

Health Physics Final Exam: 1:00 PM, June 17, 2000 (Closed Book); 32-108

Problem 1 (15 points) You have been asked to estimate the age of the antique wood ornament that they first discovered. Using the C-14 technique, you found out that C-14 content in the antique was 1/3 of that in the present wood. What is the estimated age of the antique ornament? The half-life of C-14 is 5,600 years. Assume that due to recent nuclear bomb tests and nuclear reactor operations, the equilibrium of C-14 is broken and the content of C-14 is 10% higher than the original.

$$\frac{1}{3} = \frac{1}{2} \left(\frac{1}{2} \right)^{t/5600}$$

$$\ln \frac{1}{3} = \ln \frac{1}{2} \left(\frac{1}{2} \right)^{t/5600}$$

Problem 2 (15 points) Na-24 is produced in a Liquid Metal Reactor by neutron activation of Na-23 reactor coolant. Assume the average radiative capture X-section of Na-23 (σ_n) is 0.53 b. The half-life of Na-24 is 15 hours.

- a) Considering the average neutron flux level of 5×10^{14} n/cm².sec, find the specific activity of Na-24 in the sodium coolant (Ci/gm of Na) during reactor operation.
- b) What is the specific activity of the coolant after 24-hour cool?

$$N_{Na-24} = \sigma_n \phi N_{Na-23}$$

Problem 3 (15 points) What is the exposure rate at 1 meter away from a 1 Ci Na-24 point source? If a 10 cm-thick lead block is available for shielding, what will be the exposure rate behind the lead shield?

Data: Na-24: $E_1 = 1.369$ MeV (100%) & 1.254 MeV (100%)
 $(\mu)_{1.369} = 0.615$ cm⁻¹ for 1.369 MeV gamma.
 $(\mu)_{1.254} = 0.487$ cm⁻¹ for 1.254 MeV gamma
 Assume $b(E, \mu) = 1 \mu r$ where $r =$ shield thickness.

$$N_{ex} = A_{Na-24} (4\pi r^2)$$

$$\mu_{ex} = \mu_{1.369} + \mu_{1.254}$$

$$I_{ex} = N_{ex} e^{-\mu_{ex} r}$$

Problem 4 (20 points) The walls of a apartment room (115m²-widthx2.32m-height) are partitioned by gypsum board panels of 152m². The thickness of the gypsum board is 9.5 mm and its density is 0.85g/cm³. Assuming the gypsum board contains 1 pCi/g of Ra-226 ($T_{1/2} = 1620$ y), find the Rn-222 ($T_{1/2} = 3.82$ d) concentrations (pCi/L) in the room as a function of the room air ventilation rate (volumes/hour). The radon gas emission rate of the gypsum board (pCi/cm².sec) is given by:

$$F = R_0 \rho E \sqrt{2D} \tanh \left(x \sqrt{\frac{\lambda}{D}} \right)$$

where, $R_0 =$ radium concentration in the gypsum board (pCi/g), $\rho =$ density of the gypsum board ($= 0.85$ g/cm³), $E =$ radon emanation coefficient of gypsum board ($= 0.08$ for uncovered board), $\lambda =$ transformation constant of Rn-222, $D =$ radon diffusion coefficient of gypsum board ($= 2 \times 10^{-6}$ cm²/sec), $x =$ thickness of gypsum board ($= 0.95$ cm).

Problem 5 (15 points) A BF₃ counter which is filled with 95% enriched B¹⁰F₃ gas. The pressure is 10 cmHg at 0°C. When a thermal neutron counting is 2,000 counts for one hour, what is the thermal neutron flux? The absorption X-section of B-10 for 0.0253 eV neutron is 4,010 barns.

Problem 6 (20 points): 5 measurements taken. Gross for 2-minute and background for 10 minutes for each measurement. Measurements are as follows:

	gross	background
1	230	220
2	229	210
3	228	200
4	227	190
5	226	230

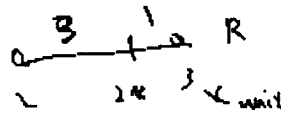
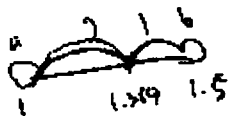
$\mu = 0.0179$ cm⁻¹

$\frac{2000}{3600} = 0.556$ counts/sec

STP

$\frac{2000}{3600} = 0.556$ counts/sec

Find the net count rate (cpm) with standard deviation.



$$30 \text{ cpm} / 100$$