American Board of Health Physics

Examination No. 4 - November 1961

Part I - Answer 3 Questions

1. Explain the meaning of the following terms:

   a) Dose build-up factor
   b) Standard deviation
   c) Compton scattering
   d) K capture
   e) Biological half-life of an isotope

2. Describe the chronic effects of whole-body exposure to gamma radiation.

3. A 4-Mev alpha particle produces a track parallel to the axis of a cylindrical ionization chamber. Assuming that a saturation voltage has been applied and that all the energy of the alpha particle is absorbed in the chamber, compute the charge deposited on the collecting electrode. Calculate the voltage rise if the total capacity of the collector electrode and associated circuit is 20 μμfd, neglecting leakage.

4. a. An isotope with a 3.05 minute half-life is being measured. During a two-minute interval, a total of 1000 counts is observed. What was the true counting rate at the beginning of the measurement?

   b. What is meant by the terms "absorbed dose" and "exposure dose". Draw a clear distinction between them.

Part II - Answer 3 Questions

5. a. You have been selected to open an HP office in a new research area. You have one month before any radioactive materials are brought in. What would you do to prepare for safe operations?

   b. You are relieving a fellow HP on a hot maintenance job. A new maintenance crew is also coming on. What are some important facts you should obtain from the off-going HP?

6. a. Why is the energy to produce an ion pair greater, on the average, than the ionization potential?

   b. A sample of Co^{60} was assayed in the scintillation counter and the following data obtained:

   Sample: 3,800 counts in 6 minutes
   Background: 385 counts in 1 minute

   Calculate the net count rate and standard deviation.

7. I^{131} is produced in a reactor with a fission yield of 2.8%. The half-life of Iodine-131 is 8 days. The reactor operates continuously at 1 megawatt for 100 days. If 0.01 of reactor power is represented by a batch of uranium removed from the reactor, find the curies of I^{131} present in this batch 100 days after removal.

8. Discuss the relative importance of air filtration and shielding in the design of civilian fallout shelters.

Part III - Answer 3 Questions

9. a. Describe the equipment and list the advantages of the annular kinetic impactor for sampling radioactive particulate contaminants in air.

   b. Describe the equipment and list the advantages of an isokinetic sampler for sampling radioactive particulate contaminants in a stack air stream.

10. A spherical lead shield is needed for a 2000-curie Co^{60} source requiring a cavity 10 cm in diameter. Assuming a point source, what thickness of lead is required to produce a level of 5 mr/hr at 50 cm from the center of the source? What is the relaxation length of Co^{60} γ radiation in this shielding material.

11. Describe briefly the salient features of instruments suitable for measuring the following:
   a) Undisturbed γ background
   b) γ levels of 100 r/hr
   c) β doserates due to surface contamination
   d) Fast neutron exposure levels from a reactor

12. List and discuss the various methods of disposal for radioactive liquid wastes. To what levels of activity may each be applied.

Part IV - Answer 3 Questions

13. a. What is bremsstrahlung? Discuss the safety problems connected with it in a plant or laboratory working with multicurie quantities of radioactive isotopes.

   b. Discuss the advantages and disadvantages of whole-body counting for evaluation of internal contamination.

14. a. Indium, sulfur, bare gold and cadmium-covered gold have been incorporated into a film badge. What purpose does each serve?

   b. Discuss the importance of "work load", "use factor", and "occupancy factor" in the design of protective barriers.

15. For a large power reactor, give your recommendation on the regional monitoring program with regard to area to be covered, types of measurements to be made and reasons for each type of measurement.

16. Discuss the radiation safety problems involved in the design and use of a portable radiographic unit containing 100 curies of Ir^{192}.

Reference Data for ABHP Exam #4

1 roentgen = 2.08×10^{9} ion pairs per cm^3 of air (STP)

= 5.48×10^{7} Mev per gram = 87.7 ergs per gram

electronic charge = 1.6×10^{-19} coulombs = 4.8×10^{-10} e.s.u.

$$1 \text{ amp} = \frac{1 \text{ coulomb}}{\text{sec}} = \frac{3 \times 10^{9} \text{ e.s.u.}}{\text{sec}}$$

1 Mev = 1.602×10^{-6} ergs = 1.602×10^{-13} watt-sec. = 3.83×10^{-14} calories

Energy released per fission = 200 Mev

Avogadros number = 6.025×10^{23} molecules/gm mole Molar volume = 22.4 liters

Density of lead = 11.36 gms/cc Mass absorption coeff. of lead = 0.06 cm^2/gm

Isotope	$T_{1/2}$	Max E_β (Mev)	E_γ (Mev)	R.H.M. (γ)
Na^{24}	15.0 hrs	1.39	1.37, 2.75	1.93
S^{35}	87.1 days	0.167	-	-
Co^{60}	5.27 yrs	0.309	1.17, 1.33	1.32
I^{131}	8.05 days	0.608, others	0.364, others	0.231
Cs^{137}-Ba^{137}	30 yrs	0.523, 1.19	0.661	0.356
Ba^{140}	12.8 days	-	-	-
Ir^{192}	74.5 days	0.67, 0.54 0.24	0.136 to 1.157	0.51
Au^{198}	2.70 days	0.96	0.412	0.248
Ra^{226}	1622 yrs	-	-	0.84

Dose build-up factors for Co^{60} in lead:

$\mu_o r$	1	2	4	7	10	15
DBUF	1.38	1.72	2.37	3.23	4.10	5.5