Assignment – 1

Course Instructor: Prof. Rajeev Gupta

M.Sc. Chemistry (Semester – IV)

Paper: 4104 Section: B (Nuclear & Radiation Chemistry)

Instruction: ***All questions are compulsory. Question No. 1 carries 11 marks while other two questions carry 12 marks each.***

(4 + 4 + 3 = 11)

Q1. Attempt all parts.

(a) How does growth of neutron in a given fission reaction related to the average time between two successive generation, τ, of neutrons? Calculate, how many times the number of neutrons will increase after 10 seconds if k = 1.001 and τ = 0.001 second.

(b) The ^{127}I atom in C_2H_5I undergoes a nuclear reaction $^{127}I(n, \gamma)^{128}I$ by emitting γ - ray of 2.5 MeV after irradiation by neutrons. Calculate the recoil energy of the ^{128}I due to γ - ray emission and comment if the C–I bond in C_2H_5I will be broken or not. The corresponding C_2H_5I bond energy is 3.0 eV.

(c) What do you understand by a fission nuclear reactor going “critical”? Discuss in terms of neutron multiplication factor.

OR

(c) Why fuel in the form of uranium rods or pellets are preferred compared to a homogenous mixture of fuel and moderator in a nuclear reactor? Explain.

(4 + 4 + 4 = 12)

Q2. Attempt any three parts.

(a) Calculate the number of ^{24}Na atoms formed when a 45 mg piece of ^{23}Na metal was bombarded for 35 minutes in a thermal neutron flux of 9 x 10^8 neutron $cm^{-2}s^{-1}$? The cross section for the $^{23}Na(n, \gamma)^{24}Na$ nuclear reaction is 0.36 barn.

(b) The radiation chemical yields for the various chemical species formed in the radiolysis of water (in acidic medium) in a Fricke’s dosimeter are given below:

Given: G($\bullet$H) = 3.7; G($\bullet$OH) = 2.9; G(H_2O_2) = 0.8

Calculate the radiation chemical yield, G(Fe^{3+}) in the presence and absence of dissolved oxygen. Also discuss the role of NaCl in the Fricke’s dosimeter.

(c) $^{65}Cu_{29}$ gives rise to (α, n), (α, 2n) and (α, 3n) nuclear reactions when bombarded with α particles of 28 MeV energy. Why does not the reaction stop at (α, n) reaction? Explain.

(d) Given that the nuclei of $^{176}Lu_{71}$ and $^{233}Pa_{91}$ have extreme values of electric quadrupole moments of +7 and -3 barn, respectively. Calculate the deformation index (β) for the two nuclei.

(4 + 4 + 4 = 12)

Q3. Attempt any <u>three</u> parts.

(a) What are the (i) ignition temperature and (ii) Lawson criterion for a controlled thermonuclear reaction?

(b) Does the conservation of mass and energy hold valid for *pion* exchange process between different nucleons? If the mass of *pion* is 270 times that of an electron and it moves with the velocity of light, calculate the range of nuclear forces.

(c) Nuclear reactions with 2 MeV deuterium as projectile occurs at energies below the Coulombic barrier; and (d, p) reactions are found to have cross-section much higher than the corresponding (d, n) reactions. Explain?

(d) Calculate the excitation energy of the compound nucleus when a 25 MeV α-particle is captured by a $^{65}Cu_{29}$ to form a $^{69}Ga_{31}$ compound nucleus.

(Given: mass of the α-particle = 4.002600 amu; mass of the ^{65}Cu = 64.927786 amu; mass of the ^{69}Ga = 68.925574 amu).

Values of some of the physical constants:

$N = 6.023 \times 10^{23}$

$1/4\pi\varepsilon_o = 9 \times 10^{9}$

1 amu = 931.478 MeV

$e = 1.6 \times 10^{-19}$ C

$1 eV = 1.6 \times 10^{-19}$ J

$k = 1.3805 \times 10^{-23}$ J deg^{-1}

$R_o = 1.4 \times 10^{-15}$ m; $R = R_o A^{1/3}$