

## BASIC RADIOLOGICAL PHYSICS COURSE

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

YEAR: \_\_\_\_\_  
(2004, 2005 ...)

**Objective:**

After completing this Study Guide #13, the students should be able to understand (a) radioactivity curve between the parent and daughter nuclides such as secular equilibrium, transient equilibrium, and no equilibrium, and (b) decay of naturally occurring radionuclides in particular the uranium series.

**Study Guide #13:** Radioactivity (Part 2 of 2)

Read Sections: Foundation of Radiological Physics (CBSaw)  
**Sections 8.5 to 8.7**

Suggested Reference: Faiz Khan's text – Section 2-1 to 2-6

Assignments: Answer all questions as directed in this handout

Clinical Rotation  
Assignment:

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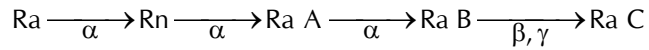
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### Study Guide

- 8.1 In your own words, define the following terms:  
(m) cumulative activity
- 8.7 State the conditions with respect to the parent–daughter half-lives and activities for (a) secular equilibrium, (b) transient equilibrium, and (c) no equilibrium.
- 8.8 Give examples of radionuclide decay that exhibits secular equilibrium, transient equilibrium, and no equilibrium.
- 8.9 Name the four naturally occurring radioactive decay series.
- 8.10 Give a reason why heavy radionuclides prefer to decay by emitting alpha particles.
- 8.11 Identify the end nuclides of the radioactive decay series.
- 8.12 Figures 8.10 to 8.13 illustrate the radioactive decay series. Identify which transformation process corresponds to an alpha particle emission and which corresponds to negatron emission.

8.13 Identify the first four daughters of the decay of uranium-234.

8.14 The radium-226 decay series is sometimes written as



Identify the nuclides Ra A, Ra B, and Ra C.

### Problems

8.8 The amount of cumulated activity in a cervical implant has been crudely related to the doses at point A (defined as the location where the artery crosses the uterine), point B (defined as pelvic sidewall), bladder and rectum<sup>1</sup> as given in Table 8.9. What is the estimated dose to point A if 65 mg Ra<sub>eq</sub> of radioactive cesium-137 was left in a patient for 3 days?

**Table 8.9** Dose rate at gynecological sites.

Point Description	Dose (cGy/mg-h)
Point A	0.91
Point B	0.25
Bladder	0.61
Rectum	0.49
External iliac lymph nodes	0.17
Common iliac lymph nodes	0.12
Para-aortic lymph nodes	0.035

8.9 A prostate is treated using only permanent implant of palladium-103. What is the initial dose rate of the implant delivering 115 Gy to the prostate?

8.10 In the decay of radium-226 to radon-222, calculate the relative daughter activity to parent activity after undergoing 5 half-lives.

8.11 In the decay of molybdenum-99 ( $\tau = 67$  hr) to technetium-99m ( $\tau = 6$  hr), calculate the daughter activity if the parent activity is 10 mCi under transient equilibrium.

### Multiple Choice Questions

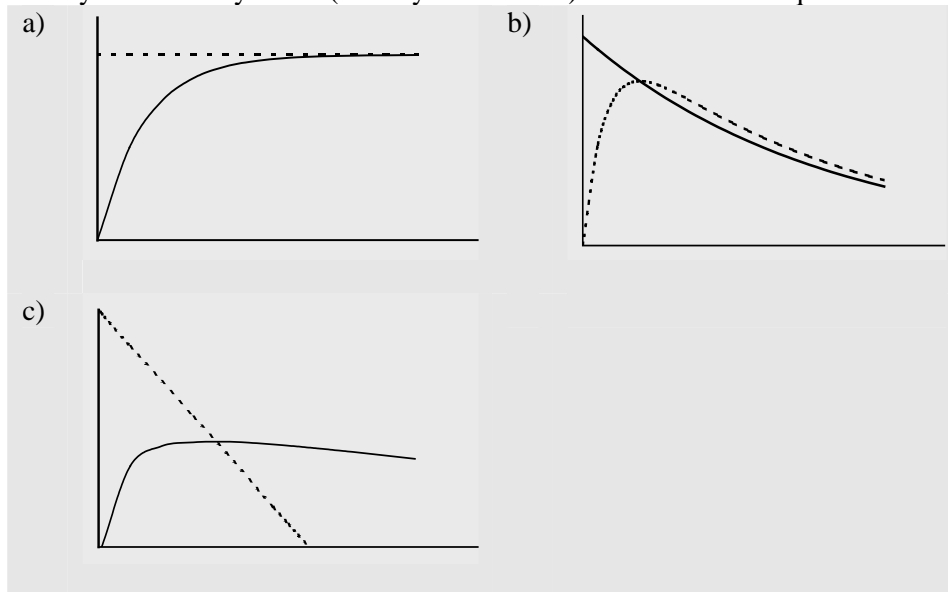
Select the one correct answer.

8.6 Cesium-137 ( $\tau=30$  yr) sources were used in a brachytherapy implant for 3 days. How much decay occurred during the procedure?

- a) 0.002%
- b) 0.02%
- c) 0.2%
- d) 2%
- e) 20%

<sup>1</sup> Jani, S.K.; Pennington, E.C.; Wacha, J.E.; Vigliotti, A.P.; Hussey, D.H. *Correlation of point doses with total activity in intracavitary cesium-137 applications for treating gynecologic cancers*. Endocurietherapy/Hyperthermia Oncology 4: 107-111; 1998.

- 8.7 Which of the following statements is NOT true?
- The amount of activity present in a sample depends on the number of parent nuclides and the time elapsed.
  - Technetium-99m exhibits transient equilibrium with its parent isotope.
  - Radon-222 exhibits secular equilibrium with its parent isotope.
  - There is no equilibrium if the half-life of the parent is shorter than the half-life of the daughter.
  - none of the above.
- 8.8 Which of the following statements is NOT true about secular equilibrium?
- The parent activity is always greater than the daughter activity.
  - The half-life of the parent is always greater than the half-life of the daughter.
  - The daughter activity approaches asymptotically towards the parent activity after some elapsed time.
  - The slope of the decay curve is steeper for the parent activity than that of the daughter activity.
  - none of the above.
- 8.9 Which of the following statements is NOT true about transient equilibrium?
- The parent activity is always greater than the daughter activity.
  - The half-life of the parent is always greater than the half-life of the daughter.
  - The daughter activity approaches asymptotically towards the parent activity after some elapsed time.
  - The slope of the decay curve is identical for both the parent activity and the daughter activity.
  - none of the above.
- 8.10 Identify which decay curve (activity versus time) exhibits secular equilibrium.



- 8.11 Gold-198 with a half-life of 2.7 days had been used in permanent implants. What is the cumulated activity for a complete decay if its initial activity was 50 mCi?
- a) 50 mCi-h
  - b) 100 mCi-h
  - c) 2245 mCi-h
  - d) 3240 mCi-h
  - e) 4675 mCi-h

CBS: 3/97

Revised: 6/14/04