3439

Your Roll No. ....

M. Tech. / VI Sem.

A

NUCLEAR SCIENCE AND TECHNOLOGY

Paper NST 627— Fusion Reactor Design

Time : 3 hours

Maximum Marks : 70

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any four questions. All questions carry equal marks.

1 (a) Draw complete block diagram of Ion Cyclotron Resonance Heating system and briefly explain the function of each block. Calculate the ion cyclotron frequencies, for second harmonic heating, at 1.5 T and 3 T toroidal magnetic fields. (9)

(b) What is critical energy E_c of a neutral beam? Discuss its role in the ion heating and the electron heating of the tokomak plasma. (5)

(c) A neutral beam of hydrogen of energy E=30 KeV is injected into a tokomak plasma with plasma temperature of 1 KeV and plasma density 5×10^{19} m^{-3}. Estimate an approximate mean free path for the neutral beam attenuation. Also estimate the critical energy. (3.5)

2(a) What are the mechanisms responsible for x-ray emissions in hot plasmas? What is the diagnostic information contained in them? (3.5)

(b) What are the major issues of diagnosing "burning plasma"? What specific precautions are taken to ensure that diagnostic systems function in the burning plasma environment? (8)

(c) Describe the "Tomography Technique" for diagnosing hot plasma. (6)

3 (a) Describe the typical radial build-up of a fusion blanket and discuss the function of each of the components. How is the neutron flux and spectra measured inside the blanket assembly? (10)

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(b) What is the principle & strategy adopted in the shielding of fast neutrons? (2.5)

(c) What is the principle of detecting neutrons by activation foils? What are the dosimetry foils proposed for diagnosing high-energy neutrons in ITER? (5)

4 (a) What are the important issues and challenges, relevant to the materials, which need to be considered while designing first wall and structures in the fusion reactor? Give the list of suitable materials. (8)

(b) Scattering cross section (σ_s) for Fe is 3 barns for Fission and Fusion. Displacement cross sections (σ_{dpa}) for Fission is 1500 barns and for Fusion is 3300 barns. What is dpa in 5 years for fission and fusion, if neutron flux φ is 5×10^{13} neutron/cm^2-s for fission and 9×10^{14} neutron /cm^2-s for D-T fusion? (7)

(c) Define Ductile to Brittle Transition Temperature (DBTT). Describe its importance in fusion reactor. (2.5)

5 (a) Draw a schematic diagram of liquid helium (LHe) storage Dewar. Show that 1 W of heat load will evaporate 1.44 l/h of LHe. (6)
(Density of LHe = 125 kg/m^3 & Latent heat of LHe = 20 J/g)

(b) What is quench in superconductors? How quench can be detected using voltage monitoring? (5.5)

(c) Describe different types of steady state heat loads acting on the cryogenic systems. Explain how to minimize these heat loads. (6)

6 (a) Draw a clear diagram of the cross-sectional view of tokamak with the divertor region. Mark the following regions; SOL, LCFS, null point, private flux region, strike points. Briefly describe each of these regions. (10)

(b) Write down the formula for the power conducted into the divertor. Calculate the total power conducted into the divertor for a fusion power of 500MW, given that the auxiliary heating power is 50MW and fraction of power radiated from the plasma and SOL is 0.25. Assuming that the total surface area of the divertor is 20 m^2, what is the average heat flux falling on the divertor? (7.5)