Syllabus

CHEM 550 - The Nuclear Fuel Cycle
Spring Semester 2014

Monday, Wednesday and Friday 12:10 PM (subject to adjustment)

Location: Fulmer Hall, room Fulmer 225
Instructors: Prof. Ken Nash (Fulmer 639A, 509-335-2654, knash@wsu.edu)
Dr. Donald Wall (NRC Director, 509-335-8641, Donald_wall@wsu.edu)

Prerequisites
Basic math skills, Understanding of physical chemistry, Interest in radiation, radioactivity, and the social implications of energy production and use, 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 will be dedicated to the basics of nuclear chemistry, radiochemistry and radiation chemistry. The remaining 14 weeks will be dedicated to study of the chemical science and technology of the Nuclear Fuel Cycle. After an initial orientation section potentially lasting the first few weeks, there will be two lectures and one hour long discussion period per week.

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 the Pulitzer Prize winning history of nuclear technology, *"The Making of the Atomic Bomb"* by Richard Rhodes. The most useful reference source, hence recommended "textbook" 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 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
- 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, January 13. 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 probable. The course grading structure will be determined after the initial diagnostic examination, but it will include a significant contribution from the "Making of the Atomic Bomb" discussion periods. The final grading scheme will be announced by January 20.

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."

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.

Planned Schedule:

Week #	Mon	Wed	Fri
1: Jan 13 - 17	Syllabus, Diagnostic "Quiz"	basic orientation: definition of terms basic nuclear chemistry, mass defect, etc	radioactive decay, interactions of ionizing radiation with matter, detection and shielding
2: Jan 20 - 24	NO CLASS MLK	Actinides natural vs. man made	mining, milling – U & Th, separations and tailings
3: Jan 27 – 31	fuels and fabrication, including MOX	enrichment fuel vs. weapons →	basic features of fission; fission yield, isotopes of fission
4: Feb 3 – 7	Rhodes discussion demo/model	reactors past present and future	reactors past present and future
5: Feb 10 – 14	Rhodes discussion 1	Spent fuel composition, characteristics and management	Spent fuel composition, characteristics and management
6: Feb 17 – 21	no class, President's day	reprocessing PUREX and precursors	reprocessing for improved waste mgmt
7: Feb 24 – 28	Rhodes discussion 2	reprocessing and breeder reactors, pyro	pyro, reprocessing for An transmutation
8: Mar 3 – 7	Rhodes discussion 3	Repositories, waste management	Repositories, waste management
		Saturday March 8 →	***Mid-term exam***
9: Mar 10 – 14	Rhodes discussion 4	nuclear weapons history and legacy	weapons proliferation – science and politics
10: Mar 17 – 21	SPRING BREAK		
11: Mar 24 – 28	Rhodes discussion 5	environmental radioactivity	Th/U fuel cycle
12: Mar 31 – Apr 4	Rhodes discussion 6	nuclear forensics & counter proliferation	nuclear forensics & counter proliferation
13: Apr 7 – 11	Rhodes discussion 7	criticality accidents	criticality accidents
14: Apr 14 – 18	Rhodes discussion 8	additional topics/expansions	reactor accidents
15: Apr 21 – 25	Rhodes discussion 9	additional topics/expansions	additional topics/expansions
16: Apr 28 – May 2	Rhodes discussion 10	Rhodes discussion 10	Prospects and challenges for NFC review semester
17: May 5 – 9	FINAL EXAM WEEK		