ENGY 3310 Fundamentals of Nuclear Science and Engineering

Spring 2016

HW #3: Basic Concepts and Terminology

Problem 1 (5 points)

a. What is the wavelength of a photon with an energy of 7.84×10^{-18} J?

b. Is this ionizing radiation? Explain...

Problem 2 (5 points)

Consider the nuclides: ${}^{64}_{32}\mathrm{Ge}$, ${}^{20}_{8}\mathrm{O}$, and ${}^{212}_{84}\mathrm{Po}$. Classify each of these nuclides as neutron rich, neutron poor, or too heavy, identify an appropriate decay process that moves each of these radioactive nuclides closer to the island of stability and, finally, write out a possible decay equation for each of the processes chosen.

Problem 3 (5 points)

Consider an experimental setup that contains only a bare sphere of U235. If 57.5 % of the fission neutrons escape from the sphere, is this system critical? Explain...

Note: An average value of η for this system is 2.31.

Problem 4 (5 points)

A typical conversion ratio in a PWR system is about 0.62. If the system has a thermal power of 2600 MW and a capacity factor of 0.88, estimate the mass of fissile plutonium produced per year of operation (use α = 0.17 for U235).

Problem 5 (5 points)

Explain why the turbine room in a BWR is uninhabitable during normal operation.

Problem 6 (5 points)

A 1000 MWe nuclear plant has a thermal conversion efficiency of 33%.

a. Estimate the thermal power rejected through the condenser to the cooling water.

b. What is the required coolant flow rate (kg/s) if the temperature rise of the cooling water is 12 C (use 4180 J/kg-C as the specific heat of water)?

Problem 7 (5 points)

Consider a nuclear plant that operates at a net electrical output of 470 MW. The overall efficiency of the plant is 32.5%. Approximately 60% of the plant's power comes from fissions in U235, with the remainder from fissions in the converted plutonium (mostly Pu239). The value of the capture to fission ratio in U235 is about 0.169 and about 0.362 in Pu239.

a. If the plant were operated at full power for a full year, how many kilograms of U235 and Pu239 would be fissioned?

b. How much U235 and Pu239 are consumed under the same conditions?

Problem 8 (5 points)

A certain fossil fueled generating station operates at a power of 1000 MWe at an overall efficiency of 38% and an average capacity factor of 0.70.

a. How many tons of 13,000 BTU/lbm of coal does the plant consume in one year?

b. If an average coal carrying railroad car carries 100 tons of coal, how many carloads must be delivered to the plant on an average day?

c. If the coal contains 1.5% by weight sulfur and, in the combustion process, this all goes up the stack as SO_2, how much SO_2 does the plant produce in one year?

This problem should give you a feel for the actual amount of material needed to produce a given amount of energy within a conventional fossil fuel plant. Really think about the mass flows here...