2009 Harris Teaching Workshop on Inorganic Chemistry
Survey Responses

This year's meeting was aimed at the content of the Inorganic Chemistry syllabus that is taught after general chemistry (i.e., course(s) having freshman general chemistry as a prerequisite).

Question 1: Does your Department currently teach such course(s)? If so, how large are the classes? Do they have an associated lab? What textbook is currently used?

Bieringer/UManitoba

YES: CHEM2380 (Chemistry of the Main Group Elements) with 110 students. There is a lab associated with this course (8 experiments)
Shriver & Atkins "Inorganic Chemistry" 4th Edition.

Gates/UBC

Yes: Chem 202 – *Coordination Chemistry* - ca. 275 students - incl. lab
Chem 309 - *Foundations of Inorg. Chem.* – ca. 100 students – incl lab
Chem 310 - *Chem. of the Elements* - ca. 100 students - incl. lab
Textbook currently used: Miessler and Tarr

Hicks/UVictoria

The University of Victoria has the following inorganic curriculum beyond 1st year:

Chem 222: introduction to inorganic chemistry. Usually about a hundred students enroll. # lectures/week plus lab. Textbook is Housecroft & Sharpe. This is a survey course which gives students a broad introduction to inorganic chemistry. **(**s-, p-, and d-block elements and their compounds). Main themes include Periodic trends in physical and chemical properties ; Solid state structures: ionic, covalent, metallic systems ; Molecular orbital diagrams for simple molecules; Coordination chemistry, including colours and magnetism of transition metal complexes; All accompanied by examples of descriptive chemistry and applications as time permits

Chem 324: Introduction to transition metal chemistry. 40-60 students, no lab directly associated with the course (although there is a 3rd year inorganic lab which is independent from the class). Housecroft & Sharpe is the text. This builds on the basics of d-block chemistry which were covered in 222 and includes more detailed descriptions of ligands, structures, stereochemistry, bonding, and spectroscopy. Some reaction chemistry is included, including basic reaction mechanisms, redox chemistry (electron transfer). Introductory aspects of organometallic chemistry are integrated into the course. At times other topics such as bioinorganic chemistry have been included.

Chem 353: Structure, bonding, and reactivity. 40-60 students, no lab. No required text. This is actually a multidisciplinary class which has as the main emphasis development of qualitative MO theory as applied to inorganic and organic molecules (but excluding

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d-block). Symmetry and rudimentary group theory are covered, and then methods for MO diagram construction and interpretation. Progression from very simple molecules to relatively complex ones. The role of d-orbitals in main group chemistry is discussed. About a third of the course is devoted to organic reactions under orbital symmetry control (Woodward-Hoffman rules etc).

Chem 421: Advanced topics in inorganic chemistry: 5-20 students, no lab, no required text. This course is an advanced treatment of contemporary topics in inorganic chemistry, chosen by the instructor.

Chem 423: Advanced organometallic chemistry.10-25 students, no lab. This builds on Chem 324 and places a strong emphasis on reactions at metal centres and catalysis.

MacKinnon/LakeheadU

Our main two (compulsory for all chemistry majors) inorganic courses are a 2nd-year intro and a 3rd-year transition metal course. There are also two 4th-year courses (they alternate years, sometimes cross-taught with a grad course) - Advanced Organometallic and Structure and Spectroscopy in Inorganic Chemistry.

The 2nd-year course has a lab, enrollment is typically 15-20 (concurrent education majors who want to teach chemistry as a 2nd teachable often take this course, which inflates the numbers by 3 or 4 a year). The 3rd-year course is also a lab course, usually a little smaller, maybe 12-16. This year we used Miessler and Tarr; last year we used Shriver and Atkins; neither are great, but both are more general (include more main-group stuff) than the alternatives. Also, I find the "descriptive inorganic" textbooks to be dull and superficial.

Hayes/ULethbridge

We do not have a second year inorganic chemistry course which requires only first year as a pre-requisite, but rather, we have two, third year inorganic chemistry courses (essentially main group chemistry (Chem 3830) in the fall followed by transition metal chemistry (Chem 3840) in the spring) which have both first year and second year organic chemistry as pre-requisites.

Both Chem 3830 and 3840 generally have between 5 and 15 students with an average of about 10. These students are almost exclusively chemistry or biochemistry majors.

Yes, both of these courses have a corresponding lab (4 hours per week).

Textbook currently used: Shriver and Atkins.

Mozol/UCalgary

Yes. Our second year inorganic chemistry courses are Chemistry 331 and 333.

First term has varied from 90-100 students, second term has varied from 55-70 students

An associated lab: Yes

What textbook is currently used? Housecroft and Sharpe 3rd edition (Vogel's Quantitative Analysis for the lab). Content for Shriver and Atkins and Hueey is frequently referred to.

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Sterenberg/URegina

We have two inorganic chemistry classes as part of our core undergraduate curriculum. Both classes have labs associated with them. CHEM 230 has a typical enrolment of 60-70. CHEM 330 has a typical enrolment of 10-15. The current textbook is Shriver & Atkins, 4^{th} edition.

Prokopchuk/UWinnipeg

Yes, we teach a one-term course at the 2nd year level for 120 students (split over two sections). There is a lab. Current text book is "Inorganic Chemistry" by Housecroft and Sharpe. Last year we used "Inorganic Chemistry" by Shriver and Atkins. I'm still looking for the perfect book.

Whitcombe/UNBC

CHEM 202 Inorganic I - typically, mid-20s (2009: 19 students)
CHEM 320 Inorganic II - typically, high-teens (2009: 18 students)
CHEM 321 Inorganic III - typically, high-teens (2008: 21 students)
CHEM 403 Special Topics - very dependent - last offering was a course that turned into Inorganic Industrial Chemistry and had 27 undergraduate students and 1 graduate student enrolled.
Associated labs? No. We have a separate laboratory course, CHEM 322 which is 6 hours per week. Typical 12 students per offering.
Textbook currently used: Inorganic Chemistry, 3rd Ed., Housecroft & Sharpe, Pearson.

Ooms/King'sUC

Yes
Class size: 9 to 13
Associated lab: Yes
Textbook currently used: Inorganic Chemistry By Miessler and Tarr.

Veinot/UofA

The University of Alberta has the following inorganic/materials curriculum beyond 1^{st} year.
Chemistry 241, Inorganic Chemistry I: The chemistry of main-group elements including a survey of the structure, bonding, and reactivity of their compounds. Transition-metal chemistry will be introduced. The course will include applications in industrial, biochemical, environmental, and materials science. **Includes lab.**
Enrollment: 120-140 students, Textbook: Inorganic Chemistry, Freeman
Authors: Shriver/Atkins

Chemistry 243, Inorganic Chemistry II: An extension of CHEM 241 with emphasis on the bonding, structure, and reactivity of transition-metal elements. The course will include applications in industrial, biochemical, environmental, and materials science. For

Chemistry Honors and Specialization students only, except by consent of Department. **Includes lab.**
Enrollment: 28-40 students, Textbook: Inorganic Chemistry, Freeman
Authors: Shriver/Atkins

Chemistry 333, Inorganic Materials Chemistry: Fundamentals of the synthesis, structure and properties of inorganic solids, thin films, and nanoscale materials, to be complemented with case studies of modern applications of inorganic materials; selected topics such as catalysis, molecular and nanoparticle-based computing, telecommunications, alternative energies, superconductivity, biomedical technologies, and information storage will be discussed. Techniques for characterization and analysis of materials on the nano and atomic level will be introduced. **Includes lab.**

Enrollment: 35-60 students, Textbook: Materials Chemistry, Springer Publishing,
Author: Bradley Fahlman

Chemistry 433 (Now Chem 434), Structure in the Solid State: covers the following topics: (1) the nature and origin of X-rays; (2) crystal symmetry; (3) diffraction theory; (4) theory and practical aspects of X-ray data collection; (5) Fourier analysis and structure solution; (6) least-squares refinement and other techniques used in structure solution; and (7) discussions and interpretations of X-ray structures from the literature.

Enrollment: 13 students, Textbook: "Crystal Structure Determination", 2nd ed., Author: Massa

Chemistry 436, Synthesis and Applications of Inorganic & Nano-materials:
Introduction to methods of synthesizing inorganic materials with control of atomic, meso-, and micro-structure. Topics include sol-gel chemistry, chemical vapor deposition, electro-synthesis of materials, solid-state reactions, solid-state metathesis and high-temperature self-propagating reactions, template-directed syntheses of micro and mesoporous materials, micelles and colloids, synthesis of nanoparticles and nanomaterials. Applications of these synthetic techniques to applications such as photonic materials, heterogeneous catalysts, magnetic data storage media, nanoelectronics, display technologies, alternative energy technologies, and composite materials will be discussed.
Enrollment: 30 students, Textbook: Synthesis of Inorganic Materials, Wiley-VCH 2005,
Authors: Schubert and Hüsing

Chemistry 437, Transition Metal Chemistry: CHEM 437 is an introduction to organotransition metal chemistry. The course will deal with the synthesis, basic bonding, and reactivity of organotransition metal complexes. Topics to be covered include transition metal complexes of hydrides, phosphines, carbonyls, olefins, alkynes, polyolefins, cyclopentadienyl and related cyclic p-ligands; metal-carbons and multiple bonds. The application of these complexes to homogeneous catalysis and to organic synthesis will be discussed when appropriate.

Enrollment: typically 20 students, Textbook: None, handouts of articles from source literature instead, Author: Folks that carried out the research in the article.

Chemistry 438, Solid State Chemistry: Introduction to the chemistry of extended inorganic solids. The topics covered include synthesis, symmetry, descriptive crystal chemistry, bonding, electronic band structures, characterization techniques, and phase diagrams. The correlation of structure with properties of electronic and magnetic materials will be discussed.
Enrollment: 14 students, Textbook: Basic Solid State Chemistry, 2nd ed., Author: West

Chemistry 444, Characterization Methods in Nanoscience Introduction to techniques in determining the composition and structure of materials on the nanometer scale. Characterization of atomic, meso-, and micro-structure of materials including impurities and defects. Major topics will include diffraction (X-ray, electron, neutron), electron microscopy (transmission, scanning, and Auger) and associated spectroscopies (EDX, EELS), surface sensitive spectroscopies (e.g., XPS, AES, IR) and spectrometry (SIMS), synchrotron techniques, X-ray absorption, fluorescence and emission, and scanned probe microscopies (AFM, STM, etc.). The strengths, weaknesses, and complementarity of the techniques used will be examined via case studies on the characterization of real-world nanotechnologies, such as heterogeneous catalysts, surfaces and interfaces in semiconductor devices, organic monolayers on metals and semiconductors, nanotube- and nanowire-based electronics, and biocompatible materials.
Enrollment: 30 students, Textbook: none

Question 2: Are you using the internet in a unique way in teaching Inorganic Chemistry?

Bieringer/UManitoba
YES/NO: WebCT has been used during the last 4 years providing exercises, a few interactive tools, lecture notes etc. This is not a unique use of the internet. The laboratory manual is also being distributed via WebCT.
The most unique approach is that we started using powder X-ray diffraction as a characterization tool, individual data sets have been distributed via the internet, software downloads are being made available, etc.

Gates/UBC
No. Each course does have a website (usually on Vista), but it is used primarily to relay information (handouts, problem sets, etc.).

Hicks/UVictoria
Not that I am aware. All classes have websites which are the primary means of dissemination of course materials.

MacKinnon/LakeheadU
I have not been using internet resources in any meaningful way, but it's something that I would be interested in learning about.

Hayes/ULethbridge
No, not in a unique way.

Mozol/UCalgary
In 331 on a daily basis current research is addressed as it relates to the topics of study. No interactive work has been done. In 331 CPS has also been used to determine if students are grasping a concept. Nothing has been done for 333 in the past, in Winter 2010 it will mimic what was done for 331 in fall 2008.

Sterenberg/URegina
In CHEM 230, course notes are distributed via internet. I also use some freely available programs (Orbital Viewer, Mercury) for visualization in class, and also encourage students to download and use these programs.

Prokopchuk/UWinnipeg
No, I only use the internet for providing handouts and assignments.

Whitcombe/UNBC
No

Ooms/King'sUC
Online contact with students for assignments and notices.

Veinot/UofA

All courses have websites for dissemination of course materials. Chemistry 241, 243 and 333 all have websites associated with the laboratory components. These sites are used for general information/communication and web-based tutorials.

Chem 437 uses ASAP pages of prominent journals to obtain articles that illustrate current use of course material.

Question 3: **Describe briefly the amount of (a) organo-metallic chemistry; (b) structure elucidation techniques; (c) bio–inorganic chemistry; (d) materials science and (e) other topics.**

Bieringer/UManitoba

a) very little organometallic chemistry
b) structure elucidation techniques probably about 10% (dispersed throughout the term)
c) very limited bio-inorganic
d) materials science considerable amount but not a main focus
e) bonding models, electrochemistry

It is really difficult to describe the course under the suggested headings.
The main focus is structure and reactivity but limited to main group chemistry.

Gates/UBC

(a) Organometallic chemistry is taught in Chem 310 – this includes classic catalytic processes (polymerization, Wilkinson, Monsanto, Wacker)
(b) multinuclear NMR is used in Chem 309/310 – particularly in applying knowledge of Inorg. Chem. to problem solving (i.e. roadmap style problems). In addition IR is used, particularly when discussing organometallic carbonyls.
(c) Very little taught at 2^{nd} / 3^{rd} year. We do offer Chem 435/526 on Bioinorg. Chem..
(d) Very little taught at 2^{nd} / 3^{rd} year. p-block chemistry in Chem 309 introduces some materials science – i.e. solids, III/V semiconductors.
(e) Some descriptive p-block chemistry is taught in combination with MO/Group theory in Chem 309.

Hicks/UVictoria

See above (question 1) for general content. Organometallic chemistry is well-represented in Chem 324 and 423. Structure elucidation techniques are covered partly in Chem 213, an introductory spectroscopy course, and as needed elsewhere, e.g. EPR spectroscopy often comes up in Chem 421. I would say bio-inorganic chemistry is under-represented – it barely gets mentioned in Chem 324 if at all and usually only focuses on the basic and obvious stuff (hemoglobin). We have a separate advanced course on materials chemistry which has a lot of inorganic content, but relatively little elsewhere except anecdotally.

MacKinnon/LakeheadU

(a) The 3rd-year mandatory course has a significant organometallic portion (30%?). Obviously the Organometallic chemistry 4th-year course has a lot! There is virtually none in the 2nd-year course (except incidentally when teaching about ligands that happen to bind through carbon.

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(b) There is little on structural elucidation techniques except in the symmetry portion of the intro course (we do IR and Raman activity of vibrations). The Transition Metal course introduces the idea of crystallography and uses NMR as well. The 4th-year Structure and Bonding course has several weeks of crystallography, NMR, EPR, in-depth vibrational spectroscopy, etc.
(c) no bio-inorganic (except incidentally when discussing other topics, like porphyrins),
(d little to no materials science, except incidentally,
(e) the bulk of the first course is symmetry and bonding, ligands and transition metals (including electrochemistry), and some descriptive stuff.

Hayes/ULethbridge
~20% organometallic chemistry, ~10% structure elucidation techniques, 0% bio-inorganic chemistry, ~5% materials science, ~10% group theory, ~20% molecular orbital theory, ~10% kinetics and reaction mechanisms, ~10% catalysis, ~15% coordination chemistry.

Mozol/UCalgary
In 331 it is 50:50 basic structural principles for inorganic compounds and then examination of the main group compounds with a focus on group and periodic trends; structure elucidation (2 lectures); bio-inorganic chemistry (2 lectures); materials science (5 lectures), other topics - basic structural principles for inorganic compounds (Lewis/VSEPR review, MO theory, Molecular Symmetry, Lattice structures and energy,).
In 333 all is primarily organometallic chemistry (12 lectures), structure elucidation techniques (2 lectures); bio–inorganic chemistry (3 lectures); materials science (3 lecture), and (e) other topics - basic coordination chemistry principles (CFT, LFT, mechanisms, magnetism)
These courses have not really been revamped for many years and desperately need to be.

Sterenberg/URegina
CHEM 230 focuses on main group chemistry and covers atomic structure, bonding, the solid state, acid/base, oxidation/reduction, and description chemistry of the elements. Some materials chemistry (semiconductors), and some aspects of bioinorganic chemistry are discussed (particularly biochemistry of phosphorus). Structural elucidation techniques are mentioned briefly, but covered more fully in other parts of our curriculum.
CHEM 330 focuses on transition metal chemistry, primarily coordination chemistry and organometallic chemistry, including some structure elucidation techniques.

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Prokopchuk/UWinnipeg

In this second-year course:

(a) no organometallic chemistry
(b) briefly mention structure elucidation techniques (some IR in the lab)
(c) briefly mention bio-inorganic chemistry (in relation to hard/soft acids/bases)
(d) no materials science
(e) other topics include: covalent bonding; metallic bonding; solid structure (packing and unit cells); acids/bases (Lewis and Bronsted); redox chemistry and Frost, Latimer, Ellingham diagrams; Chemistry of the main group elements (transition metal coordination chemistry is 3rd year and organometallic chemistry is 4th year).

Whitcombe/UNBC

CHEM 202	first half - structure and bonding; second half - intro to inorganic and transition metal chemistry
CHEM 320	first half - group theory second half - organometallic chemistry
CHEM 321	first half - survey of transition metal chemistry second half - bio-inorganic chemistry
CHEM 403	industrial processes.

Note: I don't explicitly teach any course content associated with materials science.

Ooms/King'sUC

(a) organometallic chemistry: 4 weeks,
(b) structure elucidation techniques: 2 weeks,
(c) bio–inorganic chemistry: 3 weeks,
(d) materials science, and: 3 weeks,
(e) other topics in your Inorganic course(s). Molecular orbital structures and applications.

Veinot/UofA

In terms of course content, describe the quantity of:
(a) organometallic chemistry:
Chem241: briefly covers: metal carbonyls, CO poisoning and hemoglobin, the final lab experiment includes the preparation of a compound with a nickel-carbon bond.
Chem 243: extensively covers: reactivity, catalysis/mechanisms, metal carbonyls, Chem 243 has two experiments (approximately 40%) of lab work deals with organometallic compounds.
90% of the material covered in Chem 437
(b) structure elucidation techniques:
Chem 241: only UV-vis/IR discussed.
Chem 243: UV Vis/IR in more detail (selection rules, types of electronic transitions etc..), NMR (currently ^{1}H, ^{13}C, ^{31}P) as it pertains to understanding fluxionality, X-ray (only brief discussion of how it works).
Chem 333 continues application of IR and UV-visible spectroscopy and adds excitation/emission spectroscopy

Chem433 covers X-ray diffraction.
Chem437 ^{13}C, ^{31}P, ^{1}H of organometallic compounds is discussed on a case-by-case basis, not as a stand alone course section.
Chem444 covers materials characterization including XPS, diffraction methods, electron microscopy, probe microscopy, synchrotron techniques.
(c) bio-inorganic chemistry: is under represented
Some cytochrome P450 was discussed in Chem 437.
(d) other topics covered: Materials chemistry is introduced in Chem333. Solid-State Chemistry is covered at an advanced level in Chem 433. Inorganic Materials chemistry (synthesis and applications) is covered at an advanced level in Chem436.