Chapter 0

Basic Nuclear Science - Chem. 436 :

0.1 Who, When and Where

Lecturer: Professor Lee G. Sobotka

Lectures: MWF 11-12, initially we will meet in Louderman 561

Office: 259 RadioChemistry (RC)

Office hrs: Th. morning or afternoon

Textbook: Detailed lecture notes will be handed out. Beyond these notes the most useful single text book is: *Nuclear and Radiochemistry,* Friedlander, Kennedy, Macias and Miller, 3rd edition. (Hereafter FKM^2).Purchase of this text is strongly recommended.

Supplementary Texts

1. Chart of the Nuclides, 16th ed. (You must either own a copy or have a wall chart readily available.)
2. Table of Nuclides, by Shirley and Lederer, 6th or 7th edition. (Need copy readily available)
3. Radiation Detection and Measurement, by Glenn F. Knoll.
4. Fundamentals of Nuclear Physics by N.A. Jelley.
5. Introduction to Nuclear Physics and Chemistry, by B. Harvey.
6. Nuclei and Particles, by E. Segré, 2nd edition.
7. Nuclear Physics, by Meyerhof
8. Introduction to Nuclear Physics, by Harald Enge
9. Introduction of Nuclear Reactions, by G.R. Satchler

These books are on reserve in the Chemistry library and are also available (from the instructor) for use in the RC common area.

0.2 Course content

This course is an introduction to the atomic nucleus, radioactivity and the interaction of radiation with matter. Basic models for nuclear stability and structure are presented. All nuclear decay modes are thoroughly discussed as are how all forms of ionizing radiation interact with matter. Some of the technical issues and problems with nuclear power and nuclear waste are presented along with other selected applications in biology, chemistry, physics, earth science, and medicine.

0.3 Syllabus

Each topics will each occuy 2-4 lectures.

1. General introduction and nomenclature
2. Atomic Masses and macro. nuclear mass models
3. Interaction of radiation with matter and radiation safety
4. Radiation detectors
5. Laws of Radioactive decay
6. Fermi gas model of degenerate matter
7. Nuclear Shell model
8. Alpha decay
9. Beta decay
10. Gamma decay
11. Fission
12. Reactions and Nucleosysthesis
13. Applications of nuclear science
14. Nuclear Power Reactors (Generations I - IV)

0.4 Grading

There will be regular ($\sim$ weekly) homework assignments, a midterm exam and a final. One or both of the exams will be of the take home variety. The course grade will be composed on an approximately 50-50 basis of homework and the exams. Some of the homework will require working problems in some symbolic or numerical software (i.e. MATHCAD, MATLAB, MAPLE or MATHEMATICA.) While these packages are available on various university machines, personal purchase of some package is recommended.

0.5 Useful constants

(See chart of nuclides for more complete table.)

1 amu = 931.494013 MeV

= 1.66053873 $*10^{-27}$ kg

m_e = 9.109382 $*10^{-31}$ kg

= 5.485799 $*10^{-4}$ amu = 511 keV/c^2

m_n = 1.6749272$*10^{-27}$ kg

= 1.008664926 amu = 939.56533 MeV/c^2

m_p = 1.67262158$*10^{-27}$ kg

= 1.00727647 amu = 938.271998 MeV/c^2

m_H = 1.67353249$*10^{-27}$ kg

= 1.007825017 amu = 938.78298 MeV/c^2

$\frac{1}{\alpha} = \frac{\hbar c}{e^2} = 137.03608$

$r_e = \frac{e^2}{m_e c^2} = 2.817935 \cdot 10^{-15}$ m

$\hbar = 1.0546 \cdot 10^{-27}$ erg·s = $6.582122 \cdot 10^{-22}$ MeV·s

= 6.465 MeV$^{1/2}$·amu$^{1/2}$·fm

$\hbar c$ =197.3 MeV$*$fm

$\lambda bar = \frac{\lambda}{2\pi} \overset{UR}{=} \frac{197.3}{E(MeV)}$ [Result in fm.]

$K_b = 1.38065 * 10^{-23} \frac{J}{K}$

$= 0.86171 * 10^{-10} \frac{MeV}{K} = 0.86171 * 10^{-4} \frac{eV}{K}$

$e^2 = 1.44$ MeV·fm

$\mu_B \equiv \frac{e\hbar}{2m_e} = 9.27400899 \times 10^{-26}$ J /T

$\mu_N \equiv \frac{e\hbar}{2m_p} = 5.05078317 \times 10^{-27}$ J /T

$\mu_n = -1.9135$ n.m. $= -9.6623707 \times 10^{-27}$ J /T

$\mu_p = 2.79275$ n.m.$= 1.41060761 \times 10^{-26}$ J /T

$c = 29.8782458$ cm/ns

1 eV = 1.60219×10^{-12} erg =1.60219×10^{-19} J

1 yr = 365.25 d = 3.15576×10^7 s

v$(\frac{cm}{ns}) \overset{NR}{=} 1.389\sqrt{\frac{E(MeV)}{A(amu)}}$