BASIC RADIOLOGICAL PHYSICS COURSE

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

YEAR: _____
(2004, 2005 …)

Objective:

After completing this Study Guide #17, the students should be able to understand the interaction of photons with matter. It covers coherent scattering, photoelectric effect, Compton scattering, pair and triplet production, and photodisintegration. The predominant interactions at the diagnostic energy range is photoelectric effect and in the therapeutic range is the Compton scattering.

Study Guide #17:	Interaction of Radiation with Matter (Part 1 of 2)
Read Sections:	"Foundation of Radiological Physics" by CB Saw **Sections 11.1 to 11.6**
Suggested Reference:	Faiz Khan's text – Chapter 5
Assignments:	Answer all questions as directed in this handout
Clinical Rotation Assignment:	

Study Guide

11.1 In your own words, define the following terms:
(a) cross section (b) characteristic radiation
(c) positron annihilation

11.2 List the five processes in which photons interact with matter.

11.3 Is there any energy absorption, ejection of electrons, or scattering of incident photons in coherent scattering?

11.4 How does the probability of photoelectric effect vary with the atomic number of the absorber and the energy of the incident photon?

11.5 Explain why a lead apron is effective in shielding radiation in the diagnostic range.

11.6 How does the probability of Compton scattering vary with the atomic number of the absorber and the energy of the incident photon?

11.7 What are the maximum energies of the scattered photon at 90^{o} and 180^{o}, relative to the direction of the incident photon in Compton scattering?

11.8 Which basic interacting mechanism is dominant if the incident photon energy is 10 keV, 50 keV, and 4 MeV?

11.9 The energy spectrum of a radiation beam striking a tungsten target showed enhancements at 11.28 keV and 69.5 keV. Explain the existence of these enhancements.

11.10 Identify the two necessary conditions for pair production.

11.11 Is it necessary for the electron and positron produced during pair production to be traveling in opposite directions?

11.12 Differentiate between pair production and the positron annihilation processes.

11.13 What are the energy requirements for triplet production?

Problems:

11.1 Estimate the photon energy at which the Compton interaction and the photoelectric interaction are equally probable in water.

11.2 A lead atom absorbed a 100 keV photon. If a K-shell electron (with 88 keV binding energy) is ejected, what is the kinetic energy of this electron?

11.3 A 100 keV photon is scattered through an angle of 60^{o}. Compute the energies of the scattered photon and the Compton electron.

11.4 What is the maximum energy transferred to the Compton electron if the energy of the incident photon is 90 keV?

11.5 An absorber A has an atomic number of 3 while another absorber B has an atomic number of 6. What is the ratio of their probabilities of photoelectric interactions?

11.6 A 70 keV electron is incident to a special atom having three energy-states: K-shell = –50 keV; L-shell = –12 keV; and M-shell =– 6 keV. Identify whether the photon observed is bremsstrahlung or characteristic radiation if the energy of the photon is (a) 80 keV, (b) 44 keV, and (c) 40 keV?

Multiple Choice Questions
Select the one correct answer.

11.1 Which statement is NOT true about photon interactions?
a) Coherent scattering does not involve energy transfer.
b) Photoelectric effect involves the ejection of atomic electrons.
c) Compton scattering involves the interaction with valence electrons.
d) Pair production involves the creation of an electron-positron pair.
e) none of the above.

11.2 The emission of a photoelectron is always followed by further radiation because
a) the photoelectron eventually annihilates with ordinary electron.
b) the photoelectron eventually annihilates with an Auger electron.
c) the photoelectron will be Compton scattered producing bremsstrahlung.
d) the emission of a photoelectron leaves a vacancy in the atomic shell.
e) none of the above.

11.3 Compton scattering results in the ejection of an electron and
a) a scattered photon with a longer wavelength than the original photon.
b) a scattered photon with the same wavelength as the original photon.
c) a scattered photon with a shorter wavelength than the original photon.
d) an equal sharing of the photon energy by the electron and recoil nucleus.
e) none of the above.

11.4 Which is NOT true of pair production?
a) The threshold energy is 1.022 MeV.
b) The electron and positron are created.
c) The electron and positron may not travel in opposite directions.
d) An example of energy mass conversion.
e) Two photons are created.

11.5 A 70 keV photon is incident onto an atom and a 40 keV electron is ejected. Which of the following statements is NOT true if the binding energy of the K-shell is 30 keV?
a) This is a photon absorption interaction.
b) A 30 keV photon may be emitted.
c) Characteristic radiation may be emitted.
d) Auger electron is probable.
e) none of the above.

11.6 Which statement is NOT true about positrons?
a) They annihilate when combined with electrons.
b) They annihilate after losing almost all of their kinetic energy.
c) Their properties are identical to electrons except for the charge.
d) After annihilation, two 511 keV photons are produced.
e) none of the above.

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