2022

(November)

PHYSICS

(Elective/Honours)

[PHY 03 (T)]

(Thermal Physics, Optics)

Marks : 56

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer *any* **eight** questions

1. *(a)* What are the main postulates/assumptions of the kinetic theory of gases? Which of these assumptions were modified in the van der Waals equation? 2½+1=3½

(b) 1 mole of a gas is kept in a container of volume $0{\cdot}5\ m^3$ at 0 °C. Calculate the pressure that will be exerted on the

walls of the container assuming that the gas obeys—

(i) the ideal gas equation;

(ii) van der Waals equation.

Given

$R = 8{\cdot}3\ \text{J mol}^{-1}\ \text{K}^{-1}$, $a = 0{\cdot}4\ \text{N m}^4\ \text{mol}^{-1}$

and $b = 50 \times 10^{-6}\ \text{m}^3\ \text{mol}^{-1}$

1½+2=3½

2. *(a)* State the law of equipartition of energy. Use the law to derive the ratio of specific heats γ for diatomic gases. 1+2½=3½

(b) What is meant by mean free path of gas molecules? Derive the expression for Clausius' mean free path. 1+2½=3½

3. *(a)* Derive an expression for the coefficient of thermal conductivity of a gas in terms of the r.m.s. velocity of the gas molecules. 4

(b) What are indicator diagrams? What physical quantity does the area under a *P-V* diagram represent? 1+1=2

(c) State Carnot's theorem. 1

4. *(a)* Describe the absolute zero temperature in the thermodynamic scale of temperature. Why is absolute zero not attainable? 3+1=4

(b) How is cooling achieved in a gaseous system by using adiabatic expansion? 3

5. *(a)* State and derive the Stefan-Boltzmann law. 1+4=5

(b) Derive the expression for Rayleigh-Jeans law starting from the Planck's law formula. 2

6. *(a)* Using the Fermat's principle of extremum path, derive the laws of reflection at a plane boundary. 4

(b) Show that the distance between the two principal points of a lens system is equal to the distance between its two nodal points. 3

7. *(a)* Derive the lens maker's formula for a thin lens using the matrix method. 4

(b) What is chromatic aberration? Distinguish between axial and lateral chromatic aberration. 1+2=3

8. Give the construction and working principle of a Huygen's eyepiece with the help of a neat diagram. Derive the expression for the equivalent focal length. Give any two demerits of Huygen's eyepiece. 3+2+2=7

9. *(a)* Write down the important conditions for obtaining sustained interference pattern. 2

(b) Show that the fringe at the apex of a wedge-shaped film is dark. 2

(c) With the help of a neat diagram, describe the construction of a Michelson interferometer. 3

10. *(a)* Distinguish between the Fresnel diffraction and the Fraunhofer diffraction. 2

(b) What are Fresnel's half-period zones? Derive the expression for the radius of the *n*th half-period zone. 1+2=3

(c) How is rectilinear propagation of light explained in view of the phenomenon of diffraction? 2

11. *(a)* What is circularly polarized light? Describe a method for the production of circularly polarized light. 1+3=4

(Continued)

(b) What is a half-wave plate? Calculate the thickness of a half-wave plate of quartz for a wavelength of light of 4000 Å. Take the value of the refractive indices as 1·553 and 1·554 for the extraordinary and the ordinary rays respectively. 1+2=3

12. *(a)* Describe the construction and working of a He-Ne laser. 4

(b) What is an optical fibre? Describe the basic principle behind its working. 1+2=3

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