# BASIC RADIOLOGICAL PHYSICS COURSE

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

YEAR: _____
(2004, 2005 …)

**Objective**:

In the continuation of the study of nuclear transformations, the students should be able to understand (a) positron decay, (b) electron capture, (c) gamma emission, and (d) internal conversion after completing this Study Guide #15. The modes of decay can compete with each other to gain nuclear stability. Different types of radionuclides used in medicine will also be discussed.

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|---|---|
| **Study Guide #15**: | Nuclear Transformation (Part 2 of 2) |
| Read Sections: | Foundation of Radiological Physics (CBSaw)<br>**Sections 9.5 to 9.10** |
| Suggested Reference: | Faiz Khan's text – Section 1-2, 1-3, 1-6, and 1-7 |
| Assignments: | Answer all questions as directed in this handout |
| Clinical Rotation Assignment: | |

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**Study Guide**

9.1 In your own words, define the following terms:
(e) metastable state (f) K-capture
(g) internal conversion (h) conversion electron

9.8 Explain the electron capture process and the subsequent emission of characteristic x-rays.

9.9 Identify two conditions where electron capture competes with positron emissions.

9.10 Estimate the typical half-life of an excited nuclear state.

9.11 Identify two ways by which an excited nuclear state can decay.

9.12 Define the coefficient of internal conversion.

9.13 What is the difference between an Auger electron and an internal conversion electron?

9.14 What are the decay products of the following radioactive nuclides?
(a) radium-226 (b) cesium-137
(c) cobalt-60 (d) molybdenum-99

**Problems**

9.5 Calculate the Q-value for the electron capture of iodine-125 in Figure 9.13. Is it possible for this radionuclide to undergo positron emission?

9.6 Iodine-131 decays 89.3% by beta emission to the 364 keV excited state of xenon-131. Then it decays 81.2% to the ground state by gamma emission. If there are 10,000 nuclides of iodine-131, how many gamma rays are emitted through this path?

9.7 Identify the decay modes of A, B, and C in the decay scheme shown in Figure 9.16.

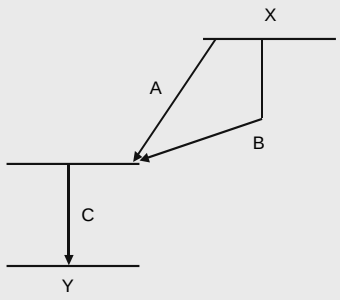

**Figure 9.16** Decay scheme of nuclide X

9.8 In Figure 9.16, the transition through path A is 10% and path B is 90%. If there are 1000 disintegrations of nuclide X, compute the number of radiation emission of each of the following: (a) with C gamma rays, (b) 0.511 MeV photons, (c) positrons, and (d) characteristic x-rays from nuclide Y. Are there characteristic x-rays being emitted from nuclide X?

9.9 In the sodium-22 decay, compute the number of positron disintegration from 1 μCi of sodium-22.

**Multiple Choice Questions**
Select the one correct answer.

9.6 Which statement is NOT true of electron capture?
a) There is a decrease in unit charge.
b) Electron capture competes with positron decay when the energy difference between the parent and the daughter nuclei is greater than 1.022 MeV.
c) Electron capture involves the emission of an anti-neutrino.
d) Electron capture is followed by characteristic x-ray emission.
e) none of the above.

9.7 Which statement about internal conversion is NOT true?
a) Internal conversion competes with positron decay.
b) Internal conversion competes with gamma decay.
c) Internal conversion is analogous to Auger electrons.
d) Internal conversion is a direct nucleus and orbital electron interaction.
e) none of the above.

9.8 Which statement is NOT true about cobalt-60?
a) Cobalt-60 is produced by bombarding cobalt-59 with neutron.
b) Cobalt-60 decays to nickel-60.
c) Cobalt-60 emits gamma rays with energies of 1.17 MeV and 1.33 MeV.
d) Cobalt-60 has a half-life of 5.26 years.
e) For every negatron emission, there are two gamma rays emission for 99% of the time.

9.9 The decay of a radionuclide X is as follows:

$$^{A}X \rightarrow {}^{Am}Y \rightarrow {}^{A}Y$$

where A is the mass number. Identify the sequential decay modes as
a) $\beta^-$ followed by isomeric transition
b) isomeric transition followed by $\beta^-$
c) $\beta^-$ followed by $\beta^-$
d) $\beta^+$ followed by $\alpha$
e) EC followed by $\beta^-$

9.10 How many gamma rays are emitted per beta ray emission, according to the decay scheme shown in Figure 9.17?
a) 0
b) 1
c) 2
d) 3
e) 4

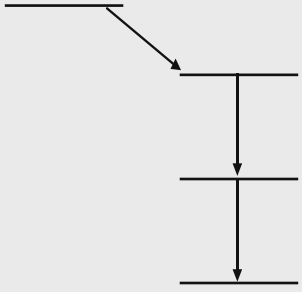

**Figure 9.17** Decay scheme of an unknown nuclide

CBS: 3/97
Revised: 6/14/04