no longer than 2 typed pages (notice that the template is *single* spaced!).  It should include a short introduction (1-2 paragraphs), results and discussion (including chemical equations and structures), and a conclusion (1-2 paragraphs).  You should read and cite at least 3 references (the more the merrier, within reason), of which at least 1 must be a primary (journal) source.  Web sources and this lab manual will NOT count toward the required 3 references. Your *concise* experimental (what you did!) can be included as a footnote, or included in “Supplementary Material.”  Supplementary Material will be either paper or electronic copies of all spectra, etc. plus your experimental if you don’t have room in the actual lab report.  To see what an example of a communication looks like, go look at a recent issue of the *Journal of the American Chemical Society* or *Inorganic Chemistry* and find the “Communications” section.  Laboratory reports are due at the beginning of the lab period two weeks after the lab is finished (the exception is the final lab, which is due the last day of class).  The *rare* exception must be negotiated with me in person before the deadline (this means the Friday before the Monday that it is due).  Late or incomplete lab reports will lose one letter grade per day.  You will have an opportunity to re-write the first laboratory report after it is graded if you wish.  The VSEPR, symmetry, MO theory, and solid state model labs will have worksheets to turn in instead of formal laboratory reports and will be turned in the next laboratory period.

*Laboratory Grading*

Your laboratory grade is 120 points of your final grade in the course.  It will be distributed as:

Four worksheets 10 pts × 4 = 40 pts

Each lab report 20 pts × 4 = 80 pts

You will receive a -10% reduction in this grade for every unexcused lab absence or lateness.

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