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6 SEM TDC PHYH (CBCS) C 13

2024

(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) The value of wave impedance in free space is

(i) 390 ohm

(ii) 480 ohm

(iii) 377 ohm

(iv) 230 ohm

(b) The Brewster's angle for light incident on glass with refractive index 1·6 is

(i) 90°

(ii) 70°

(iii) 58°

(iv) None of the above

(c) Nicol prism is made up of

(i) calcite crystal

(ii) quartz

(iii) mica

(iv) nickel

(d) The angle of rotation depends upon

(i) length of the substance

(ii) concentration of the substance

(iii) Both (i) and (ii)

(iv) None of the above

(e) Which of the following cannot occur in a hollow waveguide?

(i) TM wave

(ii) TE wave

(iii) TEM wave

(iv) All of the above

(Continued)

(f) Which of the following is wrong?

(i) $n \propto \sqrt{\varepsilon_r}$

(ii) $\frac{\varepsilon}{B} = c$

(iii) $n \propto \frac{1}{\sqrt{\varepsilon_r}}$

(iv) Div $\vec{B} = 0$

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

(a) What are electromagnetic potentials?

(b) Determine the numerical aperture of a step-index fibre when the core and cladding refractive indices are respectively 1·5 and 1·4.

(c) Classify the optically active substances with examples.

(d) Obtain an expression for the electromagnetic energy density in free space.

(e) What is optic axis? Give an example of a crystal having two optic axes. 1+1=2

(f) Find the reflection and transmission coefficients for normal incidence in glass-air interface. Given refractive index of glass is 1·5. 1+1=2

(Turn Over)

3. *(a)* State the Poynting theorem and write its mathematical form. Hence discuss the physical significance of the theorem. 1+1+2=4

Or

Explain how Maxwell modified Ampere's equation for electromagnetic field. 4

(b) Obtain the boundary conditions for tangential components of electro-magnetic field vectors at the interface of two media. 2+2=4

4. *(a)* Show that electromagnetic waves in free space are transverse in nature. 3

(b) Find an expression for conductivity of ionized region on the basis of propagation of electromagnetic waves through ionized gas. 4

5. Explain the phenomenon of total internal reflection with the help of electromagnetic theory. What are evanescent waves? 4+2=6

Or

Obtain the Fresnel's equations for non-conducting media when the electric field vector is normal to the plane of incidence. 6

(Continued)

6. *(a)* Discuss how circular and elliptical polarization of electromagnetic waves can be obtained. 3+2=5

Or

Describe the action of Nicol prism as analyser with the help of proper diagram. 5

(b) Derive the eigenvalue equation for a plane dielectric waveguide. 4

7. Write short notes on any *two* of the following : 4×2=8

(a) Double refraction

(b) Laurent's half-shade polarimeter

(c) Half-wave plate

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6 SEM TDC PHYH (CBCS) C 14

2024

(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 option from the following : 1×5=5

(a) The thermodynamic probability of a system in equilibrium is

(i) maximum

(ii) minimum but not 1

(iii) 1

(iv) zero

(b) Rayleigh-Jeans law of radiation

(i) applies to smaller wavelengths

(ii) applies to longer wavelengths

(iii) applies to all wavelengths

(iv) does not apply to any wavelength

(c) According to which statistics, the energy at absolute zero cannot be zero?

(i) MB

(ii) BE

(iii) FD

(iv) None of the above

(d) Five particles are distributed in two-phase cells. Then the number of macrostates is

(i) 6

(ii) 10

(iii) 32

(iv) $\frac{5}{2}$

(e) Deduction of Planck's law is possible on the basis of

(i) Fermi-Dirac (FD) statistics

(ii) classical statistics

(iii) Maxwell-Boltzmann (MB) statistics

(iv) Bose-Einstein (BE) statistics

(Continued)

2. (a) Define statistical ensemble. Differentiate among canonical, microcanonical and grand canonical ensembles. 1+3=4

(b) Define entropy. Show that the entropy of the system is proportional to the logarithm of probability of that system. 1+3=4

(c) Show that the number of molecules in a cell of energy ε_i in the equilibrium state is given by $n_i = Ae^{-\varepsilon_i/kT}$, where A is any constant. 6

Or

Derive the expression for entropy, enthalpy and Helmholtz's free energy in terms of statistical parameters. 2+2+2=6

3. (a) State Stefan-Boltzmann law of radiation. Deduce this on the basis of thermodynamic considerations. 3

(b) What is black-body radiation? Explain its temperature dependence. 1+2=3

(c) What is Planck's law of black-body radiation? Derive an expression for it. 2+3=5

(Turn Over)

(d) State and explain Rayleigh-Jeans law. Explain its validity in terms of experimental results. 2

Or

Calculate the energy radiated by unit area of a blackbody in one second when its temperature is 1000 K.
($\sigma = 5 \cdot 672 \times 10^{-8}$ J/S/m^2)

4. (a) "Bosons may condense at very low temperature." Give a statistical mechanical interpretation. 4

Or

How many photons are present in 1 cm^3 of radiation at 727 °C?
[Given, $\int_0^\infty \frac{x^2 dx}{e^x - 1} = 2 \cdot 405$]

(b) What is photon gas? What are the properties of photon gas? 1+2=3

(c) Derive an expression $n_i = \frac{g_i}{e^{\alpha + \beta E_i} - 1}$ for the most probable distribution of the particles of a system obeying BE statistics. 4

(Continued)

Or

Derive the expression for energy of a strongly degenerate Bose gas.

5. (a) What is the cause of degeneracy pressure inside a white dwarf star? Explain the limit depending on which some stars become white dwarf star and other becomes neutron star or black hole. 1+4=5

Or

Derive the expressions for entropy and Helmholtz free energy of a strongly degenerate Fermi gas. 5

(b) Derive an expression for Fermi-Dirac law of energy distribution for free electrons in a metal. 5

Or

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

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