<u>Assignment – 2</u>

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M.Sc. Chemistry (Semester – IV)

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

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

Q1. Attempt all parts. **(4 + 4 + 3 = 11)**

(a) The semi-empirical binding energy equation corresponding to the binding energy of a nucleus is given by

$$-\text{B. E.}\ (A, Z) = aA - bA^{2/3} - cZ^2/A^{1/3} - d(A - 2Z)^2/A \pm e/A$$

Explain each term of this equation including the sign used to justify the equation.

(b) Na (Z = 11) with mass numbers 22 and 23 have spins 3 and 3/2, respectively. Explain.

(c) How does α and β radiations interact with matter?

Q2. Attempt any <u>three</u> parts. **(4 x 3 = 12)**

(a) A radiation source is to be calibrated using Fricke's dosimeter for which $G(Fe^{3+})$ is 15.6. If the change in extinction (at 305 nm) of the solution is 0.3, calculate the amount of radiation received. The molar extinction coefficient for Fe^{3+} species is 2174 $M^{-1}cm^{-1}$ and the density of the solution is 1024 kg/m^3. The cell used in the experiment has a path length of 1 cm. Is calibration of the dosimeter possible in presence of an organic impurity?

(b) Calculate $E_{critical}$ for ^{235}U and ^{238}U nuclei taking help from the semi-empirical binding energy equation. Explain why ^{235}U can be fissioned by the thermal neutrons whereas ^{238}U can only be fissioned by the fast neutrons.

(c) How does growth of neutrons 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 1 second if $k = 1.01$ and $\tau = 0.1$ second.

(d) What is plasma and how can it be confined? For deuterium – tritium fusion reaction, the value of Lawson criterion is 10^{14} sec/cm^3. What do you understand by this value?

(e) What are the effect of (i) excitation energy, and (ii) mass number of the nucleus undergoing fission, on the distribution of the fragments in a nuclear fission reaction? Explain with examples.

Q3. Attempt any <u>three</u> parts. **(4 x 3 = 12)**

(a) What is a compound nucleus and how does the Ghoshal's experiment help in understanding the "compound nucleus theory"? Explain with a suitable example.

(b) Do you agree that most nuclei have nearly identical nuclear density? Prove by calculating the density in gm/cm^3 of the nuclei ^{19}F and ^{239}Pu. Assume that both nuclei are spherical in shape.

(c) Find out the Coulomb barrier for the approach of α particle towards $^{232}Th_{90}$ nucleus. How much this value will change if the approaching particle is a proton?

(d) After irradiation by neutrons, ^{127}I undergoes a nuclear reaction $^{127}I(n, \gamma)^{128}I$ by emitting γ - ray of energy 4.8 MeV. How is it that the hot I – atom causes the bond rupture in C_2H_5I and not in HI given the corresponding C_2H_5I and HI bond energies as 3.0 and 2.0 eV, respectively. Justify.

(e) Examine the following data and comment if it is possible to set up a <u>fast neutron</u> breeder reactor using $^{233}U_{92}$ or $^{235}U_{92}$ as the fuel:

Fuel	σ (n, fission)	σ (n, capture)	ν	η
$^{233}U_{92}$	2.20	0.15	2.59	2.43
$^{235}U_{92}$	1.44	0.22	2.52	2.19

Also explain the role of blanket in breeder reactor?

<u>Values of some of the physical constants:</u>

$N = 6.023 \times 10^{23}$
$1/4\pi\varepsilon_o = 9 \times 10^9$
1 amu = 931.478 MeV
$e = 1.6 \times 10^{-19}$ C
$1eV = 1.6 \times 10^{-19}$ J
$k = 1.3805 \times 10^{-23}$ J deg^{-1}
$R_o = 1.4 \times 10^{-15}$ m; $R = R_oA^{1/3}$