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King Mongkut's University of Technology Thonburi
Midterm Examination in Academic Year 1/2018

Subject: PHY 431 Introduction to Radiological Health **Student: Physics Students**
Date: **3th October, 2018** **Time: 1.00 p.m. – 4.00 p.m.**

Instructions: 1. This examination consists of 8 questions (5 pages, including the cover page).
2. Total score is 100 points. The total time allowed for this examination is 3 hours (1.00 p.m. – 4.00 p.m.)
3. This is "Closed book examination".
4. Use of an approved calculator is allowed.
5. You must answer the questions in the answer notebook provided.
6. Do not forget to fill in your name and your information in the space provided.

(อนุญาตให้ใช้เครื่องคิดเลขได้ตามระเบียบของมหาวิทยาลัย แต่ห้ามนำเอกสารใดๆเข้าห้องสอบ)

Nakarin Pattanaboonmee
Examiner

No.	Full points	Earned points
1	15	
2	35	
3	5	
4	25	
5	5	
6	5	
7	5	
8	5	
Total	100	

This examination has been approved by the committee of physics department.

Wanlee Chanbray
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Examination *(Midterm: Semester 1/2018)*

PHY431: Introduction to Radiological Health

(Dr.Nakarin Pattanaboonmee, department of physics, KMUTT)

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1. Explain about the definition and physical meaning of (a) Activity, (b) Exposure dose, (c) Absorbed dose, (d) Equivalent dose and (e) Effective dose. (10 marks)

   Please write down your "Mind Map" for radiation dosimetry. (5 marks)

2. Answer the following questions.
   (a) Explain about ionizing and non-ionizing radiations and give some example of those? (2 marks)
   (b) Explain briefly about Bragg-Gray principle and absorbed dose measurement. (4 marks)
   (d) Explain about alpha, beta, gamma rays and neutron radiation. (4 marks)
   (e) What are the definitions of rem, Sievert, rad and Gray? (4 marks)
   (f) What are the meaning of Decay constant, radiological, biological and effective half-life? (4 marks)
   (g) Explain about deterministic and stochastic effects of radiations and give some example of those? (4 marks)
   (h) Explain about acute effects, late somatic effects, genetic effects and teratogenic effects of radiations. (4 marks)
   (i) What are the meaning of threshold effect and LD-50 Dose/30 days? (4 marks)
   (j) What are 3 basic tenets stated in ICRP's publication 26 for the system of dose limitation recommended by ICRP? (3 marks)
   (k) What is the meaning of ALARA in radiation protection guides of ICRP? (2 marks)

3. The opening of the diaphragm in the entrance port of a free air ionization chamber is 2 cm in diameter, and the length AB of the sensitive volume is 4.5 cm. A 200 kV X-ray beam projected into the chamber produces a steady current in the external circuit of 0.04 μA. The temperature at the time of the

measurement was 30 °C and the pressure was 740 mmHg. What is the exposure rate from this beam of X-rays? (ρ_{air}=1.293x10^{-6} kg/ cm^3)
(5 marks)

4. (a) Figure 1 gives the activities of three radioactive samples (X, Y and Z) versus time. Rank the samples according to their (a) half-life and (b) disintegration constant, greatest first. Determine the half-life of radioactive sample C from this graph if the initial activity is 1400 Bq. (6 marks)

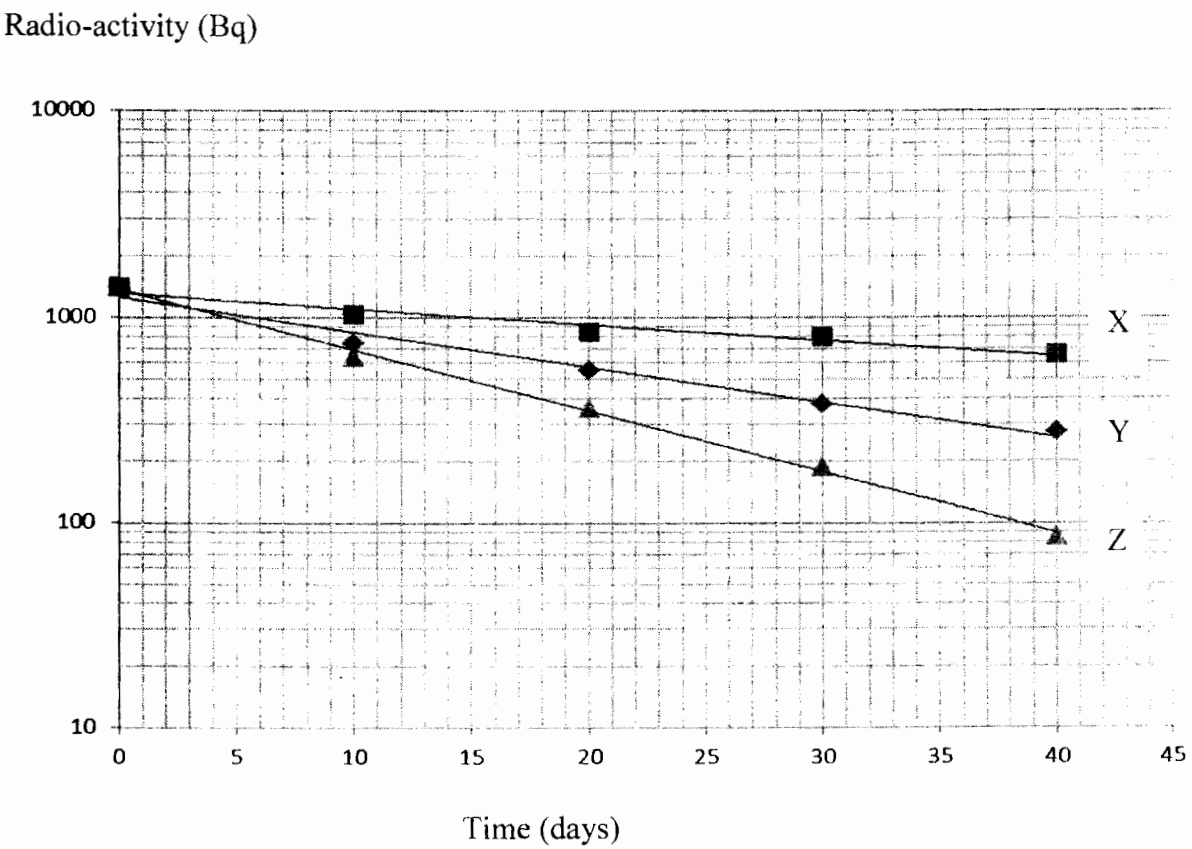

Figure 1 The activities (Bq) of three radioactive samples (A, B and C) versus time (days).

(b) Calculate the effective half-life in the lung for unknown radio-active isotope, T_R = 45 days and T_B, the biological half-life in the lung, is reported to be 545 days. (5 marks) Calculate the effective mean life or effective average life time and elimination constant of this radio-active isotope. (10 marks)

(c) A Geiger counter records 8,000 counts in 2 min. Calculate the activity of the source in Becquerel (Bq) and Curies (Ci), assuming that the counter records all decay. (4 marks)

5. Explain about biological effects of radiations in the topic of your group in this class (corresponding to your VDO clip presentation). (5 marks)

6. Calculate the total accumulated dose (Maximum Permissible Dose) for 35-year-old worker (radiation worker). (3 marks) Calculate dose limit from 40-year-old MPD for exposure of member of the general public. (2 marks)

7. For gamma-emitting isotopes, $\dot{D} = C\Gamma \int_0^V \frac{e^{-\mu r}}{r^2} dV$. Show that the dose rate at the center of the sphere (of radius R). $\dot{D} = C\Gamma \frac{4\pi}{\mu}(1 - e^{-\mu R})$.

   Hint: $dV = r^2 \sin\theta dr d\theta d\phi$. (5 marks)

8. As a result of a nuclear power plant accident, ^{131}I with radio-activity as 185 kBq were deposited in a radiological worker. In this case, 148 kBq were uniformly distributed throughout the rest of his body but only 1 μCi was deposited in his thyroid gland. By using data from bioassay measurements and body scanning, the radiological health physicist calculated a thyroid dose equivalent of 6.15 rems and a whole-body dose of 13 rems. According to ICRP 60, weighting factor of the rest of the body is 0.95 and those of the thyroid gland is 0.05. Please calculate the radiological worker's effective dose? Was his overexposed according to the ICRP 60 criteria? (5 marks)

Radiation Protection Guides

ICRP 60 Recommended Dose Limits

Application	occupational	public
Whole body	20 mSv/yr effective dose average over 5 yrs.,Maximum dose in any 1 yr = 50 mSv	1 mSv in 1 yr
Annual dose to		
Lens of the eye	150 mSv	15 mSv
Skin	500 mSv	50 mSv
Hands and feet	500 mSv	-
Fetus/embryo	2 mSv	-

Effective Dose : $H_E = \Sigma W_T H_T$

where W_T is the weighting factor for tissue T and
H_T is the dose equivalent to tissue T.

Radiation Protection Guides

Tissue Weighting Factor : W_T

Tissue or organ	W_T, ICRP 26	W_T, ICRP 60
Gonads	0.25	0.20
Red bone marrow	0.12	0.12
Colon	Not given	0.12
Lung	0.12	0.12
Stomach	Not given	0.12
Bladder	Not given	0.05
Breast	0.15	0.05
Liver	Not given	0.05
Esophagus	Not given	0.05
Thyriod	0.03	0.05
Skin	Not given	0.01
Bone surface	0.03	0.01
Remainder	0.30	0.05

Effective Dose : $H_E = \Sigma W_T H_T$