

BASIC RADIOLOGICAL PHYSICS COURSE

CLASS GROUP: _____
(Radiation Therapy, Radiation Oncology Resident, Post Doctoral..)

YEAR: _____
(2004, 2005 ...)

Objective:

After completing this Study Guide #16, the students should be able to understand (a) concept of cross-section, (b) nuclear fission, (c) nuclear fusion, and (d) nuclear reactions. Based on nuclear reactions, the students should understand also various methods of producing radionuclides for clinical use and generator as well.

Study Guide #16: Nuclear Reaction (Part 1 of 1)

Read Sections: Foundation of Radiological Physics (CBSaw)
Sections 10.1 to 10.10

Suggested Reference: Faiz Khan's text – Section 2-8 to 2-10

Assignments: Answer all questions as directed in this handout
"Foundation of Radiological Physics" by CB Saw

Clinical Rotation
Assignment:

Study Guide

- 10.1 In your own words, define the following terms:
- | | |
|------------------------|-----------------------|
| (a) cross section | (b) thermal neutron |
| (c) nuclear fission | (d) chain reaction |
| (e) moderator | (f) control rod |
| (g) nuclear fusion | (h) nuclear reaction |
| (i) endoergic reaction | (j) exoergic reaction |
- 10.2 State the conservation laws as applied to nuclear reactions.
- 10.3 Explain how a nuclear reactor works and how the chain reaction is controlled.
- 10.4 Explain nuclear fusion and the difficulty in constructing fusion reactors for energy consumption.
- 10.5 Identify the projectile, ejectile, target nucleus, and the residual nucleus in a nuclear reaction such as ${}^{14}_7\text{N}(\alpha, p){}^A_Z\text{X}$. Identify the element of residual nucleus.

- 10.6 Alpha particles are used to bombard a carbon-12 target. If a proton is emitted, write down the nuclear reaction and identify the residual nucleus.
- 10.7 What does the Q-value in a nuclear reaction denote?
- 10.8 List the three methods of producing radionuclides.
- 10.9 Give two examples of radionuclides produced by each method.
- 10.10 Describe the reaction used to produce cobalt-60.
- 10.11 What is the decay mode of fission byproducts of fuel rods in a reactor?
- 10.12 Describe a radionuclide generator. Compare the half-life of the parent with the daughter nuclides for a generator.

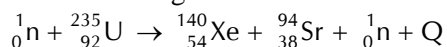
Problems

- 10.1 Oxygen-16 is used as a projectile to bombard oxygen-16 target resulting in the formation of a compound nucleus in a heavy-ion nuclear reaction. Subsequently, the compound nucleus ejects a proton. Write down the nuclear reaction and identify the compound nucleus and residual nucleus.

Multiple Choice Questions

Select the one correct answer.

- 10.1 Which of the following is NOT conserved in this reaction?



- a) mass number
b) energy
c) electric charge
d) momentum
e) none of the above
- 10.2 Which of the following statements is NOT true?
- a) Rutherford performed a nuclear reaction by bombarding nitrogen gas with alpha particles.
b) The alpha particles used by Rutherford were derived from a radioisotope.
c) All nuclear reactions follow the conservation of mass number law.
d) The conservation of momentum states that angular momentum and linear momentum are interchangeable so long as the total momentum remains unchanged in a nuclear reaction.
e) none of the above.

- 10.3 Which of the following nuclear reaction is not carried out using an accelerator?
- a) $^{22}\text{Ne} (d, n) ^{23}\text{Na}$
 - b) $^{63}\text{Cu} (p, n) ^{63}\text{Zn}$
 - c) $^{59}\text{Co} (n, \gamma) ^{60}\text{Co}$
 - d) $^{16}\text{O} (^3\text{He}, p) ^{18}\text{F}$
 - e) none of the above
- 10.4 Which of the following statements is NOT true about nuclear reactors?
- a) Neutrons are captured by nuclides in a nuclear reactor.
 - b) Control rods are used to control the chain reaction.
 - c) Moderator is used to slow down the neutrons.
 - d) To perform emergency shut down, just remove fuel rods.
 - e) none of the above.
- 10.5 The radioactive decay after the bombardment of a sample with neutrons in a reactor would be
- a) α particle emission.
 - b) β^+ particle emission.
 - c) β^- particle emission.
 - d) isomeric transition.
 - e) none of the above.
- 10.6 Radionuclides are produced in a reactor by bombarding stable targets with
- a) neutrons.
 - b) protons.
 - c) hydrogen atoms.
 - d) alpha particles.
 - e) none of the above.
- 10.7 A reaction involving the use of alpha particles as projectiles with the emission of protons is written as
- a) (α, p) reaction.
 - b) (p, α) reaction.
 - c) (α, n) reaction.
 - d) (γ, α) reaction.
 - e) none of the above.
- 10.8 Which of the following is NOT used as a projectile in producing artificial radionuclides in an accelerator or cyclotron?
- a) neutrons
 - b) protons
 - c) deuterons
 - d) alpha particles
 - e) none of the above

- 10.9 Which is true of neutron detectors?
- a) conversion of neutron into an alpha particle.
 - b) conversion of neutron into a proton.
 - c) conversion of neutron into deuteron.
 - d) conversion of neutron into gamma ray.
 - e) none of above.
- 10.10 Which of the following statements is NOT true of radionuclide generators?
- a) The half-life of the parent is greater than the half-life of the daughter.
 - b) There is a continuous supply of radionuclides.
 - c) Radionuclide generator is a two-step or three-step radioactive series.
 - d) In the $^{99}\text{Mo} - ^{99\text{m}}\text{Tc}$ generator, the daughter can be separated from the parent.
 - e) none of the above.

CBS: 3/97

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