Syllabus for CHEM3120
Chemical Systems II
Winter Quarter 2019; revised 11/03/18
Professor G. R. Eaton

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." Throughout, there will be an emphasis on periodic properties. Chemistry of the elements is a very broad field of study. To fit within a one-Quarter course, we will restrict our focus to emphasize molecular species, and usually small molecular species.

Goals

This course attempts to convey a qualitative and intuitive approach to overall trends in the periodic table. 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. You do have to practice a lot to develop insight into what approximations you can make, and in what context they are useful. When you successfully complete this course, you should be able to understand at a useful level the chapters about periodicity and transition elements in a freshman chemistry text. It is hoped that with a solid foundation in discrete monomolecular species, you will be able to extrapolate to extended solids, nanomaterials, metalloproteins, etc.

Background assumed:

This course will build upon your undergraduate education in descriptive chemistry of the elements, small amounts of introductory biochemistry, and some of the content of CHEM3310 (MS&E I). The treatment of atomic and molecular orbitals, symmetry, and group theory will follow on from where you left off in MS&E I. We will present results of current computational chemistry of transition metal complexes, including comparison of DFT with LFT.

Text:

The primary texts for this course will be Inorganic Chemistry, Fifth Edition, by Catherine E. Housecroft and Alan G. Sharpe, Pearson Prentice Hall, and R. L. Carter, Molecular Symmetry and Group Theory, Wiley, New York, 1998. You should have learned in prior courses most of the material in the first half of the Housecroft and Sharpe text. A substantial amount of relevant chemistry is in common introductory chemistry texts. Texts commonly used in undergraduate study of the chemistry of the elements also will be valuable to you. The books 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 as topics are discussed.

For the study of symmetry and molecular orbitals you will find it useful to consult additional texts, such as the ones by Hall, Cotton, etc., that are listed at the end of this syllabus.

Method of Instruction:

Instruction will be by assigned reading, homework problems that you will solve in teams (Cooperative Learning Groups), and lectures. Reading in the text book is one source of information, which will provide essential background to the material presented in lectures. Lectures will assume that you have done the reading in advance, and will usually go beyond the material in the assigned readings. Students are encouraged to work together to learn the material. Group cooperative learning projects will be graded. Everyone in the group will receive the grade of the group. Signatures certify equal contributions.

Schedule:

Class will meet MWF 9:00-9:50, in Olin 103. A tentative schedule is presented below. Classes start on Monday, January 7. January 21 is a DU holiday. The last day of classes is Monday, March 12.

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. At the discretion of students the exam could be either Tuesday March 19 or Friday March 22.

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

Tentative course outline and approximate schedule

class	Date	Topic	Reading[#]
1	M 1/7	Introduction to the course of study; review prior knowledge of topics in the reading assignments.	Ch. 1, 2, 3, 4
2	W 1/9	Periodicity	Ch. 5, 6, 15, 16, 28 and Ch. 9 in Rayner-Canham or Rodgers
3	F 1/11	Periodicity continued	"
4	M 1/14	Elements and Their Physical Properties; Oxides of the elements	"
5	W 1/16	Multicenter bonding; The nature of solids; Lattice energies and solubility	Ch. 3, 5, 6, 28
6	F 1/18	Coordination Complexes, Isomers	Ch. 19, 20
7	W 1/23	Hydrides and alkyl compounds	Ch. 10, 13, 24.9-10
8	F 1/25	Organometallics and H_2 complexes	"
9	M 1/28	MOs of metal complexes	Ch. 20
10	W 1/30	Electronic structure of metal complexes	"
11	F 2/1	"	"
12	M 2/4	Exam #1	Classes 1-11
13	W 2/6	Excited electronic states, Tanabe-Sugano diagrams, etc.	Housecroft Ch. 20 and Carter Ch. 7
14	F 2/8	"	"
15	M 2/11	"	"
16	W 2/13	Descriptive Chemistry of the Transition Elements	Ch. 21, 29
17	F 2/15	"	"
18	M 2/18	"	"
19	W 2/20	"	
20	F 2/22	Reaction mechanisms	Ch. 26
21	M 2/25	Exam #2	Classes 13-19
22	W 2/27	Reaction mechanisms	Ch. 26
23	F 3/1	"	"
24	M 3/4	Organometallic compounds and catalysis	Ch. 24, 25
25	W 3/6	"	"
26	F 3/8	Survey of Chemistry of the 2^{nd} and 3^{rd} row elements	Ch. 22
27	M 3/11	Survey of Chemistry of the Lanthanides	Ch. 27
28	W 3/13	Actinides	"
29	F 3/15	Transactinides	
30	M 3/18	review	
	???	Final exam	comprehensive

[#] Note that the Housecroft book has a very detailed table of contents and index via which you can locate additional pages of the text appropriate to each of the topics. For example,

there is a section on periodicity, bond energies, etc., in each of the chapters that discuss groups of elements.

Grading
Group projects 20%
Exam #1 20%
Exam #2 20%
Final exam 40%

Many students will find it useful to review sections on periodicity of the elements and descriptive chemistry of the main group elements, as presented in freshman chemistry texts and in the books by Rodgers and Rayner-Canham in the following list.

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. The periodic tables and graphical illustrations of discovery of the elements are worth your study.

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 11/03/18
http://www.rsc.org/resources-tools/education-resources/

www.webelements.com This site has been developed over a long time, and appears to have been prepared with care. accessed 11/03/18

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 11/03/18

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 11/03/18

A set of videos of the elements has been produced by faculty at the University of Nottingham: http://www.periodicvideos.com/ accessed 11/03/18
These are also available on youtube.com

Another useful site is www.chemicool.com/ accessed 11/03/18 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 11/03/18

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 11/03/18

If you would like a nice, colorful, periodic table, look at
http://www.theodoregray.com/PeriodicTable/Posters/index.html
http://periodictable.com/ accessed 11/03/18
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 11/03/18

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 11/03/18

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 11/03/18

http://www.rsc.org/periodic-table