OLD

2015

Part-I 3-Tier

PHYSICS

PAPER—II

(Honours)

Full Marks : 90

Time : 4 Hours

The figures in the right-hand margin indicate full marks.

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

Illustrate the answers wherever necessary.

Group—A

Answer any *two* questions.

1. (a) Determine the thickness 't' of a thin mica sheet when it is placed in front of any one of the two slits in Young's double slit experiment. Given that λ is the wave length of the light used in experiment, μ is the refractive index of the mica, β is the fringe width and the shift in central fringe is y. 3

(b) With appropriate diagram, explain the production of achromatic fringes by Young's double slit arrangement. 4

(c) Theoretically demonstrate that the reflection backed by the denser medium is associated with a Π-phase change. 3

(d) Explain the rectilinear propagation of light on the basis of the wave theory. 3

2. (a) Find out the expression of resolving power of a telescope. 3

(b) Using Fermat's principle obtain the reflection formula for a curved reflection. 3

(c) Derive an expression for the relativistic variation of mass of a moving particle. 4

(d) A number of slabs n, each of area A, but of different materials and thicknesses are placed side by side in contact. If the temparature of the exposed face of the first slab is θ_1 and that of the exposed face of the nth slab is θ_{n+1}, show that, in the steady state, the heat conducted per second per unit area is $\frac{1}{A}\frac{dq}{dt} = U\left(\theta_1 - \theta_{n+1}\right)$; where U is the overall coefficient of heat transfer and given by $\frac{1}{U} = \sum_{i=1}^{n} \frac{x_i}{k_i}$, where x_i is the thickness of the i-th slab of conductivity k_i. 5

3. (a) With the required assumptions, derive the expression of Maxwell's velocity distribution functions for two dimensional motion of an ideal gas system. Draw the figure for any of two distribution functions.

2+6+1

(b) Show that the number of ideal gas particles striking unit area of a wall per second is $P/\sqrt{2\pi m kT}$, where P is the pressure, T is the temperature, m is the mass of a particle and k is the Boltzmann constant. 3

(c) Show that the r.m.s speed can be $\sqrt{\frac{3f}{f+2}}$ times the speed of sound. f is the number of degrees of freedom.

3

4. (a) State the essential difference between the first law and second law of thermodynamics. 2

(b) A Carnot engine operates between T_1 and T_2 ($T_1 < T_2$) with a gas as working substance whose equation of state is given by $p(u-b) = RT$. Show that the efficiency of Carnot engine in that case is, $\eta = \left(1 - \frac{T_1}{T_2}\right)$.

5

(c) What is the more effective way of increasing the efficiency of Carnot engine increasing the source temperature or decreasing the sink temperature. Show mathematically. 3

(d) State and prove Carnot's theorem? 1+4

Group—B

Answer any *five* questions.

5. Obtain the expression of resultant intensity distribution of light rays passing through a Fabry-Perot (FP) etalon. Graphically show the dependence of the sharpness of fringes on the finesse factor. Is it possible to obtain zeroth order fringe through a FP-interferometer? 5+2+1

6. Write down Planck's radiation law. Derive Wien's law, Rayleigh-Jean's law and Stefan-Boltzmann law from it with sufficient physical explanations. 2+2+2+2

7. (a) For one mole of Vander Waals gas undergoing a reversible isothermal expansion from a volume V_1 to V_2. Show that the heat transferred Q is given by $Q = RT \log_e \frac{V_2 - b}{V_1 - b}$, where the parameters are of usual meaning. 4

(b) Using the relation $c_p - c_v = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$,

show that, for an isentropic transformation,

$\left(\frac{\partial V}{\partial T}\right)_S = -\frac{c_v}{c_p - c_v}\left(\frac{\partial V}{\partial T}\right)_P$. All the physical parameters are of usual meaning. 4

8. (a) What do you mean by the transverse Doppler effect in light? 2

(b) Express the Newton's second law in relativistic form. 1

(c) An astronaut is standing in a spacecraft parallel to its direction of motion. An observer on the earth finds the spacecraft's speed 0·6C (c is the ultimate speed of light) and the astronaut is 1.3 mt tall. What is the astronaut's height as measured in the spacecraft? 2

(d) Verify that $\frac{1}{\sqrt{1 - v^2/c^2}} = 1 + \frac{E_K}{m_0 c^2}$, where v is the velocity of a particle whose kinetic energy is E_K and rest mass is m_0. 3

9. (a) Establish the relations between the distances of cardinal point of a thick lens. 4

(b) Two convex lenses A and B of focal lengths 10 cm and 20 cm are placed 5 cm apart in air. Find the cardinal points of the optical system. 4

10. (a) Is the conservation of energy principle violated in interference ? Explain. 2

(b) How will you locate the fringe of zero order in biprism experiment ? Explain what happens when the eyepiece is moved away from the source ? 1+2

(c) In a Lloyd's mirror experiment, calculate the ratio of the intensities at the interference maxima and minima if the mirror reflects only 75% of the light incident on it. 3

11. (a) Show that the free expansion of an ideal gas occurs in a way so that the entropy change of the universe increases. 3

(b) Draw the T–S diagram of Carnot cycle and calculate its efficiency. 2+3

12. (a) What do you mean by plane polarised and circularly polarised light ? Distinguish between ordinary and extraordinary rays. How can you distinguish between

an unpolarised light and a circularly polarised light using $^{x}/_{4}$ plate and a *Nicol* prism. 2+2+2

(b) Find the state of polarisation when the x- and y-components of the electric fied are given by

$$E_x = E_0 \text{ Sin } (\omega t + k\zeta)$$
$$E_y = E_0 \text{ Cos } (\omega t + k\zeta)$$ 2

Group—C

Answer any *five* questions.

13. (a) Draw the intensity distribution in the central envelope of double slit diffraction pattern when the slit separation is four times the width of any of the two slits. 2

(b) Compare the resolving power of a grating with the resolving power of a prism in case of 'normal' - spectrum. 2

14. A cylindrical tube of radii 1 cm and 4 cm has temperatures θ_1 and θ_2 at the inner and outer surfaces respectively. Show that the temperature will be $\frac{1}{2}(\theta_1 + \theta_2)$ at a distance 2 cm from the central symmetry axis. Consider the radial heat flow equation in steady state without deriving it. 4

15. (a) Using Gibbs function, derive clapeyron's equation for first-order phase transition. 3

(b) Graphically show the temperature variation of entropy for first order phase transition. 1

16. (a) Show that a particle can be mass less, if it moves with the speed of light. 2

(b) Find the momentum of an electron whose Kinetic energy equals its rest energy of 511 kev. 2

17. What is Rayleigh's criteria of resolution ? How will you increase the resolving power of a diffraction grating ? 4

18. (a) Discuss briefly the principle of adiabatic demagnetization ? 2

(b) How is the temperature of the system related to the applied magnetic field. 2

19. Explain what is angle of polarisation ? Find angle of polarisation for a glass plate ($\mu = 1.5$) immersed in water. 2+2

20. (a) What is the origin of continual motion of the Brownian particles ? 2

(b) How is diffusion coefficient related to coefficient of viscosity ? 2

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