EPL332
Nuclear Science and Engineering
MAJOR

Date: 30.04.2010
Duration: 2 hrs

Full marks: 40

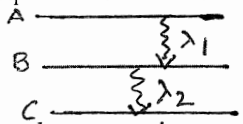
Q1. A] A thin 10 mg Mg foil is irradiated (for 2 hours) with a beam of 22 MeV deuterons (beam current 100 $\mu A/cm^2$) and make a nuclear reaction $^{26}Mg(d,\alpha)^{24}Na$ having average cross section 25 mbarns. A detector assembly having 80% counting efficiency is placed very near to the reaction chamber. Find the count rate of alpha particles in this assembly.Half life of Na-24 is 15 hours. [4]
B] A trilayer [50 nm Ni/ 10nm C/ 100 nm Si] thin film structure is analyzed by RBS using 2.0 MeV He beam. Draw qualitative RBS spectra (with mathematical formulation) in the following two cases: (i) He is incident on Ni side and (ii) He is incident on Si side. [Given that, $K_{Ni} = 0.76$, $K_{Si} = 0.5$, $K_C = 0.3$, $(dE/dx)_{Ni} = 60$ eV/Å, $(dE/dx)_{Si} = 25$eV/Á., $(dE/dx)_C = 20$eV/Å]. [4]

Q2. A] Assume human skin ($w_T = 0.01$) absorbs 93erg/g for 1R of gamma radiation in a radioactive environment. An experimentalist works at an average distance of 50 cm from a 100μCi ^{22}Na source ($\Gamma = 12$ R-cm^2/hr-MCi) for a duration of one hour. If the threshold dose of skin damage is 0.04 Sv, justify whether experimentalist has done his job safely. [4]
B] NMR involves transition between energy states of different spin quantum number. How do you use this technique to determine the nuclear magnetic moment of a nucleus? [2]
C] A brain image shows a small tumor grown at an appreciable depth from the skull. Which technique among the three listed below you will choose to damage it appropriately (i) gamma camera, (ii) heavy ion medical accelerator, (iii) BNCT, and why? [2]

Q3. A] Explosion of one H-bomb releases energy of typically 10^{30} MeV. A nuclear fusion reactor is designed to use water of a lake (area: 256, 000 km^2, depth: 0.08km) as its fuel. If the abundance of D is 0.0156% and six D atoms gives an energy release of 43 MeV, estimate how many H-bomb explosion is required to produce equivalent energy of this reactor? [4]
B] Show confinement of plasma only by schematic sketches in (i) Pinch-device, (ii) Magnetic mirror and (iii) Tokamak. [1+1+2]

Q4. A] If the half lives of radium (1 Ci equivalent) and radon are 1622 years and 3.825 days respectively, find the volume of radon gas at N.T.P. [4]

B] A three level nuclear decay system with decay constants is shown below. At time t = 0, only A state is present [However, population is unknown]. A detector capable of only detecting B state is placed near this system. If half life of B state is 0.693 sec, set up an equation to determine decay constant of state A. [4]



Q5.A] A gamma ray of energy 4MeV produces an electron-positron pair in a medium and lost its total energy. The two particles move in opposite directions with equal speeds. The electron enters a detector and losses all its kinetic energy in producing ion pairs. If a discriminator with threshold 0.8 milli-volt is set after the detector, how much signal due to gamma particle will be left for further processing after the discriminator? [Av. ionization energy/ion pair = 42.6 eV and C = 10μF] [4]

B] A detector is made with a semiconductor wafer (dielectric constant: ε, thickness: t) doped heavily with donors. If you want to use entire thickness of the wafer as detector, how much bias voltage is required to apply in this system? [Detail derivation is not required] [4]

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1 MeV = 1.6×10^{-13}J, 1 Ci = 3.7×10^{10} disintegrations/sec, $m_0c^2 = 0.51$ meV