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NPRE 201 - Quiz #4

Please show all work for all calculations.

1) *Answer the following:*
For American commercial nuclear power plants, like PWRs and BWRs, what substance acts as the moderator? What function does the moderator perform?

The moderator in American PWRs and BWRs is water, and this slows the neutrons down from their birth energy to a thermal energy to give a higher cross section of absorption.

2) *Answer the following:*
Name two major differences between Boiling Water Reactors (BWR) and Pressurized Water Reactors (PWR).

BWRs allow the water to boil into steam, while PWRs pressurize the water high enough to where there is no steam generated in the main loop. The PWR is used to indirectly heat a secondary loop to generate steam, but the BWR uses the steam generated to directly spin a turbine.

3) *Choose the correct answer*
In American commercial nuclear power plants, like PWRs and BWRs, ____neutrons are more likely to cause fission.

a. Fast
b. Intermediate
c. Non-Thermal
d. Thermal

4) *Choose the correct answer*
The composition of natural uranium is (please read the options carefully):

a. 0.7% U-233 and 99.3% U-238
b. 0.7% U-235 and 99.3% U-238
c. 3.0% U-233 and 97.0 % U-235
d. 3.0% U-235 and 97.0% U-238
e. 93% U-235 and 7% U-238

5) *Complete the following:*
Rank the following in time order of Nuclear Fuel Life (i.e. the #1 event would take place before the #2 event.):

3 Reactor Operation

2 Uranium Isotope Separation and Enrichment

5 Reprocessing Fuel

1 Yellow Cake Mining

4 Used or Spent Fuel

6) *Calculate the following:*
1 Kilogram of Plutonium-239 (Pu^{239}) is created in the year 2020. What proportion of this original quantity of Plutonium-239 will remain in the year 2320 (300 years from now)? Show your calculations.
The half-life ($t_{½}$) of Plutonium-239 is 24,110 years.

$$1kg * \exp\left(\frac{-ln(2)}{24{,}100\ years} * 300\ years\right) = .99141kg$$

7) *Choose the correct answer*
Which of the following is considered "high-level" waste?

a) Contaminated tools

b) Nuclear medical waste

c) Used water conditioner chemicals

d) None of these

8) *Calculate the following*

A 100 kg nuclear power plant worker is exposed to $5*10^{13}$ MeV of radiation. What is this person's absorbed dose? If light radiation sickness begins at a dose of about 50 to 100 rad, will he or she become ill? Show your calculations. Useful conversion factors are:
1 J = 6.24 * 10^{12} MeV and 1 J/kg = 100 rad

$$5 * 10^{13} MeV * \frac{1\ J}{6.24 * 10^{12}\ MeV} * \frac{1}{100\ kg} = .080 \frac{J}{kg} * \frac{100\ rad}{1\ \frac{j}{kg}} = 8.013\ rad$$

No, he/she will not become ill from this dosage.

9) *Choose the correct answer*
The RBMK Reactor at Chernobyl had a moderator that was different from the reactor coolant. Briefly explain why this caused a problem.

The moderator was graphite, and this was a problem because as the coolant turned to steam, instead of having a negative impact on the reactivity, like you would have with water as the moderator and the coolant, the moderator slowed down too many neutrons for the diminishing coolant to handle, which caused a runaway reaction.

10) *Choose the correct answer*
Which of the following will expose a person to the most amount of radiation in one year? (Medical X-rays happen very infrequently, but they have a concentrated dose)

a) Medical X-rays
b) Building materials (like granite rock)
c) Color Television
d) Living next to an operating nuclear power plant

11) *Choose the correct answer*
Which type of power plant has the highest cost to build?

a) Coal power plant
b) Nuclear power plant <- at least in the US
c) Residential geothermal loops
d) Natural gas turbine power plant

12) *Choose the correct answer*
A Tokamak fusion system, like ITER, is constructed in the general shape of a:

a) Tennis ball or Sphere
b) Donut or Hollow Ring
c) Right Circular Cylinder
d) Square Box

13) *Answer the following*
Give two advantages of a fusion power for energy production:

No radioactive waste
Cheap Fuel (D_2 in ocean water)

14) *Answer the following*

Does the United States reprocess nuclear fuel after it is taken out of the reactor?
Explain what is done with the spent fuel for the nuclear reactors operated in the US?

No, the US stores its spent fuel on site until the radioactivity diminishes enough to place it into a repository.

15) *Calculate the following*

Binding Energy Calculation: How much energy is released in the following D-D nuclear fusion reaction. (The answer can be in the simplest unit of energy or converted to Joules – see the conversion factors in Problem 8.)

$D^2 + D^2 \rightarrow He^3 + n$

Binding Energy Values

D^2	1.11226 MeV/nucleon
He^3	2.5727 MeV/nucleon
n	neutrons are free and not bound to other nucleons

$$(initial) - (final) = Q$$

$$\left(\left(2 * M(H_2)\right) - \left(M(He3) + M(n)\right)\right) * \frac{MeV}{amu} = Q$$

$$((2 * 2.01410177784\ amu) - (3.01602932197\ amu + 1.0086649159\ amu) = 0.00351\ amu$$

$$0.00350931781 amu * \frac{931.5\ MeV}{1\ amu} = 3.26892954\ MeV$$