Syllabus for CHEM3120
Chemical Systems II

Winter Quarter 2022; revised 11/24/21

Professor G. R. Eaton

Classes start Monday, January 3.
Classes end Monday, March 14
Final exam – to be coordinated with other graduate classes.

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.

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.

A schedule of classes is posted on Canvas.

Goals

This course attempts to convey a qualitative and intuitive approach to overall trends in the periodic table. 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. 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. It is hoped that with a solid foundation in discrete monomolecular species, you will be able to extrapolate to extended solids, nanomaterials, etc.

Background assumed:

This course will build upon CHEM3310 (MS&E I), and apply atomic and molecular orbitals, symmetry, and group theory to understanding the descriptive chemistry of the elements.

Text:

The text titled Inorganic Chemistry, Fifth Edition, by Catherine E. Housecroft and Alan G. Sharpe, Pearson Prentice Hall, will be the primary text for this course. We will also continue using the symmetry book by Carter. Texts commonly used in undergraduate study of the chemistry of the elements also will be valuable to you.

Method of Instruction:

Instruction will be by assigned reading, homework problems, and in-person classes. PowerPoint notes used in class will be posted on Canvas. Some additional readings will be posted on Canvas from time to time.

Schedule:

Class will meet MWF 9:00-9:50 in Olin 103.

Note that the final exam will be scheduled to avoid having it on the same day as the exam for another graduate core class, if requested by the class. Office hours are Tuesday, Wednesday, and Thursday 5-6 pm, or by appointment.

Grading

Exam #1 25%
Exam #2 25%
Final exam 50%

Material that may be useful for this course can be found in books such as:

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.

Web sites

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 11/24/21

www.webelements.com This site has been developed over a long time, and appears to have been prepared with care. accessed 11/24/21

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 could not be accessed 11/24/21 It moved to *http://wiki.chemeddl.org*. but did not respond. If you can find it, tell the rest of the class. It was once the best site.

The American Chemical Society web site has a lot of information about the periodic table and links to the RSC and IUPAC tables. The site has downloadable pdf files.
http://acswebcontent.acs.org/games/pt.html accessed 11/24/21

A set of videos of the elements has been produced by faculty at the University of Nottingham:
http://www.periodicvideos.com/ accessed 11/24/21
These are also available on youtube.com

Another useful site is www.chemicool.com/ accessed 11/24/21This 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 11/24/21

NIST has a very nice periodic table in pdf format, and other reference data:
http://physics.nist.gov/PhysRefData/PerTable/index.html
http://physics.nist.gov/PhysRefData/contents.html accessed 01/05/21

If you would like a nice, colorful, periodic table, look at
http://www.theodoregray.com/PeriodicTable/Posters/index.html
Accessed 11/24/21
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 11/24/21

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 11/24/21

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. https://www.youtube.com/watch?v=U3mTHhp9ahM (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 11/24/21

http://murov.info/timelines.htm very detailed timeline with pictures of discoverers etc. accessed 11/24/21