Chemistry 104: Inorganic Chemistry, Harvey Mudd College, Spring 2018

Instructor: Professor Johnson
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MWF 9:00 a.m., SHAN 2407
Course homepage: `sakai`
Text: *Principles of Inorganic Chemistry*, Pfennig, Wiley
Office hours: Thursday 10-11, Friday 1:15-2:15, or by appointment.

What is inorganic chemistry?

Inorganic chemistry interfaces and overlaps with the other areas of chemistry. Inorganic chemists synthesize molecules of academic and commercial interest, measure properties such as magnetism and unpaired electron spin with sophisticated instruments, study metal ion uptake in living cells, and prepare new materials like photovoltaics. Inorganic chemistry is a diverse field, and we will only be able to touch on some of the chemistry of the more than 110 elements in the periodic table. The major subdisciplines of inorganic chemistry are coordination chemistry, organometallics, bioinorganic chemistry, and solid-state/materials chemistry. Inorganic chemists study the s-, p-, d- and f-block elements, reaction rates, determine reaction mechanism, and prepare new compounds. In this course, you will get a broad overview of some areas, and a more detailed study of others.

By the end of the course you will be able to…[†]

- explain the history and breadth of inorganic chemistry using the inorganic Nobel Prizes
- use an appropriate theory to describe the structure and bonding of inorganic compounds
- construct qualitatively correct MO diagrams for centrosymmetric molecules
- explain bonding and magnetism in transition metal complexes using MO arguments
- draw mechanisms for common inorganic/organometallic reactions
- demonstrate how the structures of common crystalline and ionic solids are derived from simple lattices
- describe the composition of more complex solids
- explain the trends in the chemistry of the representative elements
- interpret spectroscopic methods (especially NMR and IR) for inorganic compounds

Assignments

Homework will be assigned in class approximately *daily* and will be due in hardcopy at the start of the next class meeting. I will provide suggested practice problems for your own review. It is in your best interest to *understand* the homework problems and their solutions, and to stay current with it.

Examination schedule

Quizzes: There will be four 20 minute take-home quizzes handed out on Feb 2, Feb 16, March 23 and April 13. The quizzes will be due at the beginning of the following class period. Quizzes will mostly be problems with some short answer or multiple choice.

Midterms: There will be two take-home exams. The first will be handed out Friday, March 2, is due Friday, March 9 (or before you leave for spring break). The second will be handed out Friday April 20, is due Friday April 27. Midterm exams will be a mixture of multiple choice and problems.

[†] not all topics are taught every year…

Final: A cumulative in-class final exam will be given on Monday, May 7 from 9-11 AM. Senior finals will be arranged individually on May 3-4. The final exam will be multiple choice.

Do excellent work on homework and exams. What constitutes excellence? Instead of simply answering questions, annotate your mathematical or logical reasoning with sentences and diagrams.

A Note on due dates: During the first week of the course you will have the opportunity to negotiate changes to the schedule of due dates for assignments and exams. Please use this "flex week" to plan your semester and take into account your other courses with large assignments. Extensions will not be given past the first week on any assignments without medical or other serious and unavoidable conditions. Seniors may take exams *early* to accommodate graduate school visits.

Honor code policy

All students enrolled in this course are bound by the HMC Honor Code. More information on the HMC Honor Code can be found in the HMC Student Handbook. I encourage you to collaborate with other students on homework assignments (e.g., working the problem on a whiteboard together and then copying down the solution). You may not reference step-by-step solution instructions in published solution manuals. You may reference the assignments and tests of this course from previous semesters, although the direct copying of solutions from previous assignments and tests is forbidden.

Course Grade

Midterms	15%+15%	Quizzes	5%+5%+5%+5%
Homework	10%	in class work	20%
		Final exam	20%

A	B	C	D	F
100-85%	84-75%	74-65%	64-55%	<55%

All work turned in for a grade in this course is subject to a *substantial penalty* if turned in late. Stay on top of your assignments and get them turned in on time.

Teaching philosophy

I teach through a combination of lecture and small group in-class problem solving activities. I expect you to fully engage in both learning modes. Participate in class by asking or responding to questions, and contributing in an active and generous way to the in-class activities. Ask questions *early* and *often* to make sure you understand how to solve the problems in the course. My office hours are under-utilized, but the students who take advantage of them tend to do well in my class.

Attendance is important, as we do a lot of group problem solving. Unavoidable absences due to illness or travel for athletic events or graduate school visits are of course excused, but notify me *in advance*. Missing class may reduce your in-class work grade. If you miss class, it is your responsibility to check with your classmates in order to find out what happened in class. The answer to the question "did I miss anything?" is here: http://www.library.utoronto.ca/canpoetry/wayman/poem5.htm.

Accommodations policy: It is the policy of The Claremont Colleges to accommodate students with temporary or permanent disabilities. Any student with a documented disability who requires reasonable accommodations should contact Deborah Kahn, Coordinator for Student Disability Resources at (909) 607-3148 or dkahn@hmc.edu, as soon as possible.

Course schedule: Here is the general course schedule and a list of topics we will cover. Unit I is a list of topics for you to review on your own; I will assume you know this information. Unit II is on crystal field theory and magnetism. This module is first in order to support the first two experiments in Chem 110 and to provide justification for more advanced bonding theories. Unit III will be devoted to the development of a sophisticated description of chemical bonding for main group and coordination compounds using group theory and molecular orbital theory. Physical methods (focusing on interpretation of spectra) will be incorporated throughout the course where appropriate. Unit IV will explore organometallic chemistry, and Unit V will explore bioinorganic chemistry. Detailed reading assignments and homework will be handed out weekly. All reading assignments are from Pfennig.

Unit I: Atomic structure and simple bonding theory, ***Review on your own!***

Quantum Theory (skim)	Ch. 3
Atomic Structure (skim)	Ch. 4 (not 4.5)
Simple bonding theory	Ch. 6, 7.1

Unit II: CFT and magnetism, 9 days

Crystal Field Theory	Ch. 15, 16
Magnetism	Ch. 15.6
Symmetry and point groups	Ch. 8
IR of transition metal complexes	Ch. 9

Unit III: Structure and bonding in main group and coordination compounds, 10 days

Polyatomic covalent bonding models	Ch. 10
Coordination chemistry bonding models	Ch. 16

Unit IV: Coordination and Organometallic chemistry, 10 days

Coordination chemistry	Ch. 15, 17
Organometallic chemistry	Ch. 18, 19

Unit V: Bioinorganic chemistry, 8-10 days

Biologically relevant inorganic chemistry	handouts provided

Nobel prizes in chemistry that are inorganic or pertain to inorganic chemistry

From: http://almaz.com/nobel/chemistry/chemistry.html or http://nobelprize.org/nobel_prizes/chemistry/

2010 The prize is being awarded jointly to RICHARD F. HECK, EI-ICHI NEGISHI, and AKIRA SUZUKI for palladium-catalyzed cross couplings in organic synthesis.

2005 The prize is being awarded jointly to YVES CHAUVIN, ROBERT H. GRUBBS, and RICHARD R. SCHROCK, for the development of the metathesis method in organic synthesis.

2001 The prize is being awarded with one half jointly to: WILLIAM S. KNOWLES, and RYOJI NOYORI, for their work on chirally catalyzed hydrogenation reactions and the other half to: K. BARRY SHARPLESS for his work on chirally catalyzed oxidation reactions.

1996 The prize was awarded jointly to: ROBERT F. CURL, Jr. , SIR HAROLD W. KROTO , and RICHARD E. SMALLEY for their discovery of fullerenes.

1995 The prize was awarded jointly to: PAUL CRUTZEN , MARIO MOLINA , and F. SHERWOOD ROWLAND for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.

1992 RUDOLPH A. MARCUS for his contributions to the theory of electron transfer reactions in chemical systems.

1985 The prize was awarded jointly to: HERBERT A. HAUPTMAN and JEROME KARLE for their outstanding achievements in the development of direct methods for the determination of crystal structures.

1983 HENRY TAUBE for his work on the mechanisms of electron transfer reactions, especially in metal complexes.

1981 The prize was awarded jointly to: KENICHI FUKUI and ROALD HOFFMANN for their theories, developed independently, concerning the course of chemical reactions.

1979 The prize was divided equally between: HERBERT C. BROWN and GEORG WITTIG for their development of the use of boron- and phosphorus-containing compounds, respectively, into important reagents in organic synthesis.

1976 WILLIAM N. LIPSCOMB for his studies on the structure of boranes illuminating problems of chemical bonding.

1973 The prize was divided equally between: ERNST OTTO FISCHER and SIR GEOFFREY WILKINSON for their pioneering work, performed independently, on the chemistry of the organometallic, so called sandwich compounds.

1963 The prize was divided equally between: KARL ZIEGLER and GIULIO NATTA for their discoveries in the field of the chemistry and technology of high polymers.

1944 OTTO HAHN for his discovery of the fission of heavy nuclei.

1935 The prize was awarded jointly to: FRÉDÉRIC JOLIOT and IRÈNE JOLIOT-CURIE in recognition of their synthesis of new radioactive elements.

1931 The prize was awarded jointly to: CARL BOSCH and FRIEDRICH BERGIUS in recognition of their contributions to the invention and development of chemical high pressure methods.

1922 FRANCIS WILLIAM ASTON for his discovery, by means of his mass spectrograph, of isotopes, in a large number of non-radioactive elements, and for his enunciation of the whole-number rule.

1921 FREDERICK SODDY , for his contributions to our knowledge of the chemistry of radioactive substances, and his investigations into the origin and nature of isotopes.

1918 FRITZ HABER for the synthesis of ammonia from its elements.

1913 ALFRED WERNER in recognition of his work on the linkage of atoms in molecules by which he has thrown new light on earlier investigations and opened up new fields of research especially in inorganic chemistry.

1912 The prize was divided equally between: VICTOR GRIGNARD for the discovery of the so-called Grignard reagent, which in recent years has greatly advanced the progress of organic chemistry and PAUL SABATIER for his method of hydrogenating organic compounds in the presence of finely disintegrated metals whereby the progress of organic chemistry has been greatly advanced in recent years.

1911 MARIE CURIE, née Marie Sklodowska, in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element.

1906 HENRI MOISSAN in recognition of the great services rendered by him in his investigation and isolation of the element fluorine, and for the adoption in the service of science of the electric furnace called after him.

1904 SIR WILLIAM RAMSAY in recognition of his services in the discovery of the inert gaseous elements in air, and his determination of their place in the periodic system.

1903 SVANTE AUGUST ARRHENIUS in recognition of the extraordinary services he has rendered to the advancement of chemistry by his electrolytic theory of dissociation