Syllabus for CHEM3120
Chemical Systems II

Winter Quarter 2020; revised 11/22/19

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Description:

This course is described in the bulletin as follows: "Interpretation of the chemistry of the elements in terms of orbital interactions. Most examples will be taken from the 3d transition metals and the boron and carbon groups."

Goals

This course attempts to convey a qualitative and intuitive approach to overall trends in the periodic table.

Chemical Abstracts reports more than 157 million unique organic and inorganic chemical substances, such as alloys, coordination compounds, minerals, mixtures, polymers and salts, and more than 68 million sequences.

The scope of inorganic chemistry is so broad that within a 10-week course we cannot even survey the entire field. Instead, we will focus on an approach to knowledge in this aspect of chemistry. Using symmetry, shapes of atomic and molecular orbitals, electronegativity, effective nuclear charge, etc., you can describe many chemical phenomena and you can know whether you should be surprised by a new chemical observation.

When you successfully complete this course, you should be able to actually understand at a useful level the descriptive chemistry chapters in a freshman chemistry text. For example, you should understand that one would not expect Cr^{3+} at the active site of an enzyme and that Zr is more like Hf than like Ti.

Background assumed:

This course will build upon your preparation in CHEM3310 (MS&E I). In CHEM3310 you studied the content of chapters 1-5 in the text by Housecroft. The treatment of atomic and molecular orbitals, symmetry, and group theory will follow on from where you left off in CHEM3310.

Text:

The primary texts for this course will be Inorganic Chemistry, Fifth Edition, by Catherine E. Housecroft and Alan G. Sharpe, Pearson, 2018, and R. L. Carter, Molecular Symmetry and Group Theory, Wiley, New York, 1998.

For most classes there will be notes and figures on Canvas that supplement the discussion in Housecroft. These will be labeled Class1, Class2, etc.

Texts commonly used in undergraduate study of the chemistry of the elements also will be valuable to you. The relevant sections of freshman chemistry books and the texts by Rodgers and by Rayner-Canham are important for those whose undergraduate background in inorganic chemistry requires review.

References to original papers will be provided in class from time to time as topics are discussed.

Method of Instruction:

Learning of the material in this course will be by teaching one another in teams (Cooperative Learning Groups). The composition of the Cooperative Learning Groups is in a separate file posted on Canvas. Class time will be focused on answering questions that you submit in advance of the class. You need to read the text and any notes that I post for the class, discuss the content with one another and work problems at the end of the chapter relevant to the assigned reading well in advance of the class scheduled for discussion of that topic. Each Cooperative Learning Group will then submit a question (maybe two) on a topic about which you need further clarification. The questions must include a statement of why the topic requires explanation beyond that in the text or the notes I post in advance for the class. That is, what is it that you do not understand? Merely saying “explain periodicity” or “work problem xyz” will receive zero credit. These questions are to be submitted no later than 25 hours before the class on this topic (i.e., before 8 am the preceding day). Questions must be submitted for the first class. Questions, signed by all members of the Group can be submitted either by email or on paper, whichever is more convenient for you.

Detailed schedule of readings for classes will be posted on Canvas and updated almost daily during the academic quarter.

25% of your grade will be for the quality of the questions submitted before each class. Everyone in the group will receive the grade of the group. Signatures certify equal contributions. At the end of the course, each student will confidentially grade the contribution of other students in the Cooperative Learning Group. These assessments will be taken into account for final grades in cases in which the grade on submitted questions is out of line with grades on the three exams. There will be two hour exams and a final exam, each also 25% of the grade.

Schedule:

Class will meet MWF 9:00-9:50, in Olin 103. A tentative schedule in a separate file on Canvas will be updated frequently to assign specific pages in the text. Classes start on Monday, January 6. January 20 is a DU holiday. The last day of classes is Monday, March 16.

Note that the final exam may not be at the time specified on the Registrar’s schedule, because it is scheduled the same day as the exam for another graduate core class. The exam could be moved to another day at the discretion of students.

Office hours are Tuesday, Wednesday, and Thursday 5-6 pm, or by appointment.

The background material assumed for this course can be found in books such as:

(If the library copy is checked out, ask others in the class before recalling the book.)

Rodgers, Glen E., Introduction to Coordination, Solid State, and Descriptive Inorganic Chemistry. McGraw-Hill, 1994 QD474.R63 1994. Rodgers, Glen E., Descriptive inorganic, coordination, and solid state chemistry Brooks/Cole, 2002, 2nd ed. QD474 .R62 2002, 3rd ed. QD474.R62 2012.

Rayner-Canham, Geoffrey, and Tina Overton, 2002. Descriptive Inorganic Chemistry, 5th ed., QD151.5.R39.2010, 4th ed. QD151.5 .R39 2006; W.H. Freeman, New York, (3rd ed., QD151.5 .R39 2003 ; 2nd ed 2000 QD151.5 .R39 2000;1st ed., 1996 QD151.5.R39 1996).

F. Albert Cotton, Geoffrey Wilkinson, Paul L. Gaus, Basic Inorganic Chemistry, 3rd ed. New York, J. Wiley, 1995. QD151.2.C69 1995

There are many books that describe the chemical elements. Two of rather different nature are:

T. W. Gray, The Elements: a visual exploration of every known atom in the universe. Black Dog & Leventhal Publishers, New York, 2009, QD466.G73 This book has the best pictures of the elements available in print.

J. Emsley, The Elements, 3rd ed., Oxford Univ. Press, 1998, QD466.E48 This book lists many physical properties.

For molecular symmetry and group theory, you may find useful information in:

F. A. Cotton, Chemical Applications of Group Theory, 3rd ed., Wiley, New York, 1990. QD461.C65 1990 This is the "standard" reference in this field.

L. H. Hall, Group Theory and Symmetry in Chemistry. McGraw-Hill Book Co. New York, 1969. QD461.H17 I tend to use the notation of this book.

Web sites
It is very difficult to figure out whether a web site contains reliable information and whether it is up to date. The following web sites were selected as potentially useful or potentially interesting to you.

Note that the text has a web site: www.pearsoned.co.uk/housecroft that includes exercises for you to try, rotatable 3D structures for those so designated in the text, and an interactive periodic table.

Web sites for Periodic Tables and Properties of the Elements
There are some other good web sites for sources of information about the elements:

The Royal Society of Chemistry has an extensive periodic table site:

http://www.rsc.org/periodic-table/ accessed 11/22/19

www.webelements.com This site has been developed over a long time, and appears to have been prepared with care. accessed 11/22/19

Periodic Table Live! has videos of reactions of many of the elements and been enhanced with a lot of information about each element. Many reactions that one would not easily do in a classroom were photographed. The crystal structure can be rotated so that it can be viewed from different angles. Periodic table Live is available at http://www.chemeddl.org/resources/ptl/ accessed 11/22/19

The American Chemical Society web site has a lot of information about the periodic table and links to the RSC and IUPAC tables.
http://acswebcontent.acs.org/games/pt.html accessed 11/22/19

A set of videos of the elements has been produced by faculty at the University of Nottingham: http://www.periodicvideos.com/ accessed 11/22/19
These are also available on youtube.com

Another useful site is www.chemicool.com/ accessed 11/22/19 This site includes lists of properties of the elements and links to some videos about the elements.

The audio descriptions (podcasts) at http://www.rsc.org/periodic-table/podcast give another brief perspective on each of the elements. Accessed 11/22/19

NIST has a very nice periodic table in pdf format:
http://physics.nist.gov/PhysRefData/PerTable/index.html
http://physics.nist.gov/PhysRefData/contents.html accessed 11/22/19

If you would like a nice, colorful, periodic table, look at
http://www.theodoregray.com/PeriodicTable/Posters/index.html
http://periodictable.com/ accessed 11/22/19
a small copy of this is posted on the wall in S.G.Mudd.

The following periodic table has a lot of information about each element, including links to WebElements and Wikipedia, pictures of valence orbitals, etc.:
http://www.dayah.com/periodic/ accessed 11/22/19

This site contains a comprehensive listing of alternate forms of the periodic table, and some are arranged by date and type.
http://www.meta-synthesis.com/webbook/35_pt/pt_database.php?Button=recent accessed 11/22/19

For a little entertainment, try web sites for the song "the elements" by Tom Lehrer
http://www.privatehand.com/flash/elements.html
There are also several versions of the illustrations that accompany this song on youtube.com. (search for Tom Lehrer) One version highlights each location in the

periodic table as the name is said, and another presents a picture of the element or of an application of the element as the name is said.

Web sites for symmetry were listed in the syllabus for CHEM3310

Mechanisms that Interchange Axial and Equatorial Atoms in Fluxional processes: Illustration of the Berry Pseudorotation, the Turnstile and the Lever Mechanisms via animation of transition state normal vibrational modes. Marion Cass, King Kuok (Mimi) Hii and Henry S. Rzepa J. Chem. Ed. 83(2) 336 (2006) and the on-line movies of atom motion.

Links to other chemical information

The Royal Society of Chemistry (www.rsc.org) and the American Chemical Society http://www.acs.org/content/acs/en/education.html provide links to many sources of chemical information. accessed 11/22/19