Fall Semester, 2015

Chem 503, f-Element Chemistry

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Office Hours: by appointment in 639A Fulmer

3 credit hours

Todd 303
Lectures: Monday and Wednesday, 1:10-2:00 PM
Student-led Discussion session / literature review. Times, location and details TBA

Mid-term and Final Exams (not cumulative) (each 35%), 30% for discussion sessions (leading discussions, written report, and participation evaluated)

This course is intended as a focused concentration in the chemistry of the lanthanide and actinide elements. These often neglected elements play a leading role in many modern energy technologies, though in the case of the lanthanides, their function is largely in the background. Some of the actinides are quite well known for their central role in fission-based nuclear energy and weapons. Because the actinides are intimately connected in principle and practice to nuclear chemistry, the course will include a basic orientation in nuclear chemistry. To accommodate discussions of actinide physics and the nuclear fuel cycle, it will also be necessary to provide a basic orientation in radiochemistry and radiation chemistry.

Two lectures per week will cover the subject matter as described below (accounting for two credit hours and 70% of the semester grade). The third credit hour will be used for discussion of relevant papers from the (loosely defined) nuclear science, lanthanide/ actinide literature or for the development of targeted lectures on the subject matter listed further down. For the literature review and/or targeted lecture sessions two “facilitators” (class members assigned to lead the class discussion) will be assigned for each literature discussion session. The detailed schedule and structure for these literature discussion sessions will be discussed in class. In each literature review session, all class members will be expected to read the subject paper(s) and to participate actively in the discussions. Student “performance” as facilitators will be judged primarily by the peer group and performance as participants in the discussion by the instructor. We will meet at a time and location of mutual “convenience” (evenings or weekends possibly) for these sessions.

Exams: There will be one midterm exam and a final given during class time. The format of the exam could be some mix of short answer, calculation/computation, and short essay/verbal description. The student will be responsible for bringing a calculator and a pencil to all exams. No notes or books or other electronic devices are allowed, including cell phones or any device with headphones. No make-up exams will be given. If you are unable to take a scheduled exam for documented academic reasons beyond your control, you will be allowed to schedule the exam at an earlier time.

Primary Reference Text: Lanthanide and Actinide Chemistry by Simon A Cotton (ISBN-13: 978-0-470-01005-1) (*purchase advised for those interested in the subject matter but not required – reading materials will be supplied electronically as needed*)

Supplementary reading materials provided from:

- Inorganic Chemistry, Housecroft and Sharp, third and fourth editions
- Inorganic Chemistry, Shriver and Atkins, fifth edition
- Chemistry of the f-Block Elements, Helen C. Aspinal
- Periodic Table of the Elements Lanthanides & Actinides, Monica Halka, Brian Nordstrom
- The Chemistry of the Lanthanides, Therald Moeller
- d- and f-Block Chemistry, Chris J. Jones
- Lanthanide Shift Reagents in Stereochemical Analysis, Terrence C. Merrill
- Chemistry of the Actinide and Transactinide Elements, various authors in six volumes
- Handbook of the Physics and Chemistry of Rare Earths, various selected chapters
- Analytical Chemistry of Yttrium and the Lanthanide Elements, D. I. Ryabchikov, V. A. Ryabukhin
- Transuranium Elements: Products of modern alchemy, Glenn T. Seaborg, Ed.
- The Elements Beyond Uranium, G. T. Seaborg and W. D. Loveland
- Radiochemistry and Nuclear Chemistry, Third Edition, 2001, G. Choppin, J. O. Liljenzin, J. Rydberg,
- Solvent Extraction Principles and Practice, Second Editionm Revised and Expanded, Jan Rydberg, Michael Cox, Claude Musikas, Gregory R. Choppin

And papers from the literature

Tentative Class Schedule (annotated)

Wk	date	Mon	Weds	note
1	8/24	Introductions & Basic properties of f elements	Basic properties of f elements & applications	
2	8/31	Discovery Ln	Discovery An	
3	9/7	No class Reading assignment	No class Reading assignment	*KN absent*
4	9/14	actinides and one atom at a time chemistry	actinides and trans actinides	
5	9/21	Radiation and redox chemistry	Nuclear chemistry Stability patterns Chart of nuclides	*KN absent* Joe Lapka lecture
6	9/28	Hydration and hydrolysis	Lanthanides in solution	
7	10/5	Actinides in solution – compare Ln/An	Coordination chemistry	
8	10/12	Coordination chemistry – non aqueous media	**Exam 1**	
9	10/19	Ln Complexation and redox kinetics	Actinide redox and complexation kinetics	
10	10/26	Ln optical spectroscopy – **Jeremy Lessmann**	Ln optical spectroscopy – **Jeremy Lessmann**	
11	11/2	Ln/An organometallics catalysis	Soft donor discrimination of Ln from An	
12	11/9	f-elements in the environment	**Veterans Day – no class**	
13	11/16	f-elements separations	Closing the nuclear fuel cycle	
14	11/23	**Thanksgiving week**	***no class***	***no class***
15	11/30	Fast reactors and actinide transmutation	Ln macrocycle complexes and nuclear medicine applications	
16	12/7	Review semester	**Final Exam**	
	12/14	**finals week**	**finals week**	***KN absent***

(1) The cutoff point for Exam 1 will be the October 7 lecture, inclusive of the material covered on that day.

Student reviews/discussion of papers from the literature will be done on a schedule to be determined. Each student will write a one paragraph synopsis of assigned papers (group reading). One or two students will be assigned as discussion leaders. A time and location for conducting these discussion sessions will be agreed upon by all class members.

Potential Topics for Student research, presentations and discussion:

- Lanthanides and Actinides in Nuclear Medicine (radioactive, MRI and optical applications) Biological chemistry of lanthanides and actinides
- Applications of NMR spectroscopy in Lanthanide and Actinide Chemistry / Principles of lanthanide applications in magnetic resonance imaging
- Organometallic Chemistry of f-Elements/catalysis
- Fluorescence studies of Eu^{3+}, Tb^{3+}, and Cm^{3+}
- Computational Studies of lanthanides and actinides
- Trivalent Lanthanide/Actinide Separations (soft donor effects)
- Why are actinyl ions the only linear dioxo cations in the periodic table?
- f-element chemistry in Advanced Nuclear Fuel Cycles
- Glenn Seaborg and the development of the Actinide Concept
- Fundamental basis of lanthanide applications / Lanthanide Magnetic Materials / Lanthanide Optical Materials
- Uranium, thorium and Rare earth minerals, mining, mill tailings and the Oklo Phenomenon
- Patterns of Stability in Trans-lanthanide complexes: Radii change regularly, but complexes do not. Why?

Student Learning Outcomes

Chemistry 503 is designed to advance students toward the WSU Learning Goals, especially Scientific Literacy, Critical and Creative Thinking, Quantitative Reasoning, Communication, and Information Literacy. This course will provide graduate students with a foundation in the theoretical principles and the descriptive chemistry of the lanthanide and actinide elements of the periodic table focusing on the unique nuclear and chemical properties of these elements. The objective is to introduce students to the unique chemistry of these elements through lectures, reading of the available literature, and presenting the results of a critical evaluation of the science and technology of the subject metals. The level of the course assumes an entering graduate student with a B.S. in Chemistry with some experience with the topic of inorganic chemistry.

By the end of the course it is expected that every student will have:

1) Working knowledge of f-element chemistry and physics
2) Gained confidence in his/her ability to read and understand the scientific literature and to critically evaluate same
3) Gained experience in preparing and delivering a scientific presentation
4) Gained experience in collaborative research

Students with Disabilities:

Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; 509-335-3417) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center. For more information contact a Disability Specialist on your home campus:

Pullman or WSU Online: 509-335-3417 http://accesscenter.wsu.edu, Access.Center@wsu.edu
Spokane: http://spokane.wsu.edu/students/current/studentaffairs/disability/
Tri-Cities: http://www.tricity.wsu.edu/disability/
Vancouver: 360-546-9138 http://studentaffairs.vancouver.wsu.edu/student-resource-center/disability-services

Academic integrity statement:

Serious chemistry graduate students wouldn't contemplate cheating, as the principal harm would be self-inflicted wounds. The course will be structured such that cheating is impossible – or (officially), *As an institution of higher education, Washington State University is committed to principles of truth and academic honesty. All members of the University community share the responsibility for maintaining and supporting these principles. When a student enrolls in Washington State University, the student assumes an obligation to pursue academic endeavors in a manner consistent with the standards of academic integrity adopted by the University. To maintain the academic integrity of the community, the University cannot tolerate acts of academic dishonesty including any forms of cheating, plagiarism, or fabrication. Washington State University reserves the*

right and the power to discipline or to exclude students who engage in academic dishonesty.

Safety and emergency notification:
Pullman: "Washington State University is committed to enhancing the safety of the students, faculty, staff, and visitors. It is highly recommended that you review the Campus Safety Plan (http://safetyplan.wsu.edu/) and visit the Office of Emergency Management web site (http://oem.wsu.edu/) for a comprehensive listing of university policies, procedures, statistics, and information related to campus safety, emergency management, and the health and welfare of the campus community."

Assigning Incompletes: University policy (Acad. Reg. #90) states that Incompletes may only be awarded if: "the student is unable to complete their work on time due to circumstances beyond their control".

Important Dates and Deadlines: Students are encouraged to refer to the academic calendar often to be aware of critical deadlines throughout the semester. The academic calendar can be found at www.registrar.wsu.edu/Registrar/Apps/AcadCal.ASPX.