Introduction to Nuclear Engineering & Health Physics — Fall 2021
MECH5103 MECH6003 — Dr.Spitz

QUIZ #2

PART I: There are 15 T/F questions, each worth 2 pt. (30 points total)

1. T F Charged particle interactions in an absorber are responsible for the majority of the dose delivered by photons.
2. T F Neutrons are classified according to their velocity because the type of reaction that a neutron will produce is very energy dependent.
3. T F Both neutrons and photons experience exponential absorption as they penetrate an absorber.
4. T F A photon may undergo a pair production interaction with an absorber nucleus when the photon energy is equal to or greater than the rest mass of the electron. $2m_0c^2$
5. T F Shields for beta radiation are typically made of materials having a low atomic number to minimize the likelihood of bremsstrahlung.
6. T F The attenuation of neutrons is effectively accomplished with an absorber containing large amounts of hydrogenous material.
7. T F Like alpha and beta emitting radionuclides, many other radioisotopes naturally emit neutrons.
8. T F The average kinetic energy exhibited by thermal neutrons is indistinguishable from gas molecules of the same temperature.
9. T F The macroscopic cross section describes the likelihood per unit distance that a neutron will interact passing through an absorber.
10. T F Moderation (loss of neutron energy) increases with increasing mass of the target nucleus.
11. T F ^{16}O, ^{12}C, and ^{4}He exhibit greater binding energy per nucleon than all other nuclei.
12. T F The neutron can lose all its energy in a collision with the hydrogen nucleus.
13. T F A thermal neutron absorbed by a ^{235}U nucleus can split the nucleus into two medium-mass nuclei, emitting about 200 MeV of energy and an average of 2.5 fast neutrons.
14. T F All neutrons at the time of their birth are fast.
15. T F Fissile isotopes are those that will fission with a thermal neutron.

PART II: **There are 10 questions, each worth 2 pts. (20 points total)**

1. The energy of a thermal (room temperature) neutron is

D

   A. 0.5 eV
   B. 0.05 eV
   C. 0.25 eV
   D. 0.025 eV
   E. None of the Above

2. The largest share of the energy released in fission of ^{235}U goes to

A

   A. gamma rays
   B. beta rays
   C. fission fragments
   D. neutrons
   E. neutrinos

3. All neutrons

E

   A. may collide with nuclei and under go either elastic or inelastic scattering
   B. are initially formed as fast neutrons
   C. have cross sections that are strongly energy dependent
   D. after thermalization will eventually be captured by an absorber nucleus
   E. all of the above
   F. none of the above

4. The mean free path, λ, of a neutron beam is about 135 m. The macroscopic cross section is

E

   a. 135×10^{-3} m
   b. 270×10^{-3} m
   c. $270 \times 10^{+3}$ m
   d. $7.41 \times 10^{+3}$ m
   e. 7.41×10^{-3} m

5. A neutron that interacts in the body or with water

A

   a. May be captured (absorbed) by a hydrogen atom followed by the emission of a 2.2 MeV photon.
   b. May directly ionize, excite and produce bremsstrahlung in the tissue.
   c. Has a fixed range in tissue
   d. All of the above.
   e. None of the above.

6. The macroscopic neutron cross section, Σ,

C

   A. Represents the interaction probability per cm^2.
   B. Only applies to thermal neutrons.
   C. Is the probability per unit path length for the neutron to interact.
   D. None of the above.
   E. All of the above.

7. Which of the following is NOT a desirable property for a moderator?

E

A. A material with a low mass number.
B. High scattering cross section
C. High absorption cross section
D. None of the above
E. All of the above

8. The reaction $H^1(n,\gamma)H^2$

D

A. Is an example of radiative capture.
B. Occurs only with a thermal neutron.
C. Is accompanied by the emission of a 2.2 MeV photon
D. All of the above.
E. None of the above

9. Fusion of light atoms releases more energy per event than fission of a heavier element because…

D

A. The mass of the nucleus is less than the mass of the assembled parts and the "leftover" mass is released as energy.
B. The mass deficiency decreases as the size of the nucleus increases.
C. The deuterium-tritium fusion reaction releases a neutron and a helium nucleus.
D. The deuterium-tritium fusion reaction releases more energy that other fusion reactions
E. All of the above

10. The unique properties of the special nuclear materials, ^{233}U, ^{235}U, and ^{239}Pu, that make them important in nuclear reactors include.

E

A. Thermal neutrons can induce fission
B. Their fission cross sections are significantly greater than other isotopes of uranium and plutonium.
C. None of these isotopes exist in nature and must be man made.
D. Only a small fraction of these isotopes are used in fabrication of nuclear fuel.
E. All of the Above

PART III-1: Answer only ***two*** of the ***three*** questions. (25 points each)

1. The atom density, N, of an absorber material is 4×10^{22} atoms/cm^3. A 1 cm thick absorber placed in the neutron beam reduced the neutron flux by 90%. Calculate the microscopic cross section and macroscopic cross section.

2. A beam of 0.0253 eV neutrons impinges on a slab of graphite absorber. The total macroscopic cross-section of carbon at this energy is 0.385 cm^{-1}.

   a) Calculate the mean free path of neutrons at this energy.

   b) How thick must the graphite slab be to reduce the intensity of the beam by 10%?

3. A 0.01 cm thick sample of boron is subjected to a constant 0.1 cm^2 source of neutron. Calculate (1) neutron flux, (2) macroscopic cross section, and (3) the reaction rate between neutrons and boron in a sample. The following data is useful:

   $N = 2 \times 10^7$ n/cm^3.
   v = 2200 m/sec
   $N_{boron} = 0.01 \times 10^{24}$ nuclei/cm^3
   σ = 3800 barns
   RR= $\sigma\Phi$NAx