Syllabus

CHEM 550 – Chemistry of the Nuclear Fuel Cycle
Fall Semester 2016

Monday, Wednesday and Friday 1:10 PM

Location: Fulmer Hall, room Fulmer 150
Instructor: Prof. Ken Nash (Fulmer 639A, 509-335-2654, knash@wsu.edu) plus occasional guest lectures

Prerequisites/Capabilities Expectations
Basic math skills, Interest in radiation, radioactivity, and the social implications of energy production and use, A general familiarity with the basic features of inorganic and physical chemistry concepts is expected, Willingness to become better informed and to work hard in order to accomplish these objectives.

Content and Plan of Action
This is a three credit hour graduate level Chemistry course. The level of presentations will be such that upper division undergraduates should be able to handle the work. The first week of instruction will be dedicated to an overview of the nuclear fuel cycle. In the subsequent two or three weeks the focus will be on the underpinning nuclear chemistry, radiochemistry and radiation chemistry. The remaining 11 weeks will be dedicated to study of the chemical science and technology of the Nuclear Fuel Cycle. After the initial orientation session (which may last three weeks), there generally will be two lectures and one hour long discussion period per week, as described below (schedule subject to adjustment).

A reading assignment and accompanying weekly discussion period is planned. After the orientation period there will be two lecture periods per week and one hour dedicated to a student-led presentation/participation discussion. In this discussion period we will discuss sections of the Pulitzer Prize winning history of nuclear science and technology, *"The Making of the Atomic Bomb"* by Richard Rhodes and of the very lucid (and generally accurate/entertaining) account of nuclear/radioactive accidents/incidents *Atomic Accidents* by James Mahaffey. The primary "text book" is *The Nuclear Fuel Cycle: from ore to waste* by Peter D. Wilson. The most useful general nuclear science reference source is *Radiochemistry and Nuclear Chemistry, Third Edition*, by G. R. Choppin, J-O. Liljenzin, and J. Rydberg (A fourth Edition has been recently released and it is usable, but the chapters have been reorganized relative to the third edition – though the fourth edition looks improved in appearance, if not substance, most current students (and the instructor) already have the Third edition, so we will use that as a primary reference). Additional materials will be either provided or students will be directed to a location where they can find it.

Topics covered

- Origin of the Elements/Historical development of Nuclear science/power
- Radioactive decay, radiation effects on matter
- Nuclear Reactions/fission/fusion
- Basic nuclear physics
- Actinide science
- U minerals/mineralogy/mining/extraction
- Isotope enrichment/Pu production
- Reactor operations/nuclear power
- PUREX and closing the nuclear fuel cycle
- Nuclear weapons and weapons proliferation concerns
- Repositories and waste management
- Actinides and fission products in the environment
- Cleanup of the weapons complex (US/Russia)
- Detection/intervention on nuclear weapons proliferation
- Accidents: Chernobyl, TMI, Idaho Falls, criticality incidents at National labs
- The international picture
- Where does this technology go in the future? (Nuclear Power and Global Climate Change)

Diagnostic examination

The diagnostic examination will be administered on Monday, August 22. The examination will cover basic concepts of radiochemistry, awareness of some details of nuclear energy, and will be used to make a final determination of the course curriculum for the first three weeks of the semester in response to the level of student capabilities. The most appropriate study guide for refresher/remediation study is *Radiochemistry and Nuclear Methods of Analysis* by Ehmann and Vance, chapters 1 – 6 and chapter 8.

Grading

There will at a minimum be a mid-term and final-exam. Homework assignments are possible. The course grading structure will be determined after the initial diagnostic examination, but it will include a significant contribution from the "*Atomic Accidents/Making of the Atomic Bomb*"/"*Atomic Accidents*" discussion periods. The final grading scheme will be announced by September 16, but it will be approximately 35% mid-term exam, 35% final exam, 30% in class oral presentation and discussion participation.

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 – 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."

Student Learning Outcomes; The course is designed to inform and educate graduate and undergraduate science and engineering students in the chemistry and technological aspects of the nuclear fuel cycle. It is expected that successful participants will have gained insights into the field that are far above that of the general population and probably greater than that of most of the political leadership of this country. The course features approximately 70% faculty lectures/30% student-led discussions. Student performance will be judged based on their performance on mid-term and final examinations (35% each) and on their delivery of lectures/participation in discussions on the historical monograph "The Making of the Atomic Bomb" by Richard Rhodes and "Atomic Accidents" by James Mahaffey.

Tentative Schedule:

Week #	Mon	Wed	Fri
1: Aug 22-26	Syllabus, Diagnostic "Quiz"	KN travel Reading assignment	KN travel Reading assignment
2: Aug 29-Sep 2	Nuclear fuel cycle overview	Nuclear fuel cycle overview	Nuclear fuel cycle overview
3: Sep 5-9	**Labor Day** **No class**	basic orientation: definition of terms basic nuclear chemistry, mass defect, etc.	radioactive decay, interactions of ionizing radiation with matter, detection and shielding
4: Sep 12-16	basic features of fission; fission yield, isotopes of fission	Actinides natural vs. man made/ mining, milling – U & Th, separations and tailings	enrichment fuel vs. weapons fuels and fabrication, including MOX
5: Sep 19-23	Rhodes discussion 1	Spent fuel composition, characteristics and management	Spent fuel composition, characteristics and management
6: Sep 26-30	Rhodes discussion 2	reprocessing PUREX and precursors	Reprocessing research for Advanced partitioning
7: Oct 3-7	Rhodes discussion 3	reprocessing and breeder reactors, pyro	pyro, reprocessing for An transmutation
8: Oct 10-14	KN Travel GUEST LECTURE Waste forms	KN Travel GUEST LECTURE Waste forms	Travel? GUEST LECTURE? Waste forms
		Saturday October 15 →	***Mid-term exam?***
9: Oct 17-21	Mahaffey discussion 1	nuclear weapons history and legacy weapons complex	weapons proliferation – science and politics
10: Oct 24-28	Mahaffey discussion 2	Topics of interest	Topics of interest
11: Oct 31-Nov 4	Mahaffey discussion 3	environmental radioactivity	Th/U fuel cycle
12: Nov 7- 11	Mahaffey discussion 4	nuclear forensics & counter proliferation	**Veteran's day** **no class**
13: Nov 14-18	Mahaffey discussion 5	nuclear forensics & counter proliferation	Topics of interest
14: Nov 21-25	**Thanksgiving break**	**No class**	**No class**
15: Nov 28-Dec 2	Mahaffey discussion 6	additional topics/expansions	additional topics/expansions
16: Dec 5-9	Mahaffey discussion 7	Nuclear energy global perspective and climate impacts	Prospects and challenges for NFC review semester
17: Dec 12-16	FINAL EXAM WEEK		

Other possible topics: reactors past present and future, Repositories, waste management,

Cleaning up the weapons complex, the Manhattan Project, the Cold War