RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College under University of Calcutta)

B.A./B.SC. FOURTH SEMESTER EXAMINATION, MAY 2012

SECOND YEAR

PHYSICS (Honours)

Paper : IV

Date : 21/05/2012

Time : 11 am – 2 pm

Full Marks : 75

[Use Separate Answer Books for each group]

Group - A

(Answer **any two** questions from Question No. 1 to 4 and **any one** from Question No. 5 and 6)

1. Which physical quantity is transported in the case of viscosity of gas? Explain the origin of viscosity of ideal gas and find an expression for the coefficient of viscosity. Explain how the coefficient of viscosity of an ideal gas depends on temperature. [1+1+6+2]

2. a) i) Derive the third Tds equation $Tds = C_V\left(\frac{\partial T}{\partial P}\right)_V dP + C_P\left(\frac{\partial T}{\partial V}\right)_P dV$.

   ii) Show that $Tds = \frac{C_V K_T}{\beta} dP + \frac{C_P}{\beta V} dV$.

   where K_T and β are isothermal compressibility and volume expansivity respectively. [3+3]

   b) Derive the relation $\left(\frac{\partial C_V}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V$ and hence prove that C_v of an ideal gas is a function of T only. [3+1]

3. a) Distinguish between first order and second order phase transition. What do you mean by metastable state? [4+1]

   b) Plot isotherms according to van der Waals equation of state and identify the critical isotherm. Show those regions of the isotherms which represent the metastable states of the substance. How far does these theoretical isotherms tally with experimental results? [2+1+2]

4. a) One end of a metal bar, thermally insulated from its surroundings, is periodically heated and cooled. Investigate the distribution of temperature along the length of the bar. [5]

   b) State and explain Kirchhoff's law. [2]

   c) A small body with temperature T and absorptivity α is placed in a large evacuated cavity whose interior walls are at a temperature T_W. When $T_W - T$ is small, show that the rate of heat transfer by radiation is $Q = 4T_W^3\ A\alpha\sigma(T_W - T)$, where A is the total area of the body. [3]

5. Using quantum picture of electromagnetic radiation, show that pressure due to diffuse radiation $P=u/3$, where u is the energy density of the radiation field. Hence show that $u = aT^4$, where T is the temperature of the radiation field and a is a constant. [2+3]

6. Find the critical constants and Boyle temperature of a real gas whose equation of state is given by: $\left(P + \frac{a}{TV^2}\right)(V - b) = RT$, where a and b are constants. [4+1]

Group - B

(Answer **any two** questions from Question No. 7 to 9 and **any one** from Question No. 10 & 11)

7. i) Give the theory of Newton's ring. [3]

   ii) In a young's double slit arrangement, if the distance between the centres of two slits is 0.6 mm and the separation between the two second order maximum of the interference pattern produced on a screen at a distance of 1.5 m from the source (slit) be 5.0 mm, find the wavelength of light used in the experiment. [4]

iii) In Michelson's interferometer, the distance traversed by the mirror between two successive disappearance of fringes is 0.289 mm (for sodium light). Calculate the difference in wavelengths of D_1 and D_2 lines. Assume $\lambda_{av} = 5890\,A^{\circ}$. [3]

8. Established the expression for intensity distribution of Fraunhofer diffraction pattern for double slit. Give an account of the missing order spectra of double slit diffraction pattern. [5+2]

A zone plate is constructed by drawing concentric circles of radii equal to those of dark Newton's ring formed by an equiconvex lens of radius of curvature $R = 2m$. Find the first focal length of the zone plate (for same λ). [3]

9. a) A plane e.m. wave with electric vector in the plane of incidence, is incident between two non conducting media. Write down the electric and magnetic field vectors for the incident, reflected and transmitted waves. Write down the boundary conditions and obtain transmittance and reflectance. [1+1+5]

b) A diffraction grating of width 3 cm is just able to resolve sodium D-lines (wavelengths 589.0 nm and 589.6 nm) in the second order. Find the number of rulings per cm. [3]

10. i) What do you mean by temporal and spatial coherence? [2]

ii) Calculate the coherence time and spectral width $\Delta\lambda$ for a quasi monochromatic light of mean wavelength 6438 A° and coherence length 30 cm. [3]

11. a) A beam of light is incident form air on a liquid of refractive index 1.5. The reflected rays are completely polarized. What is the angle of incidence of the beam? [2]

b) Calculate the thickness of a quarter-wave plate of quartz for light of wavelength 5893 A°. [Given $r.i$ of quartz for E-ray is 1.5333 and that for O-ray is 1.5442] [2]

Group - C

(Answer **any two** questions from Question No. 12 to 14 and **any one** from Question No. 15 & 16)

12. a) Explain briefly, what do you mean by time constant in a series L-R circuit with a DC source. [2]

b) Find out an expression for the growth of charge in a capacitor through a resistance in series with it having a DC source in the circuit. Draw the charging curve with time. [4]

c) In a series L-R circuit with R=20 ohm, L=0.1 Henry, when 1 amp current flows through it, the rate of increase of current is 20 amp/sec. Find out the electromotive force in the circuit. [4]

13. a) Find out the root mean square and average value of an alternative sinusoidal e.m.f. [2]

b) In a series L-C-R circuit connected with an AC source, find out the expression for instantaneous current. Obtain the velocity resonance condition. [3+2]

c) Draw also the impedance triangle in the above case and calculate the power factor when R=50 ohm, resistance of inductance of value 0.3 Henry is 2 ohm, C=40 micro farad, E(rms)=200 volt and frequency =50 hertz. [3]

14. a) What is depletion MOSFET. Sketch the basic structure of an n-channel depletion MOSFET, draw its drain transfer characteristics and explain pinch – off. [5]

b) Using h parameters, obtain the expressions for the current gain and input resistance of a small signal low frequency common emitter (CE) transistor amplifier connected to a resistive load. Find the current gain for a CE transistor amplifier connected to a load R_L = 10 KΩ, given the hybrid parameter values h_{fe} = 50 and h_{oe} = 24 μA/V. [5]

15. A full wave rectifier uses two semiconductor diodes with forward bias resistance R_f. Obtain the expression of ripple factor for the rectifier. [5]

16. A DC emf E is suddenly applied to a circuit containing a resistor R and a capacitor C in series. Assuming the charge on the capacitor to be zero at the initial time, determine the variation of potential differences across R and across C as a function of time. Plot them on the same graph and explain the graph. [5]

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