Chemistry 355: Intermediate Inorganic Chemistry

<u>Instructor Information</u>
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I. Course Description and Learning Outcomes.

Catalog Description: An introduction to the chemistry of inorganic compounds and materials. Descriptive chemistry of the elements. A survey of Crystal Field Theory, band theory, and various acid-base theories. Use of the chemical and scientific literature. Introduction to the seminar concept

This course is intended to be a survey of aspects of modern inorganic chemistry. As you progress through the course, you will find that Inorganic Chemistry combines elements (no pun intended) from *all* areas of chemistry, including general chemistry, organic chemistry, physical chemistry, analytical chemistry, and biochemistry. Becoming comfortable with *chemistry* is one of the most important goals of this course. A key aspect of the course will be the use of current literature. Chemical literature is one of the best places to learn about techniques and methodologies, and to get fresh ideas for research. The onus will, of course, be on you to read all of the assigned material. I will not necessarily cover every reading assignment in class; it will be up to you to ask questions on the readings.

I strive for inclusive excellence in Chem 355—regardless of race, ethnicity, gender, sexual orientation, beliefs, socio-economic status, or cognitive ability, you should feel comfortable in this class. If you ever feel uncomfortable, please come and see me.
After completing Chem 355, you should be able to satisfy the following learning outcomes.

1. Apply foundational principles of Inorganic Chemistry to identify and explain the chemical and physical properties of matter.
2. Evaluate and communicate solutions to chemistry-related issues and problems, particularly Inorganic Chemistry related issues and problems, according to accepted scientific standards as, for example, a report, poster, or oral presentation. I will focus on the oral communication aspect of the Chemistry major. This relates to the seminar concept in the catalog description. Seminars are a place where the audience has an opportunity to engage the speaker through questions, and as an expert, the speaker needs to answer those questions quickly and thoughtfully. By the way, the speaker in this class is you!
3. Search and discuss the modern chemical literature and databases.
4. Utilize modern inorganic synthetic techniques to safely synthesize and characterize inorganic compounds and report those results.

II. Course Information

Schedule for Spring 2020

	Monday	Tuesday	Wednesday	Thursday	Friday
8AM	**Off campus**	**Off campus**	**Off campus**	**Off campus**	**Off campus**
9AM	**R, P, G**	**R, P, G**	**R, P, G**	**R, P, G**	**R, P, G**
10AM	**Meetings**	**355 Lec 01 CBB 265**	**Office Hour**	**355 Lec 01 CBB 265**	**355 Lec 01 CBB 265**
11AM	**R, P, G**	**105 Lab 02L2 CBB 226**	**R, P, G**	**R, P, G**	**R, P, G**
12PM	**R, P, G**	**105 Lab 02L2 CBB 226**	**R, P, G**	**R, P, G**	**R, P, G**
1PM	**Office Hour**	**105 Lab 02L2 CBB 226**	**R, P, G**	**101 Dis 01 CBB 105**	**R, P, G**
2PM	**Meetings**	**R, P, G**	**Office Hour**	**Meetings**	**Meetings**
3PM	**Meetings**	**R, P, G**	**Meetings**	**Meetings**	**Meetings**
4PM	**R, P, G**	**R, P, G**	**Meetings**	**Meetings**	**Meetings**

R, P, G: Research; other Office Hours by appointment

A. Course Materials

1. Rayner-Canham, G., and Overton, T. *Descriptive Inorganic Chemistry*, 6th ed. (Required; available from text rental)
2. http://pubs.acs.org: American Chemical Society Journals
3. http://www.rsc.org/Publishing/index.asp: Royal Society of Chemistry Journals
4. https://www.uwsp.edu/canvas/Pages/default.aspx: Use Canvas to follow your progress!

B. Course Assessments

1. **Problem sets.** There will be a total of 6 problem sets, each worth 60 points, and each set will contain several questions, some of which will require you to use the SciFinder database. I will, however, grade only three problems from each set. Don't try to guess which problems I'm going to grade! There will be a 10-point penalty for incomplete problem sets (didn't finish a problem, when you could have come and spoken with me? Yup, that's incomplete). Late problem sets will be assessed a 10%-per-day penalty. I will drop the lowest problem set score.
2. **Examinations and Literature Discussions.** Examinations will take place on Wednesday evenings from 6 to 9 PM. Exams will be divided into two parts: a written part based on lecture material, and an oral part based on a class literature discussion. The literature discussions will be held 2-weeks prior to each exam. I will provide you with a paper from the inorganic chemistry literature, along with

questions to guide your reading. We will then meet in class on those discussion days to discuss the answers to those questions, often with you presenting your answers. The oral portion of your exam will be based on the answer to one of your questions.

3. **Quizzes.** Every so often I'll give you a quiz as a "check" on your understanding. Quizzes will be unannounced and will be a way of assessing your independently "keeping up" with material.
4. **Final Exam.** More to come!

Exams will be given on Wednesday evenings from 6-9PM. We will determine our exam dates as a class on the first Friday after class begins.

C. Grading

Assignment	Point Value
3 exams, 150 points each	450
6 quizzes, 10 points each	60
6 problem sets, 60 points each, lowest dropped	300
Final Exam	150
Total	960

Total points accumulated will be converted to a percentage of the total points possible. I reserve the right to adjust these cut-off points, but in no case will the cut-off for a particular grade be higher than those listed.

Grades will be assigned according to the following scheme: 90.0-100%, A; 88.0-89.9%, A-; 85.0-87.9%, B+; 83.0-84.9%, B; 79.0-82.9%, B-; 74.0-78.9%, C+; 68.0-73.9%, C; 65.0-67.9%, D+; 60.0-64.9%, D; 59.9% and lower, F.

Drop/Withdraw dates
Last day to add or drop a 16 week course without a grade - Jan. 30
Last day to drop a 16 week course - April 3

D. Learning Objectives and Course Material

The course schedule appears in an addendum to the syllabus. Please note I do not list what topics I will cover on a particular day; rather, I indicate which chapter from Rayner-Canham and Overton will be covered. I adjust my pace, as necessary, to accommodate the difficulty–or ease!–of material. The following are the objectives you will be able to meet after finishing a particular chapter.*

Chapter 1. The Electronic Structure of the Atom.
As we finish Chapter 1, you will be able to ...

1. … describe the components of an atom.
2. … qualitatively describe electrons in terms of the wavefunction, ψ(x) including its angular and radial parts.
3. … describe, and show, how an electron's location can change based on effective nuclear charge, Z_{eff}
4. … write electron configurations for atoms, ions, and excited states.

Chapter 2. The Structure of the Periodic Table.
As we finish Chapter 2, you will be able to...

1. … define and identify basic periodic trends.
2. … define and identify basic group trends (includes ideas from Chapter 9).
3. … define and utilize concepts from the following to place elements and ions in energetic order:
   (a) Ionization energy, IE
   (b) Electron affinity, EA
   (c) Electronegativity (Pauling), χ
4. … utilize Slater's rules to quantitate Z_{eff} ***Viper activity (Slater's Rules, PS)***
5. … identify and utilize other periodic trends such as the "diagonal relationship"
6. ***VIPEr activity (Hoffmann lit discussion, TBA, LD)***

Chapter 3. Covalent Bonding and Molecular Spectroscopy.
As we finish Chapter 3, you will be able to...

1. … define and identify the basic symmetry elements and operations: E (identity), σ (mirror plane and reflection), C_n (rotational axis), S_n (improper rotational axis), and *i* (inversion)
2. … draw Lewis structures, including assigning formal charges to atoms.
3. … use Lewis structures in conjunction with VSEPR to draw 3-dimensional representations of molecules.
4. … apply symmetry elements and operations to VSEPR structures.
5. ...assign point groups to molecules. ***VIPEr activity (Symmetry Resources at Otterbein, PS)***
6. ...use valence-bond theory to describe bonding.

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* Please note that I will be using a number of Learning Objects from VIPEr (**V**irtual **I**norganic **P**edagogical **E**lectronic **r**esource). VIPEr is a community of Inorganic Chemists who work collaboratively to improve the teaching of Inorganic Chemistry. ***LD*** stands for literature discussion, and ***PS*** stands for problem set.

7. ...use hybrid orbital theory to describe bonding.
8. ...use molecular orbital (MO) theory to describe bonding.
9. ...construct qualitative frontier MO diagrams for diatomic molecules.
10. ... identify Lewis acids and Lewis bases (includes ideas from Chapter 7).
11. ...use Lewis acid/base theory from a frontier orbital perspective to describe bond formation in inorganic complexes (includes ideas from Chapter 7).
12. ... define hard-soft acid-base theory (HSAB) (includes ideas from Chapter 7).
13. ... use HSAB to rationalize bond formation (includes ideas from Chapter 7).
14. ***VIPEr* activity *(Modeling of the Flavodiiron Nitric Oxide Reductase Active Site, LD)***

Chapter 19. Transition Metal Complexes.

As we finish Chapter 19, you will be able to ...

1. ...describe and identify the characteristics of a transition metal complex (coordination number, ligands).
2. ... identify and/or determine the number of stereoisomers of transition metal complexes.
3. ...name transition metal complexes. ***VIPEr* activity *(IUPAC Brief Guide to the Nomenclature of Inorganic Chemistry)***
4. ... explain the bonding in transition metal complexes using crystal field theory (CFT).
5. ...calculate crystal field stabilization energy (CFSE) in octahedral and tetrahedral transition metal complexes.
6. ...differentiate between high-spin and low-spin transition metal complexes.
7. ... use CFSE to explain trends in the properties of transition metal complexes.
8. ... apply concepts from CFT to explain the electronic absorption spectra of transition metal complexes, including the energy of electronic transitions, and the nature of the transitions.
9. ... qualitatively explain the differences between CFT, ligand-field theory, and MO theory of transition metal complexes.
10. ...explain the difference between kinetic and thermodynamic factors in transition metal complex formation. Describe general mechanisms of transition metal complex formation (substitution reactions, cis versus trans effects).
11. ... rationalize the syntheses of transition metal complexes using a variety of principles, including thermodynamics, HSAB, CFSE, etc.
12. ***VIPEr activity* (*Characterization and Investigation of a Binuclear Manganese(III)-Peroxo Metastable Intermediate, LD*)**

Chapter 23. Organometallic Chemistry.

As we finish Chapter 23, you will be able to...

1. ... extend principles of transition metal complexes to organometallic complexes.
2. ...identify organometallic complexes.
3. ...identify ligand types in organometallic complexes (σ-donor and π-acceptor), and how their electronic structures affect the metal.
4. ... describe the synthesis and reactivity of some main-group organometallic complexes.

5. ... use the so-called 18-electron rule (effective atomic number rule, EAN) to rationalize the stability and reactivity of transition metal organometallic complexes.
6. ...describe bonding in organometallic complexes, especially in terms of σ-donor and π- acceptor ligands. ***VIPEr activity (Homework 1, Stanley, Organometallics, PS)***
7. ...identify some common "spectroscopic handles" for transition metal organometallic complexes.
8. ... explain the steps of a common transition metal organometallic catalytic cycle in terms of the 18-electron rule, and terminology such as reductive elimination and oxidative addition. ***VIPEr activity (Working with Catalytic Cycles, PS)***

Chapters 4 and 5. Solid State Chemistry.
As we finish Chapter 4, you will be able to...

1. ...describe bonding in extended structures (solids).
2. ...identify and compare various unit-cell packing arrangements. ***VIPEr activity*** **(*Solid State Structures, PS/Discussion*)**
3. ... define a unit cell and use that definition to determine properties such as unit cell volume and side length.
4. ...describe differences between ionic and covalent solids.
5. ... use periodic trends such as anion and cation size to describe the properties of ionic com- pounds.
6. ...describe various types of ion packing.
7. ... use the "radius ratio rule" to determine optimal packing arrangements.
8. ... describe common classes of solid-state clusters, e.g. perovskites and spinels.
9. ***VIPEr activity (Using Solid State Chemistry and Crystal Field Theory to Design a New Blue Solid, LD)***

E. Etiquette and Inclusive Excellence. It is absolutely essential that you show respect to your peers and your instructor. As such, the following will not be tolerated:

1. Cell phones/iPhones/other electronic devices. Turn them off during class!
2. Informal e-mails. Sending an e-mail is not like texting or tweeting. A properly formatted e-mail should look like a letter, with a subject, salutation, body, and signature. Well-written e-mails are effective at communicating ideas. Poorly written e-mails only serve to confuse and annoy the reader, and portray you in a less than flattering light.

F. Academic Misconduct. Full information on academic misconduct can be found at https: //www.uwsp.edu/dos/Pages/Student-Conduct.aspx. Academic misconduct is a serious mat- ter, with a wide-range of penalties. Please familiarize yourself with faculty, staff, and student rights and responsibilities regarding academic misconduct. Please let me know if you have questions per- taining to academic misconduct.

G. Disability Services. There are a number of resources available for students with documented disabilities. A full listing of them can be found at https://www.uwsp.edu/datc/Pages/ default.aspx. Please be aware that, in order to take advantage of some of the services, you must provide me with an Accommodation Request Form which I will sign. You must return the form to Disability Services.