(This Question paper contains 2 printed page) **Roll No. ________**

Sr. No. of questions Paper	**:**	**7445**
Name of the Course	**:**	**B.Sc. Hons.–(Physics)_NEP: UGCF-2022**
Semester	**:**	**VIII- Semester (DSE Paper)**
Name of Paper	**:**	**Plasma Physics**
Unique Paper Code	**:**	**2223010043**
Duration	**:**	**3 Hours**
Maximum Marks	**:**	**90**

Instructions for Candidates:

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

Question No.1 is compulsory. Answer any four of the remaining five. Use of non-programmable scientific calculator is allowed.

Q1. *Attempt any six questions:* **(6 x 3 = 18)**

(a) Define a plasma and write down the appropriate conditions to qualify a gas to be a plasma.

(b) Discuss the concept of inertial confinement fusion (ICF).

(c) Explain the role of the ionosphere in long-distance radio wave communication.

(d) A proton enters a uniform magnetic field B = 0.5 T with a velocity v = 2×10^6 m/s perpendicular to the field. Calculate its Larmor radius (r_L) and cyclotron frequency (ω_c).

(e) What is the plasma coupling parameter (Λ)? Write its expression in terms of Debye length and particle density.

(f) What is a magnetic mirror? Write the condition for a particle trapping in a magnetic mirror.

(g) What is the Saha ionization formula and discuss its significance in plasmas.

Q2. (a) Derive the Debye shielding potential around a test charge in a plasma. Show that the electric potential decreases exponentially in the Debye sphere. Discuss the physical significance of Debye shielding for collective plasma behavior. **(10)**

(b) Define plasma resistivity and electrical conductivity. For a plasma with electron–ion collision frequency, $\nu_{ei} = 10^9\ s^{-1}$ and electron density, $n_e = 10^{19}\ m^{-3}$, calculate the electrical conductivity. Explain that the high-temperature plasma is a good conductor. **(8)**

Q3. (a) Using single particle orbit theory, derive the expression for grad-B drift of an electron in a non-uniform magnetic field. Discuss the direction of drifts for electrons and ions, and the role of this drift in plasma confinement. **(10)**

(b) A proton moves in a magnetic mirror with mirror ratio, $R_M = B_{max} / B_{min} = 5$. (i) Calculate the loss-cone half-angle. (ii) If the proton's initial pitch angle at the midplane is 30°, determine whether it is confined. **(8)**

Q4. (a) Derive the expression for diamagnetic drift from the fluid description of plasma. How does a pressure gradient in a plasma column drive this drift? **(10)**

(b) Describe laser ablation as a plasma application. How is laser ablation used in thin-film deposition and industrial plasma processing? **(8)**

Q5. (a) Using a neat diagram, explain the mechanism of plasma electron oscillations. Suppose the electron plasma waves of frequency 1 GHz are propagating in a uniform plasma with electron temperature 100 eV and density $10^{16}\ m^{-3}$. Find the wavelength of the wave. **(10)**

(b) Compare the dispersion curves for electron plasma waves and ion acoustic waves using dispersion relations and approximations. **(8)**

Q6. (a) Starting from Maxwell's equations and the equation of motion for electrons, derive the dispersion relation for electromagnetic waves propagating in an unmagnetized plasma. Show the existence of a cutoff frequency and the role of ω_p. **(12)**

(b) In a plasma with electron temperature, $T_e = 8$ eV and ion temperature, $T_i = 1$ eV, the ions are singly ionized argon ($m_{Ar} = 6.68\times10^{-26}$ kg). The adiabatic index for ions is $\gamma_i = 3$ and assume isothermal electrons ($\gamma_e = 1$). Calculate the ion acoustic speed. **(6)**

<u>Physical Constants</u>

$\varepsilon_0 = 8.85\times10^{-12}$ F/m, $\mu_0 = 4\pi\times10^{-7}$ H/m, $c = 3\times10^8$ m/s, $k_B = 1.38\times10^{-23}$ J/K, $m_e = 9.1\times10^{-31}$ kg, $e = 1.6\times10^{-19}$ C, 1 eV = 1.6×10^{-19} J, $h = 6.63\times10^{-34}$ J·s, Mass of proton, $m_p = 1.67\times10^{-27}$ kg, Deuteron mass, $m_d = 3.34\times10^{-27}$ kg, Atomic mass unit=1.66×10^{-27} kg.