Chemical Engineering 412

Introductory Nuclear Engineering

Lecture 33

Exam 3 Review

Spiritual Thought

1. Your Family
2. Your Career
3. The Church
4. Youself

Elder Renlund

Chapter 11.6-11.7

- Nuclear Fuel Cycle: front and back end
- Enrichment Calculations
  - Waste factor, feed factor, separation potentials
  - Use these factors to determine cost given price
- Grades and forms of Uranium
- Separation Techniques
- LWR Fuel compositions
- Radiopharmaceuticals
- Once-through cycle
- Other fuel cycles – recycle, mixed oxides, etc.

Chapter 8

- Detector Types
  - Dead times, interaction rates, performance, paralyzable, etc.
  - Examples & Diagrams, etc.
  - Fundamental operation principles
- Detection and Operation Modes
- Spectroscopy
- Efficiency
- Related equipment (PMTs, SCPHA, MCA)

Chapter 9

- Know Big picture of Radiation Doses
- Know various measurements, units conversion from one to another
  - KERMA, exposure, Absorbed Dose, etc.
  - Know how to correlate to biological impacts
- Calculation of dose
- Hazards of Radiation (Table usage)
- Exposure limits – amounts, history, etc.
- Perspective on radiation effects
- Acute and latent effects/symptoms
- Does model – Linear, threshold, hormesis

Chapter 13

- Beneficial Uses of Radiation +Applications
  - Specific isotopes and production
- Advantages/Disadvantages of radioactive
- Uses of Tracers (calculate amount needed)
- Uses of “Materials affecting Radiation”
- Uses of “Radiation affecting Materials”
- Particle Accelerators
- Economics and Widespread applciations

Chapter 14

- Medical Uses of Radiation
  - Diagnostic vs. theraputic
- X-Rays
- Mammography & Densitometry
- CT Scan
- SPECT
- PET
- MRI

Example I

- Some people have decided that it's a good idea to enrich higher enrichment Uranium tails (0.2%), which is essentially free, so that you don't have to pay for natural uranium. The waste stream feed would be 0.05%, and the~~y are~~ final fuel uranium would be 4.95% U235 enrichment. What is the SWU/kg for this process?
- The cost of Uranium and SWU for natural uranium enrichment are \$39.5/lb and \$80/SWU. Is this plan cheaper than using natural uranium?

$$\frac{F}{P} = \frac{x_p - x_w}{x_f - x_w} \qquad \frac{W}{P} = \frac{x_p - x_f}{x_f - x_w}$$

$$V(x_i) = (2x_i - 1)ln\left(\frac{x_i}{1 - x_i}\right)$$

$$\text{SWU/kg} = V\left(x_p\right) + \frac{W}{P} \cdot V(x_w) - \frac{F}{P} \cdot V(x_F)$$

$$\frac{SWU}{kg} = 40.968 \qquad \frac{SWU}{kg} = 8.847$$

Example II

- If potatoes receive gamma-ray doses between 60 Gy and 150 Gy, premature sprouting is inhibited. Such irradiation can be done in an irradiator with a large ^{60}Co source. Assume all the gamma rays are absorbed in the potatoes. What is the minimum activity of 60Co needed in an irradiator to deliver such a dose of 250kGy to 100,000 kg of potatoes in 8 hours?

- From appendix D, E_γ = 2.5 MeV

$$E_{abs} = \frac{2.5 \times 10^5 \text{ J/kg} \times 10^5 \text{ kg}}{8 \times 3600 \text{ s} \times 1.602 \times 10^{-13} \text{ J/MeV}} = 5.42 \times 10^{18} \text{ MeV/s.}$$

- A = 2.17E18 Bq

Example III

- A Lithium 6/Hydrogen 3 sample is bombarded with neutrons (in a flux of 4.5E11 neutrons/cm^2/s) for 15 hours to determine how much ^6Li is present in a given sample. The cross section of Lithium 6 is 943 b. If the final number of Lithium 7 atoms is N = 4.3E18 atoms, what was the original number of ^{6}Li atoms?

$$\frac{dN^7}{dt} = \sigma_a N^6 \cdot \phi - N^7 \lambda^7$$