ASSIGNMENT

1. Define the following terms:
   Fissile, Fertile and Fissionable Nuclides giving examples of each.
2. What is the purpose of neutron source and give an example of neutron source.
3. Derive the semi empirical mass formula
4. Calculate the BE/A for U-235, U-238
   Given : mass of proton – 1.007825 amu, mass of neutron – 1.008665 amu , 1amu = 931 Mev
5. Explain the mechanism of fission on the basis of liquid drop model
6. What is critical energy? Explain the fission on the basis on the potential energy curve.
7. Draw the fission yield curve for thermal fission of U-235 and fast fission of U-238
8. What is critical mass? What is the critical mass for U-235 and Pu-239?
9. Define micro-scopic and macro-scopic cross sections.
10. The micro-scopic cross sections for the capture of (slow neutrons) at 0.025 ev by hydrogen is 0.33 barns and for oxygen is 2x10e-04 barns. Calculate the macro-scopic x sec of H2O molecule for thermal neutrons.
11. Nat U is a homogenous mixture of 99.28 wt% of U-238 (σ_b=2.7 b) and 0.72 wt% U-235 (σ_b=681 b). The density of nat. U is 19.0x10E03 kg/m^3. Determine the total macro-scopic and micro-scopic absorption cross section of this material.
12. Plot micro-scopic cross section vs neutron energy.
13. Explain Doppler effect.
14. What are the properties of good moderator?
15. Calcualte the ξ of hydrogen atom.
16. Explain the kinematics of elastic coliision.
17. Explain neutron cycle.
18. Derive the four factor formula.
19. Explain the following terms: critical, super critical and sub critical state.
20. Explain the terms: neutron flux, neutron current, reaction rate, diffusion length, lethargy, logarithmic energy decrement, migration length.
21. Plot neutron flux vs neutron energy.
22. Calculate the avg. no of collisions required to reduce the neutron energy from 2Mev to 1 ev in the moderator region for H atom and D atom. Ξ for H and D atom is 1.0 and 0.726.
23. Stainless steel type 304 having density of 7.86 g/cm3 has been used in some reactors. The nominal composition by weight of this material as follows C- 0.08%, CR-19%, Ni-10% and Fe the remainder. Calculate the macroscopic absorption x-sec of SS304 at 0.0253 ev.
    C $\sigma(n,\gamma)$ = 0.0034 barns , Mol wt. 12.0
    Cr $\sigma(n,\gamma)$ = 3.1 barns , Mol wt. 52.0
    Ni $\sigma(n,\gamma)$ = 4.43 barns , Mol wt. 58.7
    Fe $\sigma(n,\gamma)$ = 2.55 barns , Mol wt. 55.8
24. How four factor changes by fuel lumping?
25. In a critical reactor, the Effective multiplication factor is
    i. slightly greater than unity
    ii. equal to unity
    iii. slightly less than unity
    iv. equal to zero
26. Doppler broadening is caused by
    i. increase in temperature of the fuel
    ii. decrease in temperature of the fuel
    iii. is independent of temperature of the fuel
    iv. decrease in temperature of the moderator
27. Resonance escape probability in a heterogeneous system is

i. equal to that of homogeneous system for the same fuel/moderator composition
ii. greater than that of homogeneous system for the same fuel/moderator composition
iii. less than that of homogeneous system for the same fuel/moderator composition
iv. independent of fuel/moderator composition

28. Write the two group diffusion equation and explain the terms

29. Thermal utilization factor in a heterogeneous system is

i. equal to that of homogeneous system for the same fuel/moderator composition
ii. greater than that of homogeneous system for the same fuel/moderator composition
iii. less than that of homogeneous system for the same fuel/moderator composition
iv. independent of fuel/moderator composition

30. The amount of total energy released in a nuclear fission is about 200 MeV, out of which most of the energy is carried by

[a] Prompt neutrons [b] Fission products

[c] prompt gammas [d] Neutrinos

31. Which of the following moderator material has largest migration area/length:

[a] D_2O [b] H_2O [c] Beryllium [d] Graphite

32. In a nuclear fission, <u>most</u> of the prompt neutrons are emitted with kinetic energy approximately equal to

[a] 0.0625 eV [b] 1 eV [c] 1 keV [d] 1 MeV

neutron flux then

33. If 'Σ_a' is the macroscopic absorption cross section and 'Φ' is the reaction rate is

[a] $\Phi\ \Sigma_a$ [b] $1/(\Phi\ \Sigma_a)^2$ [c] $1/\ \Phi\ \Sigma_a$ [d] $(\Phi\ \Sigma_a)^2$

34. Main source of thermal neutrons in a reactor core is:

[a] Fissile material [b] Moderator

[c] Fertile material [d] Absorber

35. By integrating which of the following variables in neutron transport equation, one obtains the diffusion equation:

[a] Angular, Ω [b] Energy, E

[c] time, t [d] Space, r

36. In a chain reaction system, if infinite multiplication factor, k_∞, is 1.005, the neutron density increases 10 times in approximately

[a] 46 generations [b] 6 generations

[c] 462 generations [d] 1460 generations

37. With the decrease in the size of the reactor system, the non-leakage probability:

[a] decreases [b] increases

[c] remains constant [d] depends on k-eff

38. . Define quantities 'η' and 'ν'. If the macroscopic absorption and fission cross section are defines as Σ_a and Σ_f respectively, what is the relation between 'η' and 'ν'.

39. . Various mechanisms by which neutrons can be gained or lost from an arbitrary volume, in the neutron transport formulation.

40. The migration length is a measure of the net vector distance travelled by
(a) a thermal neutron before getting absorbed
(b) a fission neutron before getting absorbed
(c) a fission neutron before leaking out
(d) a thermal neutron before leaking out

41. Fick's law is not valid
(i) far away from the boundaries
(ii) when the neutron flux strongly varies with distance
(iii) for a uniform medium
(iv) near strong absorbers

42. The flux at a distance $\boldsymbol{r}$ from a point source of neutrons in an infinite medium is given by

(a) $\phi(r) = \dfrac{S}{4\pi D}\dfrac{e^{-r}}{r}$

(b) $\phi(r) = \dfrac{4S}{\pi D}e^{-r/L}$

(c) $\phi(r) = \dfrac{1}{4\pi D}\dfrac{e^{-r}}{L}$

(d) $\phi(r) = \dfrac{D}{4\pi S}\dfrac{e^{-L}}{r}$

43. Linear extrapolation distance is the distance over which
(a) thermal absorption goes to zero
(b) neutron diffusion coefficient becomes zero
(c) neutron flux goes to zero
(d) derivative of neutron flux becomes zero

44. In a certain critical reactor having a geometrical buckling B^2, if M^2 is doubled, then k_∞ should be
(a) $k'_\infty = k_\infty$
(b) $k'_\infty = 2k_\infty$
(c) $k'_\infty = 2\,k_\infty + 1$
(d) $k'_\infty = 2\,k_\infty - 1$

45. As the neutron loses energy while slowing down
(a) the average logarithmic decrement increases
(b) the average logarithmic decrement decreases
(c) the neutron lethargy increases
(d) the neutron lethargy decreases

46. The diffusion area termed as L^2 for thermal neutrons
(a) is inversely proportional to the diffusion coefficient
(b) directly proportional to the macroscopic absorption cross section
(c) inversely proportional to the absorption ~~mean free path~~ cross section
(d) directly proportional to the absorption ~~mean free path~~. (diffusion coeff) $^{1/2}$

47. The average logrithmic energy decrement ξ for isotropic scattering
(a) independent of initial energy
(b) dependent on initial energy
(c) dependent on scattering angle

(d) independent of the scattering angle

48. Identify the critical relation for diffusion of two group of neutrons in a multiplying medium for a bare reactor

(a) $k_\infty = 1 + L^2 B_g^{\ 2} + \tau$

(b) $k_{eff} = \dfrac{k_\infty}{(1 + L^2 B_g^{\ 2})(1 + \tau B_g^{\ 2})}$

(c) $k_{eff} = \dfrac{k_\infty}{(1 + L^2 B_g^{\ 2})\tau}$

(d) $k_{eff} = \dfrac{\tau B_g^{\ 2}}{(1 + L^2 B_g^{\ 2})}$

49. The unit of fermi age τ is
(a) sec (b) sec^{-1} (c) cm^2 (d) cm^{-2}

50 Explain the following
(i) Diffusion length
(ii) Geometrical buckling

51. Explain how the four factors η, ε, p and f change for homogenous and heterogeneous reactors ?

52. Define the terms fissile, fertile and fissionable materials giving examples. Write the nuclear reactions leading to the production of fissile plutonium and uranium.

53. Write a note on two types of neutron sources with their possible role in the reactor operation.

54. Explain the terms involved four factor formula. How does the expression change if leakage on neutrons is considered.

55. What is the basic purpose of reflector?

56. A nuclide is said to be fertile if
   a) It can be fissioned.
   b) It can be fissioned with fast neutrons.
   c) It can be converted to fissile species.
   d) It can be fissioned by neutrons of any energy.

57. Resonance escape probability is the probability
   a) that a neutron is captured in the resonance.
   b) that a neutron escapes the resonance.
   c) that a neutron undergoes fission.
   d) that a neutron leaks out while slowing down.

58. Delayed neutrons are the ones
   a) which are produced by fission products.
   b) which are produced due to (n,γ) reaction with fission products.
   c) which are produced during fission.
   d) which are produced neutron sources in the reactor.

59. The unit of **J**, current density are
   a) neutrons/m.
   b) neutrons/sec.
   c) neutrons/sq. m/sec.
   d) neutrons/m/sec.

60. Fast reactor is one where
   a) the fission occur at a fast rate.
   b) most of the fissions are caused by fast neutrons.
   c) the heat is transferred to the coolant at a fast rate.
   d) the fission neutrons are born with fast energies.

fissioned.
61. If a U^{235} nucleus is ~~split into its constituent neutrons and protons~~
   a) then 2500 MeV energy is released.
   b) then 2500 MeV has to be supplied.
   c) then 200 MeV is released.
   d) then 200 MeV has to be supplied.

62. Migration length is a measure of
   a) the distance travelled by a thermal neutron before getting absorbed.
   b) distance travelled by a fission neutron before getting absorbed.
   c) distance travelled by a fission neutron before leaking out.
   d) the distance travelled by a thermal neutron before leaking out.

63. A good moderator is one
   a) which has a small scattering cross section.
   b) which has a small diffusion length.
   c) which has a high absorption cross section.
   d) which has a small ξ value.

64. As a size of the reactor increases the leakage
   a) increases.
   b) decreases.
   c) does not change.
   d) can not be predicted.

65. The number of collisions required to a neutron for a hydrogen atom to slow down to thermal energy (0.025 ev) from 2 Mev is
   a) 18.
   b) 55.
   c) 200.
   d) 150.

66. If $B_g^2 >> B_m^2$ then
   a) the system is over sized.
   b) the system is critical.
   c) the system is supercritical.
   d) the system is subcritical.

67. If the enrichment of the fuel is increased, then one can say that
   a) **f** decreases.
   b) η increases.
   c) **p** increases.
   d) non leakage probability increases.

68. The diffusion theory is not valid for a

a) homogeneous medium.
b) far away from the boundaries.
c) heterogeneous medium.
d) near strong absorber.

(I). Write short note on following-
(II). Microscopic and macroscopic cross section
(III). Delayed neutrons in fission and their significance.
(IV). Average logarithmic energy decrement.
(V). Four factor formula.

69. Answer the following:

(i) Calculate η and α for thermal neutron fission of U^{233} and P^{239} from the following quantities;

	U^{233}	Pu^{239}
σ_a	580 b	1010 b
σ_f	530 b	740 b
ν	2.492	2.871

70. Diffusion theory is not valid
(a) for a homogeneous system
(b) far away from the boundaries
(c) when there are no neutron sources
(d) near strong absorbers

71. If ξ of Oxygen is 0.158, the number of collisions required for a neutron to slow dwon from 2 MeV to 0.025 eV upon scattering is around

(a) 18 (b) 115 (c) 151 (d) 221

72. The average logrithmic energy decrement ξ for isotropic scattering
(a) independent of initial energy
(b) dependent on initial energy
(c) dependent on scattering angle
(d) independent of the scattering angle

73. The unit of fermi age τ is
(a) sec (b) sec^{-1} (c) cm^{-2} (d) cm^2

74. . A thermal reactor is one in which

(a) fission neutrons are generated with thermal energies

(b) most of fissions are caused by thermal neutrons

(c) fission reactions take place at a slow rate

(d) neutrons are slowed down to thermal energies

75. In an critical reactor, the effect multiplication factor

(a) slightly greater than unity

1.067

a) 3   b) 1.3   c) $\sqrt{3}$ d) 1.14

84. An average lethargy gain of a neutron per scattering collision
 a) is same for collisions with any nucleus.
 b) does not depend upon the initial energy of the neutron.
 c) is higher for collisions with light mass nuclei.
 d) increases with neutron energy.

85. Average number of collisions required to slow down a neutron from 2 MeV to 1 eV energy is
 a) higher for heavy water medium than light water medium.
 b) higher for light water medium than heavy water medium.
 c) independent of the medium.

86. In a single elastic collision with a stationary nucleus, the kinetic energy of a neutron (in lab. System) can become zero if mass of the nucleus as compared to neutron mass is
 a) infinitely large   b) infinitely small   c) same   d) anything

87. In a thermal reactor the fission neutrons loose energy mainly by
 a) inelastic scattering with light nuclei.
 b) elastic scattering with light nuclei.
 c) inelastic scattering with heavy nuclei.
 d) elastic scattering with heavy nuclei.

88. Unit of neutron current density and neutron flux are
 a) neutrons/cm^3/sec
 b) neutrons/cm^2/sec
 c) neutrons.cm^2/sec
 d) neutrons.cm^3/sec

89. In elastic scattering collisions the kinetic energy of the neutron can be changed by a very small amount if
 a) the target nucleus is a proton
 b) the target nucleus is deuterium
 c) the target nucleus is uranium
 d) carbon

90. Homogenization of fuel and moderator thoroughly leads to
 a) an increase in fast fission factor
 b) an increase in the number of neutrons produced per neutron absorbed in the fuel
 c) an increased thermal utilization factor
 d) an increase in the resonance escape probability

80. In the following materials, diffusion length is the highest in
 a) Light water
 b) Heavy water
 c) Graphite
 d) Beryllium

91. Heavy water is a better moderator than H_2O because of its
 a) large α
 b) large Σ_s
 c) ~~Higher moderating ratio~~ lower absorption cross section.
 d) Higher slowing down power

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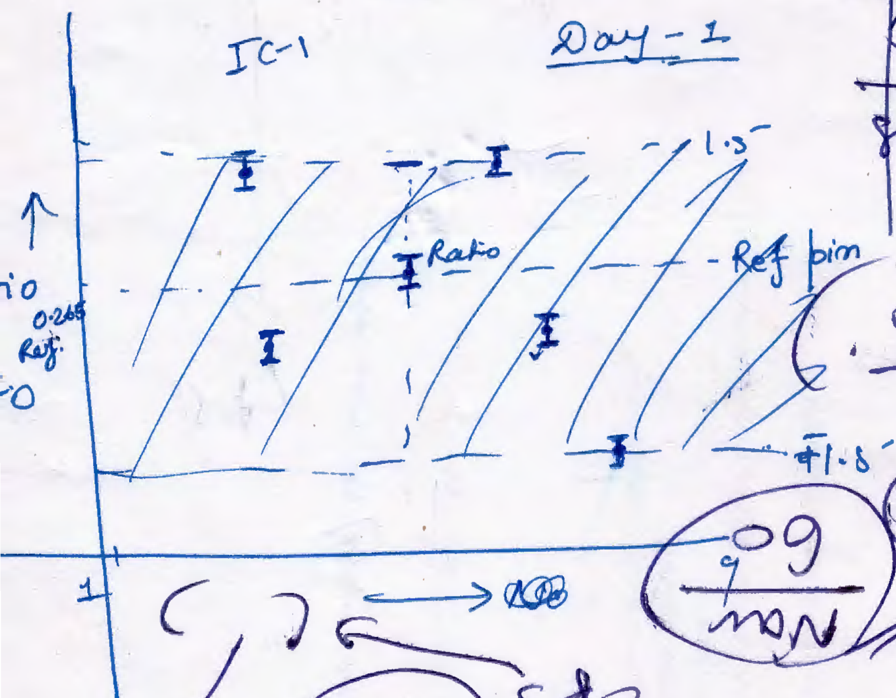
① σ_{day}
② Ratio ($\pm$ 3σ)
③



(1) $\sigma_{day} = \sqrt{\left(\frac{\sum_i (x_i - \bar{x})^2}{N_{pin\ tested\ that\ day}}\right)}$ $i = 1, N$

② cps

$N_{E_{avg}} \pm (N_E) \times 0.001$
$N_p \pm (N_p) \times 0.001$

① $\frac{N_p}{N_E}$ = we have

$\frac{N_p \pm N_p \times 0.001}{N_E \mp N_E * 0.001}$

$\left(\frac{N_p + (N_p) \times 0.001}{N_E - (N_E) \times 0.001}\right)$ max value

$\left(\frac{N_p - (N_p) \times 0.001}{N_E + (N_E) \times 0.001}\right)$ min

$\frac{\sigma}{60}$ cps

$\frac{N_{av}}{60}$

Same for IC2

$\frac{5 \text{ min}}{60}$ cps

$60 \times 14 \times$

$N_1 \pm \sqrt{N_1}$
$N_2 \pm \sqrt{N_2}$

$\sigma = \frac{\sqrt{\sigma_x + \sigma_3 + \sigma_2}}{14}$

Mea / Ref

$\frac{\sqrt{N_1}}{60}$ $\frac{\sqrt{N_2}}{60}$

$N_{avg} = \left(\frac{N_1 + N_2}{N}\right)$

with pin

N (840)

$N_1 + N_2 + N_3$

$\frac{N_1}{1} + \frac{N_2}{2} + \frac{N_3}{3}$