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 just 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.

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 ($\sigma_{n\gamma}$) 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/cm^2.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?

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_γ = 1.369 Mev (100%) & 1.254 MeV (100%)

$(\mu)_{Pb}$ = 0.615 cm^{-1} for 1.369 MeV gamma.

$(\mu)_{Pb}$ = 0.487 cm^{-1} for 2.754 MeV gamma

Assume $B(E,\mu r) = 1 + \mu r$. where r = shield thickness.

Problem 4 (20 points) The walls of a apartment room (115m^2-width x 2.32m-height) are partitioned by gypsum board panels of 152m^2. The thickness of the gypsum board is 9.5 mm and its density is 0.65g/cm^3. 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/cm^{2}sec) is given by: $F = R_a \rho E \sqrt{\lambda D}\tanh\left(x\sqrt{\lambda/D}\right)$ where, Ra = radium concentration in the gypsum board (pCi/g), ρ=density of the gypsum board (= 0.65 g/cm^3), E = radon emanation coefficient of gypsum board (= 0.08 for uncovered board), λ=transformation constant of Rn-222, D = radon diffusion coefficient of gypsum board (= 2×10^{-3}cm^2/sec), x=thickness of gypsum board (= 0.95cm).

Problem 5 (15 points): BF_3 counter which is filled with 95% enriched $B^{10}F_3$ 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	[illegible]	230

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