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Paper Code : BS-PH-201(N)

PHYSICS – I

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) The moment of inertia of a thin uniform rod of mass M and length L about an axis perpendicular to the rod, through its centre is I. The moment of inertia of the rod about an axis perpendicular to the rod through its end point is

   a) $\frac{I}{4}$ b) $\frac{I}{2}$

   c) $2I$ d) $4I$.

ii) The action of Nicol prism is based on the phenomenon of

a) scattering
b) double refraction
c) refraction
d) reflection.

iii) The relaxation time is defined as the time during which the amplitude of a damped oscillator

a) grows to e times the initial value
b) decays to $1/e$ times the initial value
c) grows to e^2 times the initial value
d) decays to $1/e^2$ times the initial value.

iv) Velocity of plane electromagnetic wave is given by

a) $c = \frac{1}{\mu_0 \varepsilon_0}$
b) $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$
c) $c = \frac{\mu_0}{\varepsilon_0}$
d) $c = \mu_0 \varepsilon_0$.

v) The ferromagnetic susceptibility is given by

a) $\chi = \frac{c}{T + T_c}$
b) $\chi = \frac{c}{T - T_c}$
c) $\chi = c(T + T_c)$
d) $\chi = \frac{cT}{T - T_c}$.

vi) Above the Curie temperature ferromagnetic materials reduces to

a) paramagnetic
b) diamagnetic
c) anti-ferromagnetic
d) ferrimagnetic.

vii) The maximum energy density of radiations of a black body at absolute temperature T = 0K is displaced towards the shorter wavelength. This law is known as

a) Wien's radiation law

b) Wien's displacement law

c) Rayleigh-Jeans law

d) Planck's radiation law.

viii) Electrons are emitted with zero velocity from a metal surface due to incident radiation of wavelength λ = 6800Å. The work function (W) is

a) 1.82eV b) 1.80eV

c) 1eV d) 182eV.

ix) The value of $\left[\hat{x}, \hat{p}_x\right]$ is

a) $ih/2\pi$ b) 0

c) $-ih/2\pi$ d) 1.

x) MB statistics is applicable for

a) Ideal gas b) Electron

c) Proton d) Photon.

xi) The ground state energy of a particle moving in a one dimensional potential box is given in terms of length l of the box by

a) $\frac{2h^2}{8ml^2}$ b) $\frac{h^2}{8ml^2}$

c) $\frac{h}{8ml^2}$ d) 0.

xii) The equation tells about non-existence of magnetic monopole is

a) $\text{curl } \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ b) $\text{div } \vec{B} = 0$

c) $\text{curl } \vec{H} = \vec{J} + \frac{\partial \vec{B}}{\partial t}$ d) $\text{div } \vec{D} = \rho$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. a) Find $\vec{\nabla} . \vec{F}$ where $\vec{F} = \vec{\nabla}(x^3 + y^3 + z^3 - 3xyz)$.

b) Show that the vector field $\vec{F} = \frac{x\hat{i} + y\hat{j}}{\sqrt{(x^2 + y^2)}}$ is a "source" field. $2\frac{1}{2} + 2\frac{1}{2}$

3. a) What is resolving power of grating ? Find the expression for resolving power of a grating with number of lines N.

b) For a diffraction grating with $N = 1000$, find the two closest wavelengths for a light of wavelength 600nm, so that the first order of principal maximum just able to resolve them with respect to 600 nm light. $1 + 2 + 2$

4. a) Establish the relation between dielectric constant K and electric susceptibility χ_e of a dielectric material.

b) Find the relation between electric polarizability and atomic radius. $2 + 3$

5. Find the expression for energy of a recoil electron in Compton scattering. Explain why a photon cannot transfer all of its energy to the recoil electron in Compton scattering. 3 + 2

6. Find the possible arrangements of three particles *A*, *B*, and *C* in three cells according to the *M-B*, *B-E* and *F-D* statistics. 2 + 2 + 1

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Distinguish between interference and diffraction of light.

b) Write down the differential equation of a discharging series LCR circuit. Identify the natural frequency of the circuit. Under what condition will this circuit show an oscillatory decay ?

c) Calculate the damped frequency of oscillation and relaxation time of an LCR circuit with L=3H, C=0.05μF and R=100Ω.

d) Derive an expression with illustration for logarithmic decrement.

e) Write down the expression for the intensity of light due to Fraunhofer diffraction in a single slit and hence find the conditions for maxima and minima in the diffraction pattern. 2 + 3 + 3 + 3 + (1 + 3)

| Turn over

8 a) Estimate the temperature of the sun, if λ_m for the sun is 490nm.

b) Starting from Planck's radiation law show that in the high wavelength limit it reduces to Rayleigh-Jeans law.

c) Starting from de Broglie's hypothesis show that group velocity associated with a particle is same as particle velocity.

d) Explain the physical significance of a wave function. A particle confined to move along the x-axis has a wave function $\Psi = \sqrt{3}\, x$. Find the probability of finding the particle between $x = 0.35$ to $x = 0.45$.

e) State Brewster's law ? The critical angle of the glass plate is 42° with respect to air. Calculate the angle of polarization and the corresponding angle of refracted light. 2 + 3 + 3 + (1 + 2) + (1 + 3)

9. a) An electron is confined in a one dimensional infinite potential well of length L = 1Å. Apply the Schrodinger equation to find the normalized wavefunction of the electron and its energy in the ground state. Mass of electron = 9.11×10^{-31} kg.

b) Find the expectation value of position of the above electron in the first excited state.

c) Write down Maxwell's equation in electromagnetic field and explain physical significance of four equations.

d) Show that electronic polarizability α_e is $\alpha_e = \frac{\varepsilon_0(\varepsilon_r - 1)}{N}$, where the symbols have their usual meaning. (4 + 1) + 3 + (2 + 2) + 3

10. a) What is double refraction ? Distinguish between ordinary ray and extraordinary ray.

b) State Malus' law. Two polaroids are so adjusted so as to obtain the maximum intensity. Through what angle should one Polaroid be rotated to reduce the intensity to half ?

c) Calculate the minimum thickness of a calcite plate which would convert plane polarized light into circularly polarized light. $\mu_o = 1.685$, $\mu_e = 1.486$ and $\lambda = 5890\text{Å}$.

d) Write a short note on working principle of LASER. Derive the relationship between Einstein's A and B coefficients. (1 + 3) + (1 + 2) + 3 + (2 + 3)

11. a) Draw the Fermi distribution curve of (i) $T = 0K$ and (ii) $T > 0K$. Explain their significance.

b) What are fermions and bosons ? Give two examples of each.

c) Consider a three particle system each of which can exist in a state 0, E, $2E$ and $3E$. The total energy of the system is $3E$. What are the possible microstates if the particles obey (i) MB statistics, (ii) BE statistics.

d) Evaluate the absolute temperature at which a state with an energy 0.5 eV above the Fermi energy will have 1% probability of being occupied by an electron. 4 + 4 + 4 + 3