RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College under University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2014

SECOND YEAR

Date : 23/05/2014 **PHYSICS (Honours)**

Time : 11 am – 2 pm Paper : IV Full Marks : 75

[Use a Separate Answer Books for each group]

Group – A

Answer **any two** questions :

1. a) Explain the origin of viscosity and heat conduction in a gas on the basis of kinetic theory. Find out an expression of the thermal conductivity of an ideal gas. [2+6]

   b) Is the relation $K = \eta C_V$ sufficiently confirmed by experiments? Explain. [2]

2. a) Show that the energy density of black body radiation is $u = aT^4$. Assume the expression of pressure due to diffuse radiation. [4]

   b) Find out an expression of entropy of the radiation field. [2]

   c) Abbot observed the solar spectrum attains a peak value at 475·3 nm. Find the temperature of the Sun. Deduce the formula used. [1+3]

3. a) What do you mean by the inversion temperature of a gas undergoing J-T effect? Find out the inversion temperature for a gas obeying the following equation of state :

   $P(V-b) = RT\exp\left(-\frac{a}{RVT}\right)$, where a and b are constants. [1+5]

   b) The critical constants of the above gas are $P_C = \frac{a}{4b^2}e^{-2}$, $V_C = 2b$, $T_C = \frac{a}{4Rb}$. Show that equation of the inversion curve is $\pi = (8-\theta)\exp\left(\frac{5}{2}-\frac{4}{\theta}\right)$. [4]

4. a) Utilise the expression of Helmholtz free energy F(T,V), to prove the following Maxwell equation : $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$. Hence find out the expression of $\left(\frac{\partial U}{\partial V}\right)_T$. [4]

   b) Show that for van der Wall's gas $\left(\frac{\partial U}{\partial V}\right)_T = \frac{a}{V^2}$. Hence find an expression of U for the gas. Use it to find the entropy change of the gas undergoing an isobaric transformation from (P,V,T) to (P_1,V_1,T_1). Assume that C_V is constant. [2+2+2]

Answer **any one** question :

5. a) Distinguish between first order and second order phase transition. [3]

   b) Explain the behaviour of water (with the help of necessary phase diagram) which expands on freezing. [2]

6. a) Explain the difference between thermal conductivity and thermometric conductivity of a material. [2]

   b) When lead is melted at atmospheric pressure the melting point is 327°C, the density decreases from $1{\cdot}101\times10^4\ kg\,m^{-3}$ to $1{\cdot}065\times10^4\ kg\,m^{-3}$ and the latent heat is 24·5 KJ Kg^{-1}. What is the melting point at a pressure of 100 atm? [3]

Group – B

Answer **any two** question :

7. a) In the Young's experiment on the interference of light beams of wavelength λ, find the condition for producing bright and dark fringes. Assume the distance between the slits is 'd' and the

interference pattern is seen on a screen at a distance 'D' where D>>d. Show that the intensity at any point on the fringe pattern is given by $I \sim 4a^2 \cos^2 \frac{\delta}{2}$ where 'a' is the amplitude of the separate waves and δ is the phase difference of the waves superposing. [6]

b) The two slits in the Young's experiment are illuminated by two lights of wave lengths 500nm and 650 nm. If d = 2mm and D = 2m, find the separation of the 3rd order bright fringes produced by the two colours. [4]

8. a) Derive the expression for the intensity distribution produced by the Fabry-Perot interferometer. Assume the relationships between the transmission and reflection co-efficients. Show the intensity distribution pattern as a function of the phase angle 'δ' between two successive transmitted beams. Indicate the role of the reflection co-efficient in bringing about the sharpness of the fringes. [6]

b) Find the chromatic resolving power of Fabry-Revot interferometer. Assume the intensity maximum of a given order of the two waves of wavelengths λ and $\lambda + \Delta\lambda$ cross at $I = \frac{1}{2} I_{max}$. Show that $\frac{\lambda}{\Delta\lambda} = m \frac{\pi r}{1 - r^2}$ where m is the order number of the fringe and r^2 is the reflectance of the silvered surfaces. [4]

9. a) A diffraction grating is ruled with N lines spaced a distance 'd' apart. Monochromatic radiation of wavelength λ is incident normally on the grating. Radiation emerging from the grating is focussed on a screen by a converging lens. Derive an expression for the intensity distribution observed on the screen. The width of each slit is 'b' and the single slit diffraction pattern may be assumed. Find the condition for principal maxima. If white light from an incandescent source illuminates the grating, what will be the nature of the spectrum in the central and the first order? [4+1+1]

b) If the slit separation d = 3b, find what orders of interference maxima in the grating spectra will be missing. [2]

c) Express the difference in wavelengths of sodium D_1 and D_2 lines in terms of the effective width of the grating, 'x' to make the lines just resolved. [2]

10. a) Suggest any arrangement by which a left circularly polarised light can be made right circularly polarised. [3]

b) How would you combine two linear vibrations to get a circular vibration. [3]

c) Describe the state of polarization of wave represented by the following set of equations : [4]

i) $E_x = E_0 \sin(kz - wt),\ E_y = E_0 \cos(kz - wt)$

ii) $E_x = E_0 \cos(kz - wt),\ E_y = E_0 \cos\left(kz - wt + \frac{\pi}{4}\right)$

iii) $E_x = E_0 \sin(kz - wt),\ E_y = -E_0 \sin(kz - wt)$

iv) $E_x = E_0 \cos(wt + kz),\ E_y = \frac{1}{\sqrt{2}} E_0 \cos(wt + kz + \pi)$

Or,

a) A plane e.m. wave with electric vector in the plane of incidence is incident obliquely on the interface of two dielectric media. Using boundary conditions derive expressions for the Fresnel formula. [6]

b) Light is incident from air perpendicular on the sheet of crown glass having an index of reflection of 1·522. Determine reflectance and the transmittance. [2+2]

11. Answer **<u>any one</u>** question :

a) i) When an unpolarized light is incident on a reflecting plane at polarizing angle, show that reflected and transmitted waves make 90° with each other. [3]

ii) A left circular light ($\lambda = 656\,nm$) is to e converted to right circularly polarized light by passing it through a quartz retarder (n_e = 1·551 and n_0 = 1·542). Compute the minimum thickness of the retarder. [2]

b) i) Explain the terms : optic axis, positive and negative crystal. [3]

ii) Two polaroids A and B are in crossed position. A third polaroid C is placed in between them so that the pass axes of A and C make an angle 30° with each other. An unpolarized light is incident on A and passes through B. Find the intensity of light coming through B if the intensity of incident light be I_0. [2]

Group – C

Answer **any two** question :

12. a) A series LCR circuit is connected to a source of sinusoidal emf of angular frequency ω and peak value V_0.

i) Find the current in this circuit. What is phase difference between the voltage and the current? Under what condition does the voltage lead the current?

ii) Also find the relation between Q-factor and voltage magnification factor of this circuit. [4+2]

b) An A.C circuit connected to a 220V, 50 Hz supply contains a 20H coil of resistance $100\,\Omega$ connected in series with $1{\cdot}0\mu F$ capacitor. Calculate the power factor and the power consumed in the circuit. [2+2]

13. a) With neat circuit diagram, explain the operation of a full-wave rectifier with capacitor filter. Find an expression for the percentage of voltage regulation of this rectifier. [3+3]

b) If the peak rectifier voltage for full-wave rectifier with a $100\mu F$ capacitor connected to a load drawing 50mA, current, is 20V. Calculate—

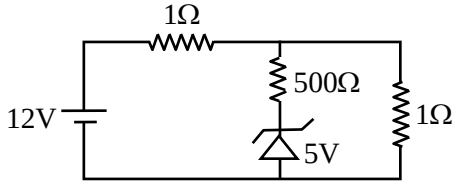
i) the nipple voltage ii) dc voltage

iii) percentage of regulation and iv) nipple factor of rectifier. [Line frequency is 50c/s] [4]

14. a) Define the stability factors of a biased transistor. Find the stability factor of a fixed bias transistor circuit. [2+3]

b) What is a Q point? How can you graphically determine it? [2]

c) In the circuit shown in figure, the zener diode has a break down voltage 5v. Find whether, the power dissipated in the zener diode exceeds the maximum power limit of 100mw specified for it. [3]



15. a) Draw a CE amplifier circuit and show its h-parameter equivalent circuit. Obtain the expressions for voltage gain, current gain and output impedance of a small signal low frequency CE amplifier connected to a resistive load. [2+4]

b) Find the current gain, voltage gain, input impedance of a CE amplifier with $R_L = 1k\Omega$ and h_{fe}= 60, h_{ie} = 1·1 kΩ, $h_{re} = 2{\cdot}5\times10^{-4}$, $h_{oe} = 24\times10^{-6}$A/V. If the resistance of the source is 1kΩ, then what will be the effect on voltage gain? [3+1]

16. Answer **any one** question :

a) What do you mean by time constant of L-R circuit? A dc emf E is suddenly applied to a circuit consisting of a resistor R and an inductor L in series. Show that total energy supplied by the emf E is equal to the sum of the energy dissipated by R and magnetic field energy stored in L. [3+2]

b) i) Define pinch off voltage, drain resistance and transconductance of a JFET.

ii) Explain how a MOSFET NOT circuit functions as an inverter. [3+2]