REV-01
MSP/04/09

2024/05

SET A

M.Sc. PHYSICS
FOURTH SEMESTER
PLASMA PHYSICS II
MSP – 401B
[USE OMR FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

Objective

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: ***1X20=20***

1. Which of the following statement is true?
   a. Single orbit motion is the best approach to study plasma.
   b. Kinetic theory vividly and intricately describes plasma.
   c. MHD theory is the complex approach for plasma study.
   d. Two fluid model describes the plasma more accurately.

2. When the electromagnetic wave in plasma is longitudinal, it is known as?
   a. Alfvén Wave
   b. Ion Acoustic Wave
   c. Magnetosonic Wave
   d. Electron Plasma Wave

3. In the limit $B \to 0, v_p \to v_s$, the magnetosonic wave turns into
   a. Alfvén Wave
   b. Upper hybrid wave
   c. Oblique lower hybrid wave
   d. Ion acoustic wave

4. The mean free path of collisions is defined as
   a. $\lambda_m = \frac{1}{\sigma n_i}$
   b. $\lambda_m = \frac{1}{\sigma n_n}$
   c. $\lambda_m = \frac{\sigma}{n_n}$
   d. $\lambda_m = \frac{\sigma}{n_e}$

5. Dispersion relation of Alfvén Wave is given by
   a. $\omega^2 = \Omega_p^2\left(1 - \frac{\Omega_c^2}{\omega^2}\right)^{-1}$
   b. $\omega^2 - c^2k^2 = \Omega_p^2\left(1 - \frac{\Omega_c^2}{\omega^2}\right)^{-2}$
   c. $\omega^2 - c^2k^2 = \Omega_p^2\left(1 + \frac{\Omega_c^2}{\omega^2}\right)^{-1}$
   d. $\omega^2 - c^2k^2 = \Omega_p^2\left(1 - \frac{\Omega_c^2}{\omega^2}\right)^{-1}$

6. Poisson's equation is used when
   a. Plasma approximation is not considered
   b. Plasma approximation is considered
   c. Quasi-neutrality is considered
   d. Quasi-neutrality is not considered

7. Boltzmann equation is true when there is
   a. Plasma diffusivity
   b. Plasma resistivity
   c. Fluid approximation
   d. Collisional effect

8. In kinetic theory of plasma, what happens to the distribution function $f(\boldsymbol{r}, v, t)$when $v \rightarrow \pm\propto$
   a. Becomes very large
   b. Grows exponentially
   c. Vanishes
   d. Damps

9. Landau damping is a
   a. Wave-wave interactional phenomena
   b. Wave-particle resonance damping
   c. Collisional damping
   d. Diffusional damping

10. Vlasov equation can precisely describe
   a. Langmuir waves
   b. Landau damping
   c. Fluid motions in plasma
   d. All of the above

11. What role does the atmospheric gas play in ARC discharge plasma?
   a. It does not affect the plasma properties
   b. It determines the color of the plasma
   c. It provides ions and electrons for sustaining the plasma
   d. It only affects the temperature of the plasma

12. Which industry commonly utilizes ARC discharge plasma for various applications?
   a. Agriculture
   b. Automotive
   c. Textile
   d. Aerospace

13. What is the typical frequency range used in RF discharge plasma systems?
   a. 50-60 Hz
   b. 1-10 kHz
   c. 100-1000 kHz
   d. 1-100 MHz

14. What happens to the breakdown voltage according to Paschen's Law as the distance between the electrodes increases?
   a. It decreases.
   b. It increases.
   c. It remains constant.
   d. It becomes zero.

15. In a DC glow discharge plasma, what happens to the potential difference across the electrodes when the discharge is initiated?
   a. It decreases.
   b. It remains constant.
   c. It increases.
   d. It becomes zero.

16. What property of solitons allows them to maintain their shape and velocity while propagating through plasma?
   a. Dispersion
   b. Nonlinearity
   c. Uniformity
   d. Discontinuity

17. What role does the Debye length play in the characteristics of a plasma sheath?
   a. It determines the thickness of the sheath.
   b. It determines the plasma temperature.
   c. It affects the plasma density.
   d. It has no influence on the plasma sheath.

18. What are nonlinear ion acoustic waves?
    a. Waves composed of nonlinear ions in a plasma medium.
    b. Waves in which the ion density oscillates with an amplitude that is comparable to the plasma frequency.
    c. Waves that propagate in a linear medium with uniform ion density.
    d. Waves that travel at the speed of light in a plasma.

19. Which of the following is NOT a characteristic of arc discharge plasma?
    a. High electron temperature
    b. High ionization degree
    c. Low electron density
    d. Strong electromagnetic radiation

20. What role does Townsend discharge play in plasma processing applications?
    a. It generates high-frequency electromagnetic waves for etching processes.
    b. It provides a stable plasma environment for surface modification and deposition.
    c. It produces intense heat for welding and cutting of materials.
    d. It facilitates the generation of magnetic fields for particle confinement

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Descriptive

Time : 2 hrs. 30 min. **Marks : 50**

[Answer question no.1 & any four (4) from the rest]

1. **a.** Elaborately describe the importance of kinetic theory of plasma. Derive the Boltzmann-Vlasov equation and write down its physical significance. **2+3=5**

   b. State and explain Paschen's law. Derive the expression for Paschen's law and explain the condition for the minimum breakdown voltage under a given pd condition? **2+3=5**

2. Deduce the Bohm-Gross dispersion relation and draw the dispersion curve. **10**

3. **a.** What is Landau damping? Explain briefly. **1+9=10**
   b. Derive the expression of Landau damping and explain its physical significance.

4. **a.** Explain briefly the transport phenomena in plasma. Derive the collision and diffusion parameters in plasma. 1+4+1+5 =10

b. What is a lower hybrid frequency wave in plasma? Derive its dispersion relation.

5. **a.** Explain elaborately how Ion-Acoustic wave is generated in plasma. Derive its dispersion relation. 5

b. Derive an expression for Townsend's current growth equation by considering secondary ionization. 5

6. **a.** What is a DC glow discharge plasma, explain. Write some applications of DC glow discharge plasma. 4+1=5

b. Discuss the Arc discharge plasma process with the working principle. Write some applications of Arc discharge plasma. 4+1 =5

7. **a.** What is electrodeless discharge? Briefly explain the breakdown mechanism of gases in a high frequency field and give the theory of breakdown of gases in RF discharge. 1+3=4

b. Explain how the current-voltage (IV) characteristic of a Langmuir probe is related to the properties of the plasma. Discuss how the slope and saturation current of the IV curve provide information about the electron temperature and density of the plasma. How can you extract these plasma parameters from the IV curve? 2+2+2=6

8. **a.** What is plasma sheath? Discuss the sheath phenomenon in a plasma discharge. 1+1=2

b. Define soliton phenomenon in plasma. Derive Korteweg-de Vries equation from the fluid equations of plasma. 1+7=8

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