No. of Printed Pages : 5 **RPHE–006**

PRE-Ph. D. (PHYSICS)

Term-End Examination

December, 2025

RPHE–006 : ELEMENTS OF REACTOR PHYSICS-I

Time : 2 Hours *Maximum Marks : 50*

Note : *(i) Attempt any* ***five*** *questions.*

(ii) Marks are indicated against each question.

(iii) Symbols have their usual meanings.

(iv) You can use a calculator.

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1. (a) (i) The wavelength (λ) of a neutron moving with kinetic energy E is given by :

$$\lambda = \frac{h}{\sqrt{2m_n \mathrm{E}}}$$ where m_n is the mass of the neutron and h is a Plack's constant.

Using the above relation, obtain expressions of wavelength in terms of energy in $e\text{V}\left(\text{E}\left(e\text{V}\right)\right)$ and temperature in Kelvin$\left(\text{E}\left(\text{K}\right)\right)$. 2

(ii) Calculate, using Weiszäcker formula, the binding energy per nucleon for ${}^{235}_{92}\text{U}$. 3

Given :

$d = 15.8$, $\beta = 17.8$, $\gamma = 23.7$, $\delta = 0.71$

$$\in = \begin{cases} 34 & \text{for even or odd-odd nuclei} \\ 0 & \text{otherwise} \end{cases}.$$

(b) A monoenergetic beam of neutrons having an intensity of $4 \times 10^{10} n$ $\text{cm}^{-2}\ \text{s}^{-1}$ impinges on a target 1 cm^2 in area and 0.1 cm thick. There are 0.05×10^{24} atoms cm^{-3} in the target and σ_t at the energy of the beam is 4.5 b.

(i) Calculate the macroscopic total cross-section.

(ii) How many neutron interactions per second may occur in the target ? 5

2. (a) Differentiate between neutron elastic scattering and neutron inelastic scattering. Draw elastic scattering cross-section curves for ${}^{1}_{1}H$ and ${}^{56}Fe$ and explain their features. 5

(b) Derive four factor formula and explain each term involved in it with mathematical steps. Hence, obtain six-factor formula. 5

3. (a) Explain the concepts of 'breeding ratio' and 'doubling time'. Explain the statement–"A fast reactor needs more than 10% fissile enrichment". Why do we promote the concept of fast reactors ? 2+2+1

(b) Show that the kinetic energy of a neutron after collision in the lab system is given by : 5

$$\left(\frac{E'_L}{E_L}\right) = \frac{\left[(A)^2 + 2A\cos(\theta_c) + 1\right]}{(A+1)^2}$$

4. (a) Obtain an expression of average logarithmic energy decrement per collision (ξ). Show that for large mass numbers : 5

$$\xi \approx \frac{2}{\frac{2}{3} + A}$$

(b) If the resonance integral of neutrons in a mixture of natural uranium and graphite moderator is approximated as $I = 3.9\left(\frac{\Sigma_{s,c}}{N_u}\right)^{0.415}$ barns. Calculate the resonance escape probability of neutrons in a medium using the following data : 5

$$\left(\frac{N_c}{N_u}\right) = 400\,;$$

$$\sigma_{s,c} = 4.8\,b \text{ and } \xi_c = 0.158$$

5. Write down the assumption made in arriving at neutron transport-equation for a homogeneous multiplying assembly. Hence derive the neutron transport equation in

terms of angular neutron flux for a heterogeneous multiplying assembly. Rewrite simplified form of this equation for a non-multiplying and homogeneous assembly. 3+5+2

6. (a) What do you understand by constant cross-section approximation ? Derive the steady-state transport equation for a plane geometry. The neutron scattering and external sources are taken to be isotropic. 5

(b) State Fick's law. Write its mathematical expression. The scattering cross-section of carbon (A = 12) at 1 eV is 4.8 *b*. Calculate the diffusion coefficient of carbon. Assume that $\sum_a$ is almost negligible. 1+1+3

7. Write *two* group diffusion equations for a critical homogenous reactor in steady state. Obtain two-group criticallity condition for a base homogeneous reactor in this approximation. 2+8

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