2022

Time - 3 hours

Full Marks - 60

*Answer **all groups** as per instructions.*
Figures in the right hand margin indicate marks.
Candidates are required to answer
in their own words as far as practicable.

GROUP – A

1. Answer all questions and fill in blanks as required. [1 × 8

(a) State the unit of Poynting vector.

(b) Identify the equation $\vec{\nabla} \cdot \vec{D} = \rho$.

(c) For perfect di-electric, the value of conductivity is _____.

(d) State the unit of skin depth.

(e) For which colour, the critical angle is maximum for water air interface ?

(f) What is the value of reflection coefficients for total internal reflection ?

(g) Give examples of one +ve and one –ve birefringent crystals.

(h) Polarisation of light shows that light waves are _____ in nature.

GROUP – B

2. Answer any eight of the following questions within two to three sentences each. [1½ × 8

(a) Define specific rotation.

(b) Give one limitation of Nicol prism.

(c) Why is Brewster's angle known as polarising angle ?

(d) Define electro-magnetic energy density.

(e) What is the condition of Lorentz gauge ?

(f) Show that in a good conductor, the skin depth is much smaller than the wave-length.

(g) Write the boundary condition for electric displacement vector. Is it continuous at the interface ?

(h) What is the working principle of Babinet's compensator ?

(i) Write Maxwell's electro-magnetic wave equation (one) both in differential and integral form.

(j) State Snell's law of refraction and write its mathematical form.

GROUP – C

3. Answer any eight of the following questions within 75 words each. [2 × 8

(a) Explain with diagrams parallel and crossed nicols.

(b) Find the thickness of quarter-wave-plate for light of wave-length 4800 Å. Given that $(\mu_0 - \mu_e) = 0.0058$.

(c) Find the specific rotation of sugar solution of plane of polarisation is turned through 11^0 if the length of tube containing 20% sugar solution is 20 cm.

(d) What is physical significance of Poynting vector ?

(e) Show that curl of $\left[\vec{E} + \frac{\partial \vec{A}}{\partial t}\right]$ vanishes.

(f) Write electro-magnetic wave equation for magnetic intensity and express each term.

(g) What are the characteristics of uniform plane-wave ?

(h) Explain briefly plasma frequency.

(i) A wave propagates from a di-electric medium to interface with free-space. If the angle of incident is the critical angle of 30^0, then find the relative permittivity.

(j) Explain the meaning of Coulomb Gauss and Lorentz Gauss.

GROUP – D

*Answer **any four** questions within 500 words each.*

4. Derive electro-magnetic wave equation for electric field vector using Maxwell's equation. [6

5. Write Maxwell's four equations. Derive any two equations and give their physical significance. [6

6. Derive boundary conditions satisfied by the electro-magnetic field-vector $\vec{E}$. Explain relaxation time. [6

7. Explain total internal reflection on the basis of electro-magnetic theory of light and hence explain evanescent waves. [6

8. Discuss construction and working of Nicol prism. Explain briefly use of Nicol prism as polariser and analyser. [6

9. Explain quarter wave-plate. Find out the thickness of a quarter wave-plate. How it is used to produce circularly and elliptically polarised light ? [6

10. Write Biot's laws of Rotatory polarisation. Briefly explain Fresnel's theory of optical rotation. A tube of sugar solution 20 cm long is placed between two crossed Nicols. If the optical rotation produced is 10^0 and specific rotation is 66^0, find the strength of the solution if light of wave-length 6000 Å is used. [2 + 2 + 2

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GROUP – A

1. Answer all questions and fill in blanks as required. [1 × 8

(a) The condition for thermal equilibrium of two subsystems is equality of _____.

(b) Is entropy an extensive quantity or intensive quantity ?

(c) The equation of state for a classical ideal gas is _____.

(d) The partition function is defined as Z = _____.

(e) Which statistics is applied to photons ?

(f) In quantum statistics, the particles are _____.

(g) The value of Stefan's constant is _____.

(h) The absolute temperature of a perfect black body is increased to twice its value. The rate of emission of energy per unit area will become _____.

GROUP – B

2. Answer any eight of the following questions within two to three sentences each. [1½ × 8

(a) How do you specify a microstate in classical statistical mechanics ?

(b) Define ensemble.

(c) What is phase space ?

(d) Using equipartition theorem, derive Dulong and Petit's law of specific heat.

(e) Write the conditions for a system to have negative temperature.

(f) Define Fermi energy.

(g) How do you define a quantum microstate ?

(h) What is a black body ?

(i) What is ultraviolet catastrophe ?

(j) Radiation from the Big Bang has been Doppler shifted to longer wavelengths by the expansion of the universe and today has a spectrum corresponding to that of a black body at 2.7 K. Find the wavelength at which the energy density of this radiation is a maximum.

GROUP – C

3. Answer any eight of the following questions within 75 words each. [2 × 8

(a) Distinguish between microcanonical and canonical ensembles.

(b) Briefly explain the partition function.

(c) What is grand canonical ensemble ? How does it differ from canonical ensemble ?

(d) What is Gibb's paradox ?

(e) Deduce Sackur-Tetrode relation using partition function.

(f) Distinguish between fermions and bosons.

(g) What is Bose-Einstein condensate ?

(h) Show that Planck's law reduces to Wien's law for shorter wavelenghts and Rayleigh-Jean's law for longer wavelengths.

(i) State and prove Kirchhoff's law of radiation.

(j) What are the properties of thermal radiation ?

GROUP – D

*Answer **any four** questions within 500 words each.*

4. Define entropy and thermodynamic probability. Establish a relation between them. [6

5. Derive the Maxwell-Boltzmann distribution law. [6

6. Derive an expression for the entropy of a classical ideal gas, using microcanonical ensemble. [6

7. State and prove the law of equipartition of energy. [6

8. Derive the expression for the Fermi-Dirac distribution law. [6

9. Prove the Stefan-Boltzmann law. [6

10. Derive Planck's radiation formula. [6

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