

1. Briefly explain the following terms.
- somatic effects of radiation
  - ALARA
  - ALI
  - dose-equivalent limits
  - LD50/30
  - dead time (of detector)
2. In a radiochemical lab (300 m<sup>3</sup> free volume), 10 Ci of I<sup>131</sup> gas was accidentally released. The ventilation rate of this lab is 150 m<sup>3</sup>/hr. If a lab technician worked for 1 hour without noticing the release, find the committed dose equivalent to the thyroid of this man.
- 25 pts)
- Data : mass of thyroid = 20 g  
 radiological half-life of I<sup>131</sup> = 8.05 days  
 biological half-life of iodine in the thyroid = 138 days  
 SEE(thyroid ← thyroid) =  $1.0 \times 10^{-2}$  MeV/g·tr  
 fraction of iodine reaching thyroid following inhalation = 20 %  
 breathing rate of worker = 0.03 m<sup>3</sup>/min
3. 1 mCi of Na<sup>24</sup> is uniformly distributed over 2 feet diameter circular area.
- 25 pts)
- Find the maximum photon flux (# of photons/cm<sup>2</sup>.sec) at 1 ft away from the source.
  - Find the exposure rate (mR/hr) at 3 ft away.
- Data : 1 roentgen =  $5.24 \times 10^7$  MeV/g of air  
 (Na<sup>24</sup>  $\gamma$  1.369 MeV (100%)  $(\mu/\rho)_{air} = 0.0262$  cm<sup>2</sup>/g at 1.369 MeV  
 2.754 MeV (100%)  $(\mu/\rho)_{air} = 0.0218$  cm<sup>2</sup>/g at 2.754 MeV
4. 1 Ci of isotropic point source emits  $10^8$   $\gamma$ -rays/sec with an energy of 1 MeV.
- 20 pts) The source is to be shielded with a spherical iron shield. What must the shield radius be if the exposure rate at its surface is to be 1 mR/hr ?
- Data :  $(\mu_a/\rho)_{air} = 0.0260$  cm<sup>2</sup>/g for 1 MeV  $\gamma$   
 $\mu_{Fe} = 0.468$  cm<sup>-1</sup> for 1 MeV  $\gamma$   
 Assume  $B(E, \mu R) = 1 + \mu R$  where R is shield thickness

Problem 5. A thermal neutron flux field exists in a certain area. A  $\text{BF}_3$  counter is used for measuring the neutron flux. 10 gross-count measurements for a 1-second interval and 10 background measurements for a 10-minute interval are made as shown in the following table, respectively. The dead time of counter is 100  $\mu\text{sec}$ .

$n_i$	gross	background	$n_i$	gross	background
1	2300	22	6	2425	24
2	2325	20	7	2390	23
3	2345	21	8	2400	20
4	2400	19	9	2320	22
5	2360	23	10	2315	21

- Find the net count rate (cpm) with  $1\sigma$  error.
- Find the thermal neutron flux level ( $n/\text{cm}^2\cdot\text{sec}$ ).  
 The  $\text{BF}_3$  counter has a sensitive volume of  $60\text{ cm}^3$  with the filling gas of 98% enriched  $\text{B}^{10}$  at 15 cm Hg and  $20^\circ\text{C}$ .  
 Data :  $\sigma_a$  of  $\text{B}^{10}$  at 2200 m/sec = 3840 b.
- Calculate the dose equivalent to a 70 kg man due to exposure from this thermal neutron flux. The dose is composed of the doses from 0.63 MeV protons and 2.23 MeV photons which are produced by the reactions :  $\text{N}^{14}(n,p)\text{C}^{14}$  and  $\text{H}^1(n,\gamma)\text{H}^2$ .  
 Data : # of nitrogen atoms per kg of tissue =  $1.49 \times 10^{24}/\text{kg}$   
 # of hydrogen atoms per kg of tissue =  $5.98 \times 10^{23}/\text{kg}$   
 $\sigma_a$  of nitrogen = 1.75 b,  $\sigma_a$  of hydrogen = 0.33 b  
 $\text{AF}(\text{WB} \leftarrow \text{WB}) = 0.278$  for 2.23 MeV photons

Problem 6. Briefly discuss the biological effects of radiation and the objectives of radiation protection. (25 pts)

Problem 7. Briefly discuss the following terms.

- (25 pts)
- classification and characteristics of various detectors
  - operating principle and conditions(regions) of the gas-filled detectors