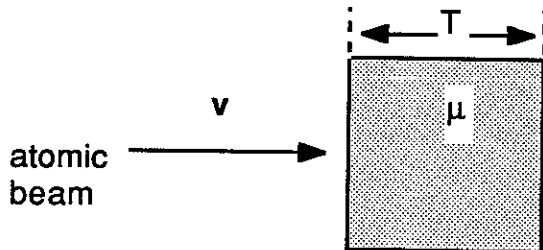


Ph.D. Qualifying Examination
Interactions

1. (20 min.) Two kilograms of bismuth are irradiated for 100 days in a thermal flux of 10^{14} neutrons per cm^2 per sec at a temperature of 200°C . Calculate the mass of ^{210}Po that will be present when the sample is removed from the reactor after 100 days. The half life of ^{210}Bi is 5 days and the half life of ^{210}Po is 138 days. The absorption cross section for the reaction is 0.015 barns.

$A = 208.98$ gm/gm atom for ^{209}Bi .

2. (15 min.) An electron from some unknown source passes through a scintillator where 10^7 ev of energy are dissipated before it is captured.
 a) Was the electron's velocity initially relativistic? Why?
 b) What was the electron's velocity upon entering the scintillator? You may express your answer in purely algebraic form with numerical values of all variables indicated.
3. (10 min.) A nonrelativistic, colinear beam of radioactive atoms, mass m , with decay constant λ , perpendicularly enters a region of thickness T between parallel boundaries in which the linear attenuation coefficient is μ . Assume that the velocity of the atoms in the beam is v .



- a) Write 2 conditions either of which would assure that only a small fraction of the incident flux of atoms A emerges from the opposite side of the slab parallel to the incident beam.
- b) If neither of these conditions pertain, write an expression for the fractional penetration of the beam through this region.
4. (10 min.) The French, during enrichment of uranium from mines in Oklo, Gabon, found that the ratio of ^{235}U to ^{238}U for this ore was not the same as for uranium everywhere else in the world. They concluded that ground water had intruded into the very rich ore body about 3 billion years ago and started a chain reaction. What was the weight % enrichment 3 billion years ago if the half-life of ^{235}U is 7.13×10^8 years and ^{238}U is 4.52×10^9 years? Take the present enrichment as 0.72 atom %. Show all work.

5. (20 min.) A uniform, monoenergetic disk source of radius R emits S photons/cm²-sec isotropically into half space. The adjacent medium has a linear attenuation coefficient μ_0 . Using the Berger buildup factor for a point source find the uncollided and collided exposure rates at a distance Z along the axis of the disk. Express the results in terms of the exponential integrals.

$$B_{X_{pt}} = 1 + a\mu_0 r e^{b\mu_0 r}$$

$$\dot{X}_U = K \phi_U$$

$$E_n(X) = X^{n-1} \int_x^\infty u^{-n} e^{-u} du$$

6. (15 min.) The absorbed dose at a depth of 47 cm. in a medium is found to be 395 rads. The absorbed dose due to the primary (uncollided) radiation at this position is only 340 rads. At the front surface of the medium, the absorbed dose due to the primary radiation is found to be 1000 rads. Calculate the buildup factor B , the linear attenuation coefficient μ , the mean effective attenuation coefficient μ' .
7. (10 min.) 40% (a) A radiative laboratory source is counted by a GM detector for 1 min giving 561 counts. The source is removed and a 1 min background count gives 410 counts. What is the net counts due to the source alone, and what is its associated standard deviation?
- (60%) (b) A 10 min count of another source plus background give a total of 846 counts. Background alone counted for 10 min give a total of 73 counts. What is the net counting rate due to the source alone, and what is its associated standard deviation?
8. (20 min.) The following questions pertain to gas-filled radiation detectors operated in the proportional mode.
- (40%) (a) A gamma-ray photon undergoes a Compton collision within the wall of the cylindrical detector, thus injecting an energetic electron into the sensitive volume. Describe the physical events which lead to a measurable signal.
- (20%) (b) What are two main advantages for using cylindrical geometry as opposed to parallel plate geometry in the construction of proportional counters?
- (20%) (c) What four factors influence the value of the multiplication factor M for proportional counters?
- (20%) (d) What is the function of the quench gas additive to the primary counting gas?