Radiation and Nuclear Systems Chemistry

Course Instructor:

Course Web-Page:

Course Description:

This course covers the nuclear reactions brought about by absorption of slow neutrons or by radioactive decay, and the chemical effects produced in a system by the absorption of ionizing radiation, alpha-, and beta-particles and gamma- and x-rays. Sources of radiation, collision of high energy radiation with electrons in matter, differences between photochemistry (solute-oriented) and radiation chemistry (solvent-oriented), the formation of ions and free radicals along the radiation tracks and the diffusion and chemical reaction kinetics of ions and free radicals are described at an introductory level. Nuclear reactors, accelerators, medical radioisotopes and other applications of nuclear technologies are also described.

Reference Books:

- "Introduction to Radiation Chemistry" by Spinks and Wood
- "Radiation Chemistry' by Farhataziz and M.A.J. Rodgers

Prerequisites: Chem 2374/2384

Detailed Outline

1. Definitions, Terms, Sources of Ionizing Radiation
   - Radiation Chemistry vs Photochemistry
   - Nuclear Chemistry and Radiochemistry
   - Radioactive decay, Half-life, First order reaction, Source strength
   - Alpha, beta, gamma-radiation, x-rays, high-energy particles
   - Accelerators, Synchrotron
2. Nuclear reactors
   - How nuclear reactor works
   - Different reactor designs – PHWR, BWR, PLWR, AGR
   - Fuel, Coolant, Moderator, pressure vessel vs pressure tubes
   - Fission, fission products, neutron activation products
3. Medical radioactive isotopes
   - Diagnostic and Imaging
   - Radiotherapy
4. Initial interaction with matters – Particle (Photon) -Particle Collisions
   - Charged particles (α, β, etc) vs. Photons
   - Bremsstrahlung radiation, inelastic and elastic collision vs. photoelectric effect, Compton scattering, coherent scattering and pair production
   - Rate of Energy loss, Penetration length, Linear energy transfer (LET)
5. Water Radiolysis
   - Time scale of physical, physicochemical, and chemical stages
   - Radiolysis products along the radiation tracks, homogeneous yields
   - Solvated electrons, and free radicals
   - Pulse radiolysis vs Steady-state radiolysis
6. Applications of Nuclear Technologies
   - Nuclear reactor system chemistry and materials
   - Metal Clusters and nanomaterials – important in catalysis
   - Wastewater remediation – Advanced oxidation processes (AOPs)
   - Molecular formation in the interstellar medium/cosmic ices – the origins of life?
   - High performance polymeric materials by irradiation
   - Radio-sterilization of drugs
   - Food irradiation
   - Radiation damage to biomolecules, Chemical protection
   - Dosimetry
   - Radiotherapy

Evaluation:

The final grade for the course will be determined by the following:

Assignments throughout the term: 10%

Report on Literature Review: 15%

Report due:
You are required to perform literature search, read at least four papers in one of the topics from the list I will provide under the subjects of radiation induced chemistry, and summarize it in 6 typed pages (double-spaced, font size 12pt, 1" margins). I will provide more specific instruction on the content of the report.

Critical Review of Your Own and Two Other Reports: 10%

Report due:

You will revisit your report and two other reports by your peers (with names withheld) at the end of the term. You are required to provide critical reviews and comments on the reports, one page per report.

Two 2-h Mid-Term Tests: 40%

Tentatively:

Final Exam: 25%

Additional Administrative Notes:

Plagiarism is a serious scholastic offense and mo