CHEMISTRY 422W FALL, 2007

ADVANCED INORGANIC CHEMISTRY

Instructor: Dr. Brian W. Pfennig
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Lectures: M W F 11:00 – 11: 50 AM, Pfahler 107

Office hours: Informally: I have an open-door policy anytime that I am on campus (most Thursdays, I will be working from home)
Formally: By appointment or at the times indicated below
Mondays, 9:15 – 10:45 AM
Tuesdays, 10:00 – 11:00 AM
Fridays, 12:00 – 1:00 PM

Description: A study of bonding theories, point groups, structure, stereochemistry, and reactivity of inorganic and organometallic materials with an emphasis on transition metal compounds. Other topics include superconductivity, catalysis, and bio-inorganic chemistry. Written and oral exercises are required, as well as a major paper. Prerequisites: CHEM-322. Three hours per week. *Three semester hours*.

Textbook: Required: Miessler, G. L.; Tarr, D. A. *Inorganic Chemistry*, 3rd ed. (Pearson Prentice Hall: Upper Saddle River, New Jersey, 2004). This course will cover Chapters 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14 (if time permits).
Supplemental: Pfennig, B. W. *Advanced Physical Inorganic Chemistry* (unpublished work, available in-house as a bound work or on CD).

Requirements:

Assignments (journal)	up to 100 pts
Two three-hour exams	300 pts
Two short papers	200 pts
Major paper	200 pts
Cumulative final exam	200 pts

Grading: Grades are to be based on your overall score out of 1000 possible points. The specific numerical range necessary for a given letter grade is not set in advance. Instead, it will depend on both the class average and on how well the class performs relative to scores for the same course from previous years. Class averages will be posted. I encourage you to discuss your grade with me at any time.

Assignments: I will periodically distribute problem sets or assign questions from the textbook(s). The target dates indicated on the assignments are only recommendations. Lectures and assigned readings provide you with the background and knowledge preliminary to learning; true understanding can only occur if you work with and apply the material. I expect that you will work as many of these problems as you can and that you will record your progress in a bound notebook exclusively dedicated to this purpose. Every Monday at 11:00 AM, you will be expected to turn in carbon copies of your journal. Your journal entries should keep a record of your studies in the course during the previous week: what pages in the textbook you read, any notes that you took on the readings, a summary of how many hours and what topics you studied, the solutions to any of the problems you attempted, etc. If, at that time, you have any specific questions about the class, you may also ask them here. I do not expect that you will do every exercise every week. I recognize that there isn't always enough time in the week to do so. In addition to grading the problems that you attempted, I will also provide feedback and encouragement. Points (up to a maximum of 100) will be awarded throughout the semester in a fair and balanced manner on the basis of consistent effort, the quality and quantity of assigned questions that you answered, attendance and active participation in class, independent thought, and intellectual insight, as evidenced by your journal entries and attendance record.

Exams: Because each exam is three hours, you will be given a 48-hour window during which time you can sign out your exam from the departmental secretary, proceed to a quiet location in Pfahler to work on your exam, and return the exam to the secretary within three hours. All exams are closed-book unless specific materials (such as a Periodic table or character tables) are allowed, in which case the allowed items will be listed on the cover of the exam. You should not discuss the exam material or level of difficulty with anyone else during the 48-hour window. The exam times are as follows:

Exam 1 begins Mon., Oct. 8 (at noon) and ends Wed., Oct.10
Exam 2 begins Wed., Nov. 14 (at noon) and ends Fri., Nov. 16
Final exam begins Mon., Dec. 10 (at noon) and ends Wed., Dec. 12

Papers

Short paper on an assigned element is due Fri., Sept. 14 (noon)
Short paper on assigned scientist is due Wed., Oct. 17 (noon)
Major paper on assigned topic is due Mon., Dec. 3 (noon)
LATE papers will not be accepted and will receive a grade of 0.

Attendance policy: Your attendance in class and your work ethic outside of class are essential to your success in this course. I will allow up to four absences without a valid excuse from the Dean's office. Students who miss five or more classes without an excused absence will be excluded from the course with a grade of F. The material in this course is cumulative and the course itself is fast-paced. Even missing one class will make it very difficult for you to catch up on your work.

Academic integrity: From the College catalog: **"**Ursinus is a small community, which functions on a social contract among students and faculty. In order for the spirit of community to endure and thrive, this agreement, based upon shared values and responsibilities and a sense of mutual respect, trust, and cooperation, must be preserved. Students have an obligation to act ethically concerning academic matters and the faculty has a responsibility to require academic honesty." Any academic dishonesty will be treated according to College policy and might well result in an F for the course.

Examples of academic dishonesty include the following (this is not intended to be a comprehensive list):

1. Copying information from a fellow student's paper or collaborating on assignments.
2. Divulging answers or information to aid another student during an examination.
3. Relaying or receiving any improperly obtained or confidential information concerning an examination. (Example: if one sees the test before it is to be given and transmits information concerning its contents or level of difficulty to other students.)
4. Using any unauthorized notes, books, calculators, electronic devices (including text messages or cell phones), problem solving aids such as "cheat sheets" during an examination.
5. Collaborating improperly with another student on an open-book or take-home quiz or examination; or obtaining information from an unsuspecting fellow student during such an exercise.
6. Plagiarizing any person's thoughts or ideas in any form.
7. Borrowing or stealing lecture notes or any information gathered by another student and presenting it as your own work.
8. Misrepresenting yourself to an instructor for the purpose of gaining special favors or extensions for academic work missed. Examples include but are not limited to lying about your health or the health of a relative, forging doctor's notes, etc.

You are an accessory to cheating and equally culpable if you:

1. Witness or have direct knowledge of any of the aforementioned forms of cheating and fail to inform the professor.
2. You bring unauthorized materials into a testing area (even if you do not use them).

Course objectives: The primary goals of this course are:

1. To introduce students to symmetry concepts and the utility of group theory in chemistry and to use this as an underlying theme for the semester.

2. To present a thorough survey of the physical principles of inorganic, organometallic, and coordination chemistry.

3. To develop analytical thinking skills and the ability to solve sophisticated problems involving molecular structure and spectroscopy.

4. To examine the reactivity, kinetics, and thermodynamics of inorganic and organometallic reaction mechanisms.

5. To be able to search the chemical literature for current information about topics relating to the course material and to present a coherent and well-reasoned written report on the assigned topics.

Academic disability: Any student who has an academic disability and who requires special accommodations as a result, such as extra time on exams or assignments, a separate examination room, etc. should contact the appropriate individual in the Dean's Office for documentation *at the start of the semester.* In consultation with the student and the Dean's Office, the instructor will then discuss what constitutes a suitable accommodation that is also fair to the remainder of the students in the course. In all cases, prior notification is essential to make the necessary arrangements. Confidentiality is assured.

Inclement weather: In the event of inclement weather that might necessitate the cancellation of a class, please call my office phone and listen carefully to my message machine and/or check your email and the course Blackboard page. In the event of a cancellation, the class will discuss a suitable time to make up the missed material.

General comments about the papers

This course is a W course, where every aspect of the writing process will be emphasized. The writing process includes searching the chemical literature, obtaining and reading the material, synthesizing and organizing your thoughts, writing effectively, using proper grammar and spelling, adhering to the stylistic guidelines of *The ACS Style Guide*, proof-reading your paper, revising your initial drafts, and printing the paper professionally. The page limits for each paper are for 1.5-line spacing, Times New Roman font-size 12 or smaller, excluding figures, tables, graphs, and references.

Short paper on an element and its properties (due Fri., Sept. 14)

For your assigned element, you should write a 5-page paper that addresses each of the following requirements: (a) the pure element-how is it found in nature, when or by whom was it discovered, where is it prevalent, how is it extracted, what is it used for?; (b) physical properties-include its melting point, boiling point, density, vapor pressure, common oxidation states, enthalpy of formation, etc.; (c) its chemistry-what kinds of chemical reactions does it undergo, what compounds does it form and how, what commercial reactions does it undergo (if any), what unusual or interesting structures or oxidation states do these compounds assume, what types of organometallic chemistry does it undergo, does it have a use in bio-inorganic chemistry? Footnote all references (minimum of three, excluding html pages) and use proper ACS-style citations. Proposed list: Ti, Cu, Rh, Ru, Ir, Pt, Mo, Ag, Au.

Short paper on an inorganic chemist (due Wed., Oct. 17)

For your assigned scientist, you should write a 5-page paper that addresses each of the following requirements: (a) a brief biography-when and where was the scientist born, where was he/she educated, what are his/her primary contributions to science, what other aspects of his/her life make him/her an interesting subject?; (b) focus on his/her contribution to inorganic chemistry-what is/are his/her seminal paper(s) in the field of inorganic chemistry, what original theory or intellectual contribution did he/she make, and describe the experimental work from which his/her conclusions were drawn; (c) historical context-how did his/her work support or refute what was known at the time, how was his/her work received by others, were there critics, how do his/her original contributions stand in the context of our present knowledge? Footnote all references (minimum of three, excluding html pages) and use proper ACS-style citations. Proposed list of inorganic chemists: G. N. Lewis, F. A. Cotton, Sophos Mads Jørgensen, Henry Taube, Linus Pauling, Alfred Werner, Marie Sklodowska Curie, Robert Bunsen, Hans Bethe.

Term paper on an area of inorganic chemistry (due Mon., Dec. 3)

Write a 10-page term paper on a subtopic of inorganic or organometallic chemistry in the style of a review article, presenting an overview of the topic (written in terms that would be understandable to a layman), a historical context, a thorough presentation of the experimental data collected to date, an interpretation of the spectroscopic or crystallographic data (make this section thorough enough that I am convinced that you can interpret the data without the use of notes), a full analysis of the inorganic or

organometallic principles involved, and a discussion of contemporary issues in the field (present a critical analysis of the data and describe what experiments you think might help to address any unresolved issues). A full literature search should be performed and a complete bibliography presented, containing no less than seven journal citations (excluding html references). Your paper should also reflect the current thinking in the field. Requests for comments on a first draft will be accepted no later than Nov. 19. Proposed list of topics: inorganic molecular magnets, mixed-valence compounds, inorganic photochemistry, the anticancer drug cisplatin, a specific organometallic catalyst or metalloenzyme, metal-metal bonding, noble gas compounds, boron cage compounds, and zeolites.

Tentative schedule: (topics are subject to change; exam dates and deadlines are firm)

Date	Topic	Miessler	Pfennig
8/27	Review of quantum mechanics and shielding	2-1 to 2-4	1.3-13
8/29	Electronegativity, introduction to bonding	2-3	2.11
8/31	Ionic solids, lattice energy	7-1, 7-2, 7-5	3.1-7
9/3	The radius ratio rule, Pauling's rules	7-1, 7-7	3.8-10
9/5	Lewis structures, resonance, formal charge	3-1	4.1-3
9/7	VSEPR theory and molecular shapes	3-2, 3-3	4.4-5
9/10	Symmetry elements and operations	4-1	5.1
9/12	Molecular point groups	4-2	5.2-3
9/14	Representations of groups; **1st PAPER DUE**	4-3	5.4
9/17	Character tables	4-3	5.5-6
9/19	Direct products, classes, reducing representations	4-4	5.7-8
9/21	Vibrational spectroscopy	4-4	5.9
9/24	Symmetry applications	4-4	
9/26	VBT and hybridization	----	6.1
9/28	MOT: homonuclear diatomics	5-1, 5-2	6.2
10/1	MOT: heteronuclear diatomics	5-3	6.2
10/3	MOT: polyatomics (SALC's)	5-4	6.3
10/5	MOT: polyatomics	5-4	6.3
10/8	MOT: Walsh diagrams; **1st EXAM AVAIL**	5-4	6.4
10/10	MOT: special cases; **1st EXAM DUE**	5-4, 15-3	6.5-6
10/12	Band theory of solids	7-3	6.7
10/17	Conductivity of solids; **2nd PAPER DUE**	7-4	6.8
10/19	Acid-base theory, HSAB,	6-1, 6-3, 6-4	7.1-3
10/22	Frontier MO theory	6-2	7.4
10/24	Coordination chemistry: history & nomenclature	9-1, 9-2	8.1-2
10/26	Stereochemistry, geometries; **DROP DEADLINE**	9-3, 9-4	8.3-4
10/29	Crystal field theory	10-2	8.5
10/31	Crystal field theory & magnetism	10-2	8.6
11/2	Ligand field theory, pi backbonding	10-3	8.7
11/5	Ligand field theory	10-3	8.7
11/7	Atomic term symbols	11-2	App. 2
11/9	Molecular term symbols	11-2, 11-3	8.8

11/12	Correlation diagrams	11-3	8.9
11/14	Tanabe-Sugano diagrams; **2nd EXAM AVAIL.**	11-1, 11-3	8.9
11/16	Electronic spectra, J-T effect; **2nd EXAM DUE**	11-3	8.9
11/19	Octahedral substitution rxn's	12-1 to 12-5	9.1-2
11/26	Square planar substitution & ET rxn's;	12-6 to 12-8	9.3-4
11/28	Inorganic photochemistry	----	9.5
11/30	Organometallic chemistry--bonding	13-1 to 13-4	10.1-2
12/3	Organometallic chemistry—pi systems;	13-4 to 13-6	10.2
	FINAL PAPER DUE		
12/5	Organometallic reactions	Ch. 14	10.3
12/7	Organometallic reactions	Ch. 15	10.4-6
12/10	**FINAL EXAM AVAIL.**		
12/12	**FINAL EXAM DUE**		

Useful books available in the chemistry library:

F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 5th ed., J. Wiley & Sons, 1988. The 6th edition may also be in the library. Do not use the first edition!

F. A. Cotton, *Chemical Applications of Group Theory*, 3rd ed., J. Wiley & Sons, 1990.

I. Hargittai and M. Hargittai, *Symmetry Through the Eyes of a Chemist*, VCH, 1987.

J. E. Huheey, E. A. Keiter, and R. L. Keiter, *Inorganic Chemistry*, 4th ed., Harper Collins, 1993.

A. von Zelewsky, *Stereochemistry of Coordination Compounds*, J. Wiley & Sons, 1996.

R. H. Crabtree, *The Organometallic Chemistry of the Transition Elements*, J. Wiley & Sons, 1988.

I. Haiduc and J. J. Zuckerman, *Basic Organometallic Chemistry*, de Gruyter, 1985.

D. W. Bruce and D. O'Hare, *Inorganic Materials*, J. Wiley & Sons, 1992.

J. Elmsley, *The Elements*, 2nd edition, Oxford Univ. Press, 1992

Dictionary of Inorganic Compounds, Chapman and Hall, 1992

Encyclopedia of Inorganic Chemistry, Wiley & Sons, 1994.