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**6 SEM TDC PHYH (CBCS) C 13**

**2025**

( May )

PHYSICS

( Core )

Paper : C–13

**( Electromagnetic Theory )**

*Full Marks* : 53

*Pass Marks* : 21

*Time* : 3 hours

*The figures in the margin indicate full marks for the questions*

**1.** Choose the correct option of any *five* of the following : 1×5=5

*(a)* Maxwell's equations give the relations between

*(i)* different sources

*(ii)* different boundary conditions

*(iii)* different fields

*(iv)* None of the above

(b) Poynting vector represents

(i) the rate of flux change per unit area

(ii) the rate of energy transfer per unit area

(iii) electric field per unit area

(iv) magnetic field per unit area

(c) For good conductor, skin depth

(i) increases with increasing frequency

(ii) decreases with increasing frequency

(iii) is independent of frequency

(iv) None of the above

(d) Brewstar angle is the angle when a wave is incident on the surface of a perfect dielectric at which there is no reflected wave and the incident wave is

(i) parallelly polarized

(ii) perpendicularly polarized

(iii) normally polarized

(iv) None of the above





(e) The magnitudes of $E_x$ and $E_y$ components are same in which type of polarization?

(i) Linear

(ii) Circular

(iii) Elliptical

(iv) Perpendicular

(f) The dominant TE mode in rectangular waveguide is

(i) $TE_{01}$

(ii) $TE_{00}$

(iii) $TE_{10}$

(iv) $TE_{11}$

**2.** Answer any *five* of the following questions : 2×5=10

(a) Write down the Maxwell's field equations in linear isotropic media.

(b) State the physical concept of electro-magnetic field energy density.

(c) What is 'relaxation time'?

(d) Explain the significance of $\nabla \cdot \vec{B} = 0$.

(e) Distinguish between *e*-rays and *o*-rays.

(f) What is 'evanescent wave'?

**3.** (a) What are the scalar and vector potentials? Explain gauge transformation used. 2+2=4

*Or*

Using Maxwell's equations

$$\text{curl } E = -\frac{\partial B}{\partial t} \text{ and curl } H = J + \frac{\partial D}{\partial t}$$

show that $\text{div} B = 0$ and $\text{div} D = \rho$. 2+2=4

(b) From Maxwell's equation for free-space condition, show that velocity of light

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$ 4

**4.** (a) Determine the boundary conditions satisfied by $B$ and $E$ at the interface between two media of different permeabilities and dielectric constants. 5

(b) What is skin depth? Write its mathematical expression for a good conductor. 2





**5.** Deduce Fresnel's equations for reflection and refraction of electromagnetic waves at a plane boundary separating two dielectric media when incident wave polarized with its vector $E$ parallel to the plane of incidence. 7

*Or*

Establish the laws of reflection and refraction at the boundary of two dielectric media for a plane electromagnetic wave propagation at an oblique incidence.

**6.** Distinguish between uniaxial and biaxial crystals. Discuss about the polarization by double reflection. 2+4=6

*Or*

Establish the Fresnel's theory of optical rotation. 6

**7.** What is a waveguide? Discuss the propagation of electromagnetic waves along a rectangular waveguide and obtain an expression for cut-off frequency. Show that a waveguide acts as a high-pass filter. 1+4+2=7

*Or*

What are TE, TM and TEM modes in waveguide? Outline the principle of operation of waveguide. What is the meaning of cut-off wavelength? Why TEM mode cannot propagate through a waveguide? 3+2+1+1=7

8. Draw the structure of an optical fibre with different parts and state the role of each part. What is the principle involved in its working? 2+1=3

*Or*

Describe with relevant sketches the different types of fibres. Also compare them. 3

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**6 SEM TDC PHYH (CBCS) C 14**

**2025**

( May )

PHYSICS

( Core )

Paper : C–14

**( Statistical Mechanics )**

*Full Marks* : 53

*Pass Marks* : 21

*Time* : 3 hours

*The figures in the margin indicate full marks for the questions*

**1.** Choose the correct answer from the following (any *five*) : 1×5=5

*(a)* In the equilibrium state, the thermodynamic probability of a system is

*(i)* zero

*(ii)* maximum

*(iii)* minimum but not 1

*(iv)* one

*(b)* Gibbs' paradox arises due to

*(i)* indistinguishability of classical particles

(ii) distinguishability of classical particles

(iii) omittance of quantum nature of the particles

(iv) absence of inter-particle interaction

(c) Rayleigh-Jeans law agrees well with the experimental result at

(i) low frequency

(ii) infinity

(iii) high frequency

(iv) None of the above

(d) At high temperature, Bose-Einstein distribution approaches Maxwell-Boltzmann distribution.

(i) False

(ii) True

(iii) Can't say

(iv) Sometimes true sometimes false

(e) From Fermi-Dirac statistics, $n_i =$

(i) $\frac{g_i}{e^{\alpha+\beta\varepsilon_i}+1}$ (ii) $\frac{2g_i}{e^{\alpha+\beta\varepsilon_i}+1}$

(iii) $\frac{g_i}{e^{\alpha+\beta\varepsilon_i}-1}$ (iv) $\frac{2g_i}{e^{\alpha+\beta\varepsilon_i}-1}$

(f) Bosons have spin value

(i) 0 (ii) 1

(iii) ½ (iv) 0 or 1



( Continued )



**2.** (a) Define and explain in brief the terms 'macrostate' and 'microstate' with the help of example. 2+2=4

(b) Define entropy. Deduce Boltzmann's entropy relation. 1+3=4

(c) Treating the ideal gas as a system governed by classical mechanics, derive the Maxwell-Boltzmann distribution law. 6

*Or*

Derive the partition function for an ideal monatomic gas.

**3.** (a) What do you mean by 'thermal radiation'? 2

*Or*

If the sun emits maximum energy at wavelength 4753 Å, calculate the temperature of its surface. (Given : Wien's constant $b = 0{\cdot}288$ cm °C)

(b) State and prove Kirchhoff's law of black-body radiation. 4

(c) State and derive Planck's law of black-body radiation. 1+4=5

*Or*

State Stefan-Boltzmann law of radiation. Deduce this law on thermo-dynamic consideration.

**4.** (a) What is photon gas? What is the difference between photon gas and ideal gas? 1+2=3

(b) What is Bose-Einstein statistics? Derive an expression

$$n_i = \frac{g_i}{e^{\alpha+\beta\varepsilon_i}-1}$$ 1+3=4



( Turn Over )

*Or*

Explain why behavior of liquid helium cannot be explained by classical statistics. How is it be overcome by quantum mechanics? 4

*(c)* Bosons may condense at very low temperature. Discuss on the basis of statistical mechanics. 4

**5.** *(a)* At absolute zero temperature ($T = 0$ K) all the energy levels up to $\varepsilon_f$ are completely filled. Calculate the total number of fermions in a Fermi gas at $T = 0$ K and express $\varepsilon_f$ in terms of number density $(N/V)$. 6

*Or*

Derive an expression for Fermi-Dirac law of energy distribution for free electrons in a metal.

*(b)* What is the cause of degeneracy pressure inside a white dwarf star? Explain the limit depending on which some stars become white dwarf and other become neutron star or black hole. 1+5=6

*Or*

A system has 7 particles arranged in two compartments. The first compartment has 8 cells and the second has 10 cells. All cells are of equal size. Calculate the number of microstates in the microstate (3, 4) when the particles obey F-D statistics. 6

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