[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 740 **B**

Unique Paper Code : 32221204

Name of the Paper : Electricity and Magnetism

Name of the Course : **B.Sc. (Hons) Physics-CBCS**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. 1 is compulsory.
4. Answer any **four** of the remaining **six** questions.

1. Attempt **all** parts of this question :

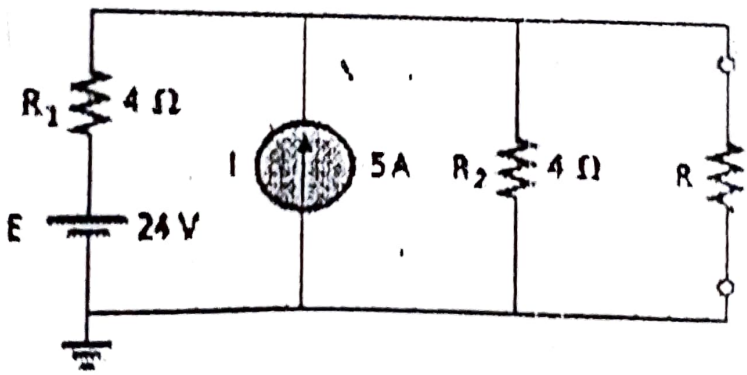
(a) The static charge distribution produces a radial electric field $\vec{E} = \frac{Ae^{-br}}{r^2}\hat{r}$ where A and b are constants. Calculate and plot the charge density distribution. What is the total charge Q? (3)

P.T.O.

(b) Determine if the vector field $A = 2s(z+1)\sin\phi\ \hat{s} + s(z+1)\cos\phi\ \hat{\phi} + s^2\sin\phi\ \hat{z}$ corresponds to an electrostatic field or a magnetic field. (3)

(c) A square coil of side 60 cm rotates about the x – axis at $\omega = 60\pi$ rad/s in a field $B = 0.8\hat{k}$ Wb/m. Find the induced voltage. (3)

(d) For the given network, find the value of R for maximum power to R, and determine the maximum power to R.



(3)

(e) In a one-dimensional device the charge density is $\rho = \rho_0 \frac{x}{x_0}$. If E = 0 at x = 0 and V = 0 at $x = x_0$, by solving the Poisson's equation find the electric potential V. (3)

(f) Show how the concept of displacement current explains the continuity of current by taking the example of a parallel-plate capacitor. (3)

(g) Define Hysteresis loss? (1)

2. (a) For a spherical charge distribution, the density is given by

$$\rho = \begin{cases} \rho_0(R^2 - r^2), & r \leq R \\ 0, & r > R \end{cases}$$

Determine the electric field E and the potential V for (a) $r \geq R$ (b) $r \leq R$. (7)

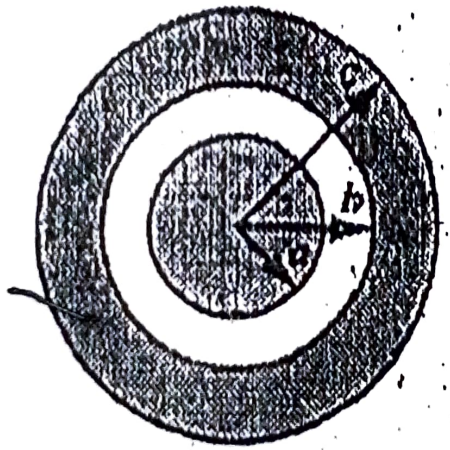
(b) An infinite uniform surface current $K = .6\hat{i}$ A/m flows over the x-y plane and a long straight wire carrying a steady current I is located along x-axis at $z = 4$ m. Determine I and its direction if $B = 0$ at (0,0,1.5) m. (7)

3. (a) A grounded metal sheet is placed in the $z = 0$ plane, while a point charge Q is located at (0, 0, a).

P.T.O.

Find the force acting on a point charge – Q placed at (a, 0, a). (7)

(b) A certain co-axial cable consists of a copper wire of radius a surrounded by a concentric copper tube of inner radius c. The space between them is partially filled (from b out to c) with a material of dielectric constant k. Find the capacitance per unit length of this cable?

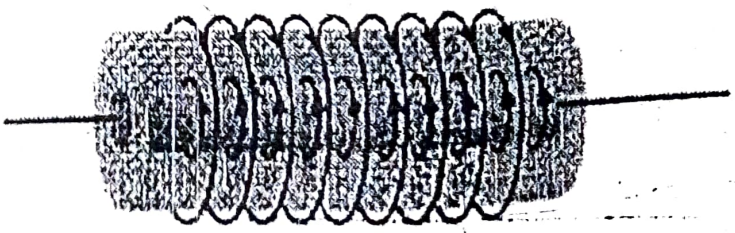


(7)

4. (a) A sphere of radius R, filled with material of dielectric constant k, have a small concentric spherical cavity of radius a. A free point charge q is placed at the center. Find the polarization vector P and bound charges σ_b and ρ_b. (7)

(b) Determine the quality factor and bandwidth for the response curve with peak current of 200 mA at its resonant frequency of 28 KHz. For capacitance C = 101.5 nF, determine the inductance L of the inductor, resistance R of the resistor and applied voltage for the series resonant circuit. (7)

5. (a) Two coaxial solenoids each carrying current I, but in opposite directions. The inner solenoid of radius a has N_1 turns per unit length and the outer of radius b has N_2 turns per unit length. Find B in each of the three regions: (i) inside the inner solenoid, (ii) between them and (iii) outside the outer solenoid.



(7)

(b) Consider a long and thin wire of radius a and made of a magnetic material with susceptibility χ_m. If the total current I is flowing in the wire such a way that the volume current density $J = kr^3 \hat{z}$ (where k is a constant, r is the distance from the axis), find H, M, and B in the region inside and outside the wire. (7)

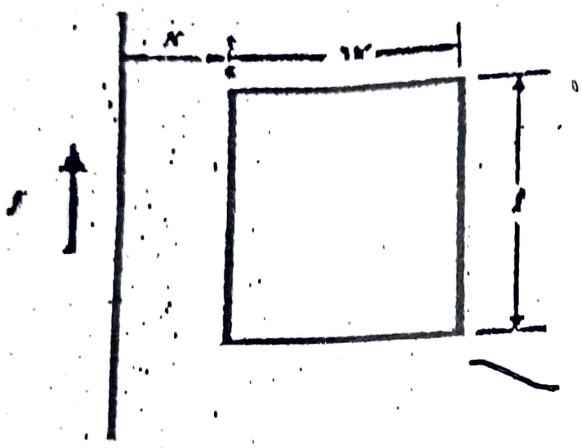
6. (a) Show that the potential of a magnetized object is given by

$$A = \frac{\mu_0}{4\pi}\int_V \frac{J_b}{r}\,d\tau + \frac{\mu_0}{4\pi}\oint_S \frac{K_b}{r}\,dS$$

where J_b and K_b are the bound volume current throughout the material and bound surface current respectively, r is the distance between the source point and the field point. (7)

(b) An infinite straight wire carries a current I is placed to the left of a rectangular loop of wire with width w and length l, as shown in the figure.

(i) Determine the magnetic flux through the rectangular loop due to current I. (ii) Compute the induced emf in the loop and the direction of the induced current for a time varying current I(t) = a + b t, where a and b are positive constants.



(7)

7. (a) A sphere of radius R carries a charge density $\rho(r) = k\left(1 - \frac{r}{R}\right)$, where k is a constant. Find the energy of the configuration. (7)

(b) Obtain the Thevenin equivalent circuit of the given circuit as shown in the figure. Draw the Norton equivalent of the Thevenin equivalent circuit.

(5)

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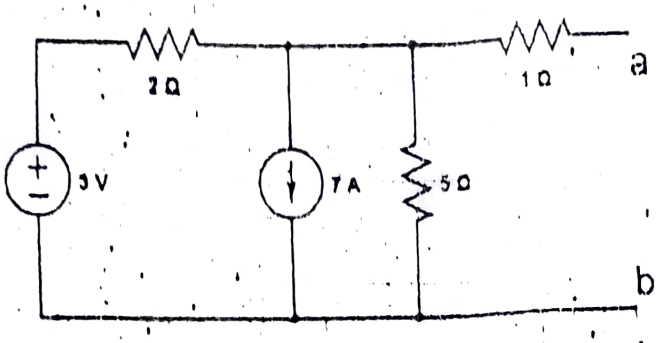

(7)

(2500)

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[This question paper contains 8 printed pages.]

Your Roll No.....

B

Sr. No. of Question Paper : 748

Unique Paper Code : 32171202

Name of the Paper : Physical Chemistry II

Name of the Course : **B.Sc. (Hons.)**

Semester : II

Duration : 3 hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Answer any **six** questions.
3. Use of calculator is allowed.

1. (a) Why ΔG is used more compared to ΔA to express the condition of spontaneity of the reaction?

(2)

(b) Give reason why reversible processes are ideal processes & cannot be carried out in practice.

(2)

P.T.O.

(c) How equilibrium constant K_p is a dimensionless quality? (2)

(d) Why it is necessary to make standard solutions in standard flasks instead of a beaker? (2)

(e) Explain Q is a path function and not a state function. (2)

(f) Predict whether the following variables are intensive or extensive :

mass, enthalpy, mole fraction, boiling point, entropy (2.5)

2. (a) A 25 g mass of ice at 273 K is added to 150 g of liquid water at 360K at constant P. What is the final state of the system? Calculate ΔS for the process. Given $\Delta H_{fus.}$ (H_2O) = 6.0095 kJ mol^{-1}, C_p (H_2O, l) = 75.29 JK^{-1} mol^{-1} & T_m (H_2O, S) = 273 K. (4)

(b) Derive the relation : (4)

$$\left(\frac{\partial V}{\partial S}\right)_T = \left(\frac{\partial T}{\partial p}\right)_V$$

(c) Show that entropy is a state function & dS is an exact differential using first law of thermodynamics. (4.5)

3. (a) Prove the Kirchhoff s relations: (4)

(i) $\Delta H_2 - \Delta H_1 = \Delta C_p(T_2 - T_1)$

(ii) $\Delta U_2 - \Delta U_1 = \Delta C_v(T_2 - T_1)$

(b) Calculate the enthalpy change for the following reactions :

(i) $C_2H_4(g) + Cl_2(g) \rightarrow C_2H_4Cl_2(g)$

(ii) $C_2H_6(g) + 2Cl_2(g) \rightarrow C_2H_2Cl_2(g) + 2HCl(g)$

Given B.E. (C-C) = 348 kJ mol^{-1}

B.E. (C=C) = 610 kJ mol^{-1}

B.E. (C–H) = 413 kJ mol^{-1}

B.E. (Cl–Cl) = 242 kJ mol^{-1}

B.E. (C–Cl) = 328 kJ mol^{-1}

B.E. (H–Cl) = 432 kJ mol^{-1} (4)

(c) Define enthalpy of neutralization. Enthalpy of neutralization of HCl by NaOH is 257.32 kJ mol^{-1} and by NH_4OH is –51.34 kJ mol^{-1}. Calculate the enthalpy of dissociation of NH_4OH. (4.5)

P.T.O.

4. (a) Prove thermodynamic equation of state :

$$\left(\frac{\partial U}{\partial V}\right)_T + p = T\left(\frac{\partial p}{\partial T}\right)_V \qquad (4)$$

(b) For an ideal gas $C_{pm} = (5/2\ R)$. Calculate the change in entropy when 3 moles of gas is heated from 300K to 600K at

(i) constant pressure

(ii) constant volume (4)

(c) Show that :

(i) $\left(\frac{\partial U}{\partial V}\right)_T = 0$ for an ideal gas.

(ii) $C_p - C_V = R$ for one mole of an ideal gas. (4.5)

5. (a) Derive Gibbs – Helmholtz equation,

$$\frac{\Delta G}{T} = \frac{\Delta H}{T} + I .$$

Where I is the constant of integration. (4)

(b) Starting from the fundamental expressions of first and second laws of thermodynamics derive the following relations :

(i) $dA = -SdT - pdV$

(ii) $dG = -SdT + Vdp$ (4)

(c) Derive Gibbs Duhem equation and prove :

$$\sum_i n_i dV_{i,pm} = 0 \qquad (4.5)$$

6. (a) (i) Show that the pressure for a gas obeying

$$\left(p + \frac{a}{V^2}\right)(V) = RT$$

is a state function. (2)

(ii) Prove that :

$$\left(\frac{\partial H}{\partial P}\right)_T = 0 \qquad (2)$$

(b) In the following reactions, involving change in number of mol, what will be the effect of increase

in pressure from external source on the equilibrium of the reactions :

$N_2O_4(s) \rightarrow 2NO_2(g)$

$2SO_2(s) + O_2(g) \rightarrow 2\ SO_3(g)$ (4)

(c) 1 mole of an ideal gas at 300K expands isothermally and reversible from an initial volume of 2 litres to a final volume of 20 litres. Calculate q, w, ΔU, ΔH, ΔS and ΔG. (4.5)

7. (a) The boiling point of chloroform was raised by 0.325K when 5.141×10^{-4} kg of anthracene was dissolved in 3.5×10^{-2} kg of chloroform. Calculate the molar mass of solute.

$K_b = 3.9$ K kg mol $^{-1}$. (4)

(b) van't Hoff factor, i, for aqueous solution of both NaCl and CH_3COOH depends on the concentration of the solution. Explain. (4)

(c) At 480K and a total pressure of 1 atmosphere, a mixture consisting of nitrogen and hydrogen in the mole ratio of 1:3 contains 16% ammonia at equilibrium. Calculate K_p for the reaction. (4.5)

8. (a) What is the Osmotic pressure at 25°C when 72.5 mL of a solution containing 4.25 grams of electrolyte $CaCl_2$ (molar mass = 111 g/mol) is prepared? (4)

(b) How much heat (in kJ) is needed to convert 100.0 grams of ice at −10°C to steam at 115°C? (4)

(c) Prove that :

(i) $TV^{\gamma-1}$ = constant

(ii) PV^{γ} = constant (4.5)

9. (a) How many grams of non-electrolyte sucrose (molar mass = 342 g/mole) must be added to 450 g of water (molar mass = 18.0 g/mole) to change its vapour pressure of 745 mm Hg at 100°C? (4)

(b) State the third law of thermodynamics. Write the expressions for the change in entropy per mole of a substance undergoing each of the phase transitions – fusion, vaporization and sublimation. (4)

P.T.O.

8

(c) Explain :

(i) Criteria for spontaneity and equilibri

(ii) Le Chatelier's principle.

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 758 **B**

Unique Paper Code : 32221202

Name of the Paper : Wave and Optics

Name of the Course : **B.Sc. (Hons) Physics CBCS**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Answer any **five** questions in all.
3. Q. No. **1** is compulsory.

1. Attempt any **five** questions. Each question carries **3** marks. (3×5=15)

(a) State and explain principle of superposition.

P.T.O.

758

(b) Two tuning forks A and B are used in an optical experiment to produce Lissajous figures. It is found that the sequence of figures repeats every 10 seconds. When fork A is loaded with a little wax, the sequence of the figures is found to repeat every 20 seconds. If the frequency of fork B is 400 Hz, determine the frequency of fork A.

(c) A parallel beam of light of wavelength 5890 A^0 is incident on a glass plate (μ=1.5) such that angle of refraction into plate is 60^0. Find the smallest thickness of the plate which will make it dark by reflection.

(d) What is the highest order of spectrum which may be seen with monochromatic light of wavelength 600 nm by means of diffraction grating with 5000 lines/cm?

(e) Explain Rayleigh's criterion of just resolution of two spectral lines of same intensities giving suitable intensity curve.

(f) Distinguish between Spatial and Temporal Coherence.

(g) How does Fraunhofer single slit diffraction pattern compare with Fresnel single slit diffraction pattern?

(h) In a biprism experiment, at a certain position of the eyepiece, the fringe width obtained is 0.2 mm. When the eyepiece is moved away by 50 cm, the fringe width becomes 0.3 mm. If the distance between two virtual sources is 0.3 cm, find the wavelength of the light used.

2. (a) What are beats? What are the necessary conditions to obtain them?

(b) Two vibrations along the same line are described by the equations

$$x_1(t) = 0.05 \cos (8\pi t)$$

$x_2(t) = 0.03 \cos (10\pi t)$

where x_1 and x_2 are in meters and t is in seconds. Derive the equation of the resultant vibration obtained by superimposing the given oscillations and hence find the beat period.

(c) Six simple harmonic oscillations each of same frequency and amplitude are superposed. The phase difference ϕ between any two consecutive oscillations is constant. If the resultant amplitude of the superposition is zero, what is the phase difference ϕ? (3+7+5)

3. (a) What are stationary waves? Write it's any two characteristics.

(b) Derive the equation that describes a standing wave and its normal modes on a string of length L fixed rigidly at ends.

(c) The equation of a stationary wave is

$$y = 6\cos\frac{\pi x}{3}\sin 60\pi t$$

Find the (i) equations of the waves constituting the stationary waves (ii) wavelength and frequencies of these waves (iii) distance between successive nodes. (3+7+5)

4. (a) Why two independent sources of light of same wavelength cannot show interference? Explain briefly.

(b) Give the theory of formation of fringes in a wedge-shaped film and hence derive an expression for the path difference and fringe width

(c) Name the four characteristics of a coherent beam of light. Discuss Stoke's treatment for reflection and refraction. (3+7+5)

5. (a) Obtain Airy's formula for transmitted light in a Fabry Perot interferometer.

(b) Show that the fringes obtained with Fabry Perot interferometer are sharper than those obtained in Michelson's interferometer.

(c) In a Newton's rings experiment the diameter of the 10^{th} dark ring in the reflected system changes from 1.4 cm to 1.27 cm when a liquid is introduced between the lens and glass plate. Calculate the refractive index of the liquid. (7+5+3)

6. (a) Obtain an expression for intensity distribution in Fraunhofer double slit diffraction pattern and hence discuss the formation of maxima and minima.

(b) How does the intensity distribution in the above pattern differ from that in the Fraunhofer

diffraction pattern due to a single slit? Illustrate with diagrams.

(c) What is the phenomenon of Missing Orders in Fraunhofer double slit diffraction?

Find the order of missing spectra in a double slit diffraction pattern where the slit width is 0.16 mm and they are separated by 0.8 mm. the screen is placed 170 cm away from the slits. (7+5+3)

7. (a) What is a zone plate and how is it constructed?

(b) Give the theory of a zone plate and show that it has multiple foci.

(c) Compare the similarity and dissimilarity between a convex lens and a zone plate. Calculate the

radius of the first and second half period elements on a zone plate behaving like a convex lens of focal length 50 cm. Given $\lambda = 5000A°$.

(3+7+5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1090 A

Unique Paper Code : 32223907

Name of the Paper : Radiation Safety

Name of the Course : B.Sc. (H) Physics, Choice Based Credit System

Semester : IV

Duration : 3 Hours Maximum Marks : 50

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. 1 is compulsory
3. All questions carry equal marks
4. Use of non-programmable scientific calculator is allowed.
5. Attempt five questions in all

1. Attempt any five of the following questions :

(i) What percentage of an original polonium sample will remain after three half-lives have passed?

P.T.O.

(ii) List three processes through which Gamma photons lose their energy during their interaction with matter.

(iii) In Compton scattering experiment, if the incident photon has a wavelength of 0.2nm and $\phi = 90°$ calculate the angle at which the recoiled electron appears.

(iv) In a Frank-Hertz experiment, an electron of energy 5.6eV passes through mercury vapours and emerges with an energy 0.7eV. What is the minimum wavelength of photons emitted by mercury atoms?

(v) Define linear stopping power. What are its typical units?

(vi) Distinguish between KERMA and CEMA.

(vii) What is the main reason for the difference in biologic effects caused by neutrons and photons?

(viii) List three nuclear techniques used in crime detection. (5 × 3 = 15)

2. (i) Explain terms mass defect and binding energy. Calculate the binding energy per nucleon of ^4He.

The masses are $m(^4He)=4.002602u$, $m_p=1.007825u$ and $m_n=1.008665u$. (7)

(ii) Explain the kinematics of nuclear reactions. (8)

3. (i) Blue light shines on the metal surface and causes photoemission of electrons. If a stopping potential of 2.6V is required to completely prevent electrons from reaching the collector, determine the maximum kinetic energy of the electrons. Express your answer in units of joules and electron volts. (9)

(ii) Derive an expression for threshold wavelength for pair production. (6)

4. (i) Discuss the interaction of neutrons with matter and explain the function of a moderator in a nuclear reactor. (9)

(ii) Explain the terms mass stopping power, range and straggling. (6)

5. (i) What is ionization and how can it be used as a means of measuring radiation? (7)

P.T.O.

(ii) Briefly discuss the working of neutron detectors. (8)

6. (i) Briefly discuss the concept and working principle of proportional counters. (7)

(ii) Explain the working principle of thermo-luminescent dosimetry. (8)

7. (i) Give a brief account of Accelerator driven Sub-critical system (ADS) for waste management. (8)

(ii) Briefly discuss application of nuclear techniques in MRI and the field of crime detection. (7)

8. Write short notes on any three of the following :

(a) Nuclear Spin

(b) Solid State Detectors

(c) Annual Limit of Intake (ALI) and Derived Air Concentration (DAC)

(d) Cherenkov radiation

(e) International Commission on Radiological Protection (5,5,5)

[This question paper contains 8 printed pages.]

Your Roll No.....

A

Sr. No. of Question Paper : 1397

Unique Paper Code : 32221403

Name of the Paper : Analog Systems and Applications

Name of the Course : **B.Sc. (Hons) Physics**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

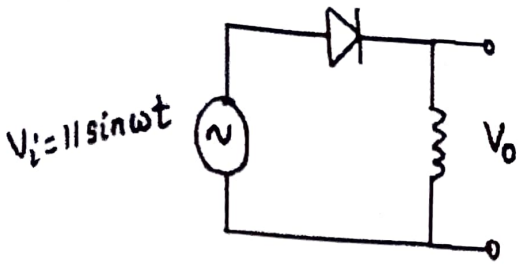
1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** is compulsory.
3. Attempt any **four** questions from the remaining **five** questions.
4. Non-programmable calculators are allowed.

1. Attempt any **five** of the following : (3×5=15)

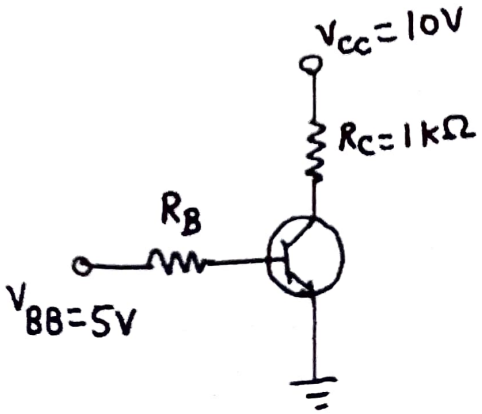
(a) Find the conductivity of an intrinsic silicon at 300K. Mobility of electrons $\mu_n = 1350\ cm^2/V\text{-}s$ and that of holes $\mu_p = 480\ cm^2/V\text{-}s$. Intrinsic concentrations of electrons and holes $n_i = 1.5 \times 10^{10} cm^{-3}$.

P.T.O.

(b) The output of the circuit given below is connected to the dc voltmeter. What is the reading on it? (Assume ideal diode).



(c) The transistor of the figure given below is specified to have β in the range 100 to 300. Find the value of R_B that results in saturation with an overdrive factor of at least 10. Assume $V_{CEsat} = 0.2V$ and $V_{BE} = 0.7V$.



(d) Design a differentiator to differentiate an input signal that varies in frequency from 10Hz to 1KHz, using op-amp.

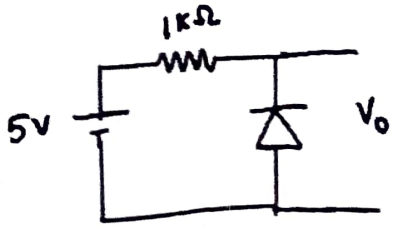
(e) Draw a circuit diagram of a 4-bit R-2R ladder type DAC and calculate its percentage resolution.

(f) Define slew rate and discuss why a high slew rate of an op-amp is desirable.

(g) Draw I-V characteristics of a Tunnel diode.

2. (a) A and B are two semiconductor materials. They have a band gap of 1.1 eV and 1.9 eV respectively. Which of these can be used for LED production? Support your answer by evaluating the wavelength of radiations emitted on recombination of electrons and holes in the two cases. Planck's constant $h = 6.626 \times 10^{-34}$ J s.

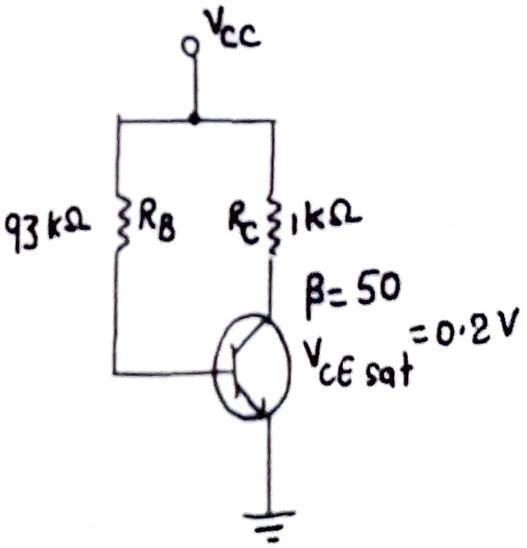
(b) For the circuit given below determine the voltage across the diode and the current flowing through it. Assume an ideal diode.



(c) Photodiodes and solar cells are both photovoltaic. What is the difference between the two?

(d) Explain Zener breakdown and discuss the main applications of Zener diode. (5,2,3,5)

3. (a) For the circuit given below, draw the load line and determine whether the transistor in the figure is in the active region or saturation region. What significant change will happen if the transistor is replaced by the one with double the value of β. (V_{CC}=10V, V_{BE}=0.7V and V_{CEsat}=0.2V).



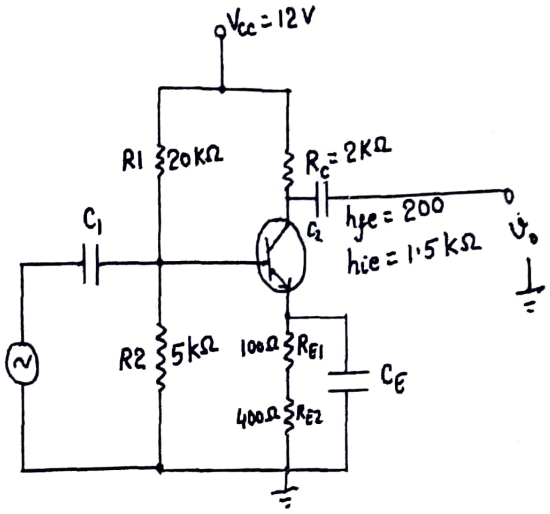
(b) In the circuit given below, evaluate :

(i) the operating point (V_{CE}, I_C)

(ii) mid frequency voltage gain

(iii) mid frequency voltage gain when bypass capacitor C_E is removed

(iv) mid frequency voltage gain when C_E is connected parallel to R_{E2}.



(5,10)

4. (a) Derive an expression for the frequency of oscillations and the condition for sustained oscillations for phase shift oscillator constructed using BJT.

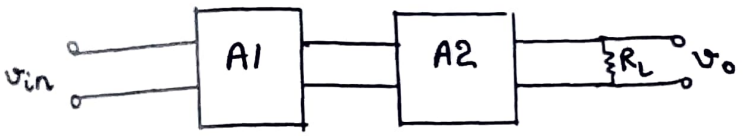
(b) A cascade connection of two voltage amplifiers A1 and A2 is shown in the figure given below. R_L=1kΩ. The open loop gain A_{V0}, input resistance

R_{IN} and output resistance R_0 for A1 and A2 are as follows:

A1: A_{V0}=10; R_{IN}=10 kΩ; R_0=1kΩ

A2: A_{V0}=5; R_{IN}=5 kΩ; R_0=200Ω.

What is the overall voltage gain?



(10,5)

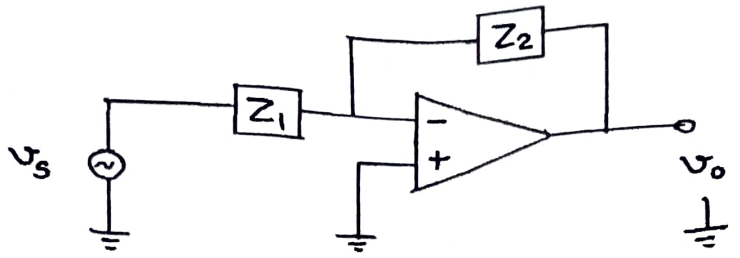
5. (a) The differential voltage gain and the common mode voltage gain of an operational amplifier are 100 dB and 2dB respectively. Calculate its CMRR. Why is it desirable to have high CMRR for an op-amp?

(b) Draw the frequency response of the gain for the circuit given below when:

(i) Z_1 and Z_2 are both resistors.

(ii) Z_1 is a resistor and Z_2 is a capacitor.

(iii) Z_1 is a capacitor and Z_2 is a resistor.



(c) Draw the circuit diagram of a basic integrator. Derive the expression for the output voltage. Discuss the problems associated with it. Also draw the circuit diagram of the practical integrator circuit that can integrate in the desired frequency range and rectify the problems associated with the basic circuit. (2,6,7)

6. (a) A silicon sample is doped with 10^{17} As atoms/ cm^3. What is the equilibrium hole concentration p_0 at 300K? (The intrinsic electron and hole concentrations for silicon is $n_i = 1.5 \times 10^{10} cm^{-3}$).

(b) Calculate ripple factor and efficiency of a full wave rectifier. What is the PIV of a bridge rectifier?

(c) An op-amp is used as a zero-crossing detector. The maximum output available from the op-amp is

+12V & -12V and the slew rate of the op-amp is 12V/ps. What is the maximum frequency of the input signal that can be applied without causing distortion in the output?

(d) What will be the output of a comparator circuit if the inverting input terminal of the op-amp is connected to the ground and a sinusoidal voltage is applied to the non-inverting input terminal.

(3,7,3,2)

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This question paper contains three pages. Your Roll No.....

Name of the Department	:	**Physics**
Name of the Course	:	**B.Sc. (Hons.) Physics**
Name of the Paper	:	**Mathematical Physics-III**
Semester	:	**IV**
Unique Paper Code	:	**32221401**
Question Paper Set number	:	**Set A**

Duration: 3 hours Maximum Marks :75

Attempt five questions in all. Question No. 1 is compulsory.

1. Attempt any five parts: (5X3=15)

   a. Find the complex solution of the equation $e^w = 1 + i$.

   b. Verify that the function $u(x, y) = x^3 - 3xy^2 - 5y$ is harmonic in the entire complex plane. Find the harmonic conjugate of $u(x, y)$.

   c. Evaluate $\oint_C z\, dz$, where C is a circle defined by $x = \cos t$, $y = \sin t$, $0 \leq t \leq 2\pi$.

   d. Expand the function

   $$f(z) = \frac{1}{z(z-1)}$$

   in a Laurent series valid for the annular domain $1 < |z|$.

   e. Prove that $\Gamma(1/2) = \sqrt{\pi}$, using Laplace Transforms.

   f. Find the Fourier Transform of $\sin\theta$ in terms of Dirac delta function.

   g. Find Fourier *sine* transform of $f(x) = e^{-mx}$.

   h. Prove that $x\,\delta'(x) = -\delta(x)$.

2. (a) Find the singularities of following functions (8)

   $$(i)\ \frac{\sin\sqrt{z}}{\sqrt{z}} \qquad (ii)\ \frac{\ln(z+3i)}{z^2}.$$

   (b) Evaluate (7)

   $$\oint_C \frac{e^{zt}}{(z^2+1)^2}\, dz \quad \text{where } t > 0 \text{ and } C: |z| = 3.$$

3 (a) Expand (7)

$$f(z) = \frac{1}{(z-1)(z-2)} \quad \text{for} \quad 1 < |z| < 2.$$

(b) Find the indicated roots of the given complex number $(-2\sqrt{3} - 2i)^{1/4}$. (8)

4 (a) Let $f(z)$ be analytic in a region R bounded by two simple closed curves C_1 and C_2 and also on C_1 and C_2 (C_2 lies within C_1), prove that (7)

$$\oint_{C_1} f(z)\, dz = \oint_{C_2} f(z)\, dz,$$

where C_1 and C_2 both traversed in the positive sense relative to their interiors.

(b) Evaluate the line integral (8)

$$\int_{1-i}^{2+i} (2x + iy + 1)\, dz$$

along (i) $x = t + 1$ and $y = 2t^2 - 1$; (ii) the straight line joining $1 - i$ and $2 + i$.

5. Using Contour Integration, solve any *two* of the followings: (7.5X2=15)

(a) $\displaystyle\int_{-\infty}^{\infty} \frac{x^2}{(x^2+1)(x^2+4)}\, dx$. (b) $\displaystyle\int_0^{2\pi} \frac{4}{5 + 4\sin\theta}\, d\theta$

(c) $\displaystyle\int_0^{\infty} \frac{\cos 3x}{(x^2+1)(x^2+4)}\, dx$. (d) $\displaystyle\int_0^{\infty} \frac{\sin mx}{x}\, dx$

6 (a) State and prove the Convolution theorem for Laplace Transform. (8)

(b) Evaluate the integral using Laplace transform (7)

$$\int_0^{\infty} \frac{e^{-t} - e^{-4t}}{t}\, dt.$$

7 (a) Plot the given function $f(t)$ with period p and find its Laplace transform (10)

$$f(t) = \frac{kt}{p} \qquad \text{where } k = \text{constant and } 0 < t < p.$$

(b) Obtain the Fourier transform of the derivative of function $f(x)$, where $f(x) \to 0$ as $x \to \pm\infty$. (5)

8 (a) Solve for $f(x)$ from the Fourier *cosine* transform (8)

$$\int_0^\infty f(x)\cos\omega x\ dx = e^{-\omega}$$

(b) A piece-wise continuous function in every finite interval and absolutely integrable on the x- axis, is given as (7)

$$f(x) = \int_0^\infty [A(\omega)\cos\omega x + B(\omega)\sin\omega x dx]$$

where

$$A(\omega) = \frac{1}{\pi}\int_{-\infty}^{\infty} f(\nu)\cos\omega\nu d\nu$$

$$B(\omega) = \frac{1}{\pi}\int_{-\infty}^{\infty} f(\nu)\sin\omega\nu d\nu.$$

Obtain the Complex Fourier Integral for $f(x)$.

8

[This question paper contains 6 printed pages.]

Your Roll No. .....

Sr. No. of Question Paper : 1361 A

Unique Paper Code : 32221602

Name of the Paper : Department of Physics & Astrophysics

Name of the Course : **B.Sc. (Hons) Physics – CBCS**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **four** questions in all.
3. **All** questions carry equal marks.
4. Non-programmable Scientific calculators are allowed.

1. (a) Given a system of 5 weakly interacting distinguishable particles which can occupy any of the three energy levels of energy 0, ε, and 2ε. Let the total energy of the system be 5ε. Write

P.T.O.

all possible macrostates and their corresponding number of microstates. Find the entropy of this system.

(b) Consider equal amount of two identical ideal gases at the same temperature T but at different pressure P_1 and P_2 in two different containers of volume V_1 and V_2 respectively which are joined by the partition. Starting with Sackur-Tetrode relation, prove that If gases are allowed to mix each other by removing the partition between them, the change in the entropy is given by :

$$\Delta S = Nk \ln [(P_1 + P_2)^2 / (4 P_1 P_2)]$$

where N denotes the number of atoms in each container. Assume that the temperature remain the same after mixing of the ideal gases.

(c) The partition function, Z (V, T), for some physical system is given as:

$$Z(V, T) = \exp[(8\pi^5 k^3 V T^3) / (45 h^3 c^3)]$$

where the symbols have their usual meaning. Calculate the internal energy and pressure for such system. (6.75,6.6)

2. Consider an isolated system of N distinguishable particles. Each particle can occupy only one of two energy levels of energy ε_1 and ε_2 (where $\varepsilon_1 < \varepsilon_2$). Particles are distributed in such a way that n_2 particles resides in energy level ε_2 and n_1 particles are present in level of energy ε_1. (Assume N is very large and $N = n_1 + n_2$)

(a) Find the entropy and energy of this system. Show that entropy of such system is maximum when n2 = N/2.

(b) Find the maximum and minimum value of the entropy.

(c) Obtain the general expression of temperature for the above mentioned isolated system and explain how is it possible to attain negative temperature in it. (6,75,6,6)

3. (a) Consider a spherical enclosure whose wall are moving outward with speed v ($v << c$) and are perfectly reflecting. Suppose that an electromagnetic wave of wavelength λ incident at an angle 0 to the normal on the wall. Show that

change in the wavelength after one reflection during adiabatic expansion of blackbody radiation is $d\lambda = (2v\lambda/c)\cos\theta$.

(where c is velocity of light)

(b) Obtain the value of Wien's constant by using the Planck's radiation formula.

(c) A radiating cavity has the maximum of its radiating power per unit area at $(\lambda_1)_{max} = 24\ \mu m$ at temperature T_1. Now the temperature of the cavity is changed to T_2 such that total power radiated per unit area by the cavity is 81 times higher than its previous value. Calculate the wavelength $(\lambda_2)_{max}$ where the maximum emission of radiation occur. (6.75,6,6)

4. (a) At what temperature would you expect a trapped gas of hydrogen atoms with peak density 1.8×10^{14} atoms/cm^3 to show the signs of Bose- Einstein Condensation.

(Given $m_H = 1.66 \times 10^{-27}$ kg)

If the number density of bosons become 8 times of its previous value, find the change in the condensation temperature.

(b) Consider a photon gas enclosed in a Volume V. The photons are in equilibrium at temperature T. The average number of photons in equilibrium is given as $N = \gamma V^{\alpha} T^{\beta}$. Obtain the value of constants α, β and γ.

(c) Plot the pressure of strongly degenerate bosons with temperature. Show explicitly the $T < Tc$ and $T > Tc$ regions in the graph. Compare it with classical gas. (6.75,6,6)

5. (a) Calculate the internal energy possessed by the non-relativistic and strongly degenerate ($T < T_F$) electrons moving in 3-dimensions.

(b) Derive an expression for Fermi velocity of electrons at $T = 0$ K and hence show that the de Broglie wavelength associated with the electrons is given by

$$\lambda_{dB} = 2\ (\pi/3n)^{1/3}$$

where n is the number density (N/V) of the electron gas.

(c) Prove that for a system consisting of fermions at temperature T ($T << T_F$), the probability that a filled state ΔE lying above Fermi level is the same as the probability of an empty state ΔE lying below the Fermi level. (6.75.6.6)

Useful constants and Integrals :

$h = 6.6 \times 10^{-23}$ Js

$k_B = 1.38 \times 10^{-23}$ J/K

$c = 3 \times 10^8$ m/s

$\int_0^\infty x^2/(e^x - 1)\, dx = 2.404$

[This question paper contains 4 printed pages.]

Your Roll No.....

B

Sr. No. of Question Paper : 770

Unique Paper Code : 42221201

Name of the Paper : Electricity, Magnetism and EMT

Name of the Course : **B.Sc. (Prog.) – CBCS**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory. Attempt **four** questions from rest of the paper.
4. **All** questions carry equal marks.

1. Answer any **five** of the following : (5×3=15)

(a) Determine the constant a so that the vector

$$\vec{V} = (x + 3y)\,\hat{i} + (y - 2z)\,\hat{j} + (x + az)\,\hat{k}$$

is solenoidal.

P.T.O.

(b) Prove that electrostatic field is conservative in nature.

(c) Assuming the earth be a spherical conductor of radius 6400km. Calculate its capacitance.

(d) Explain the physical significance of $\nabla . B = 0$. What type of vector is B?

(e) Differentiate between diamagnetic and paramagnetic materials (mention any two points). Give one example of each.

(f) A current of 2A flowing through a coil is cut-off completely in 0.2 sec. Calculate the e.m.f. induced in the coil if it has a self-induction of 0.06 H.

(g) What is Displacement current?

2. (a) Show that the vector field $\vec{V} = (x^2+xy^2)\,\hat{i} + (y^2+x^2y)\,\hat{j}$ is conservative and find the scalar potential Φ such that field $\vec{V} = \vec{\nabla}\Phi$. (9)

(b) Find the unit vector normal to the surface $x^2 - 8y^2 + z^2 = 0$ at the point (8, 1, 4). (6)

3. (a) What is dipole moment? Show that the electric field due to a dipole at a point on its axis is twice as strong as that at a point at the same distance along the perpendicular axis. (8)

(b) Derive an expression for the capacitance of a cylindrical capacitor with inner radius a, and outer radius b assuming the length of the capacitor $l >> b$. (7)

4. (a) Using Ampere's circuital law, find the magnetic field due to a current, I carrying long cylindrical_wire of radius R at a point distant r from the axis of the cylindrical wire for r>R and r<R. (8)

(b) Define magnetic susceptibility and magnetic permeability and hence derive the relation $\mu + \mu 0 (1+\chi)$. (7)

5. (a) Explain the phenomenon of self-inductance. Obtain the expression for self - inductance of a long straight solenoid having N turns per unit length and volume V. (8)

(b) A solenoid having an air core and 12 cm long has 120 turns and its area of cross-section is 6 cm^2. Find the self-inductance of the solenoid. (7)

P.T.O.

6. (a) Derive wave equations involving electromagnetic fields $\vec{E}$ and $\vec{H}$ in free space. Show that in free space, the electromagnetic waves travel with the speed of light. (8)

(b) Show that electromagnetic waves are transverse in nature and also establish the relationship between electric and magnetic field of the electromagnetic wave. (7)

7. Write short notes on (any **two**) : (15)

(i) Magnetic vector potential

(ii) Maxwell's equations

(iii) Gauss law in electrostatics

Physical Constants :

$\varepsilon_0 = 8.854 \times 10^{-12} C^2/Nm^2$

$\mu_0 = 4\pi \times 10^{-7}\ Wb/Am$

$e = 1.6 \times 10^{-19} C$

$c = 3 \times 10^8$ m/s

[This question paper contains 4 printed pages.]

Your Roll No.....

A

Sr. No. of Question Paper : 1622

Unique Paper Code : 42224412

Name of the Paper : Waves and Optics

Name of the Course : **B.Sc. Prog. – CBCS–Core**

Semester : VI

Duration : 3.5 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question no. **1** is compulsory.

1. Attempt any **FIVE** parts from the following :

   (a) The time period of tuning fork is $\frac{1}{256}$ and it produces 4 beats/second, when sounded with another fork. Calculate the frequency of the second fork.

P.T.O.

(b) If the phase velocity is given by, $v_p = \left(\frac{2\pi S}{\rho\lambda}\right)^{1/2}$

(Here, S and ρ are constant), then derive the relation between group velocity and phase velocity.

(c) Give three differences between travelling waves and stationary waves.

(d) Explain why the reverberation time is larger for an empty hall than for a crowded hall.

(e) What do you understand by wave front? Name one experiment each, which is based on division of wave front.

(f) Why do thin films appear colored in white light?

(g) How many orders will be visible if the wavelength of incident radiation is 4800 Å and the number of lines on a diffraction grating is 2500 per inch.

(5×3=15)

2. (a) What are Lissajous Figures? For the cases mentioned below, give the graphical as well as analytical representation of the Lissajous Figures

(with direction) for the motion of a particle which is subjected to two perpendicular simple harmonic motions given by,

$$x = 3 \cos(\omega t)$$

$$y = 2 \cos(2\omega t + \alpha), \text{ where } \alpha = 0$$

(b) Prove that the principle of superposition holds only for linear homogenous differential equation.

(10+5=15)

3. (a) Explain the formation of standing waves on a stretched string.

(b) For a stationary wave, the displacement (in cm) is given by,

$$y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$$

What is the distance between a node and the next anti-node?

(10+5=15)

4. (a) What do you mean by Fresnel's half period zones? What are the radii of zones of a zone plate?

(b) Explain with the help of a diagram, the intensity distribution due to diffraction at a straight edge.

(7+8=15)

5. (a) State the principle of reversibility of light. Determine the Stokes' relation for reflection of light from an optically denser medium.

(b) Discuss the theory of interference due to two slits and find the expression for fringe width. (5+10=15)

6. (a) Derive the expression for intensity distribution in case of Fraunhofer diffraction due to single slit.

(b) Show that the relative intensities of the successive maxim are in the ratio of,

$$1 : \left(\frac{2}{3\pi}\right)^2 : \left(\frac{2}{5\pi}\right)^2 \ldots$$ (10+5=15)

7. (a) Show that electromagnetic waves are transverse in nature.

(b) Explain any two methods of polarizing an un-polarized beam of light. (9+6=15)

[This question paper contains 6 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1670 **A**

Unique Paper Code : 42227637

Name of the Paper : DSE: Solid State Physics

Name of the Course : **CBCS: B.Sc. (Prog.) – DSE**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Answer **five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non-programmable scientific calculator is allowed.

1. Attempt any **five** : (3×5)

   (a) Mention the lattice type and bases in CsCl structure with diagram.

P.T.O.

(b) Obtain the Miller indices of a plane which makes an intercepts at a/2, b/2 and 3c along the primitive axes of the simple cubic unit cell. Draw a neat diagram of the plane.

(c) Determine the number of normal modes of vibration in a linear mono-atomic lattice of finite length in first Brillouin zone.

(d) Describe low temperature behavior of Einstein's theory of specific heat of solids.

(e) Calculate the Hall Coefficient when number of holes in a semiconductor is 10^{20} m^{-3}. Given that $e = 1.6 \times 10^{-19}$ coulomb.

(f) Distinguish between dia, para and ferro-magnetic materials on the basis of magnetic susceptibility.

(g) Discuss the variation of polarizability with frequency.

(h) Differentiate a superconductor with a perfect conductor.

2. (a) Mention the names of seven crystal systems in three dimensions with fourteen Bravais lattices included in them. Mention the unit cell characteristics of each system. (10)

(b) For a bee lattice, determine the diffraction angle for 1st order diffraction maximum from the (220) set of planes with interplanar spacing 1.013 Å with monochromatic X- rays of wavelength 1.790 Å. (5)

3. (a) Discuss the importance of reciprocal lattice space in understanding the structure of a crystal. (5)

(b) Prove that the reciprocal lattice vector $\vec{G}_{hkl}$ is perpendicular to the crystal plane (hkl) of a cubic crystal and that the interplanar spacing d_{hkl} is given as

$$d_{hkl} = \frac{2\pi}{|\vec{G}_{hkl}|}$$ (5)

(c) A direct lattice has the following primitive translation vectors: $\vec{a} = 2(i + j)$, $\vec{b} = 2(j + k)$, $\vec{c} = 2(k + i)$. Find out the reciprocal lattice vectors and type of lattice. (5)

4. The dispersion relation for the vibrational modes of diatomic linear lattice having masses m and M(m < M) is

$$\omega^4 - 2\alpha\left(\frac{1}{M}+\frac{1}{m}\right)\omega^2 + \frac{4\alpha^2}{mM}\sin^2 Ka = 0$$

where the symbols have their usual meanings.

(a) Obtain expressions for acoustical and optical curves. Draw the dispersion curves. (4,2)

(b) Explain its behaviors observed in acoustical and optical branches when

(i) m becomes equal to M.

(ii) m reduces to zero.

(iii) M increases to infinity. (2,2,2)

(c) Determine the smallest possible wavelength allowed by this diatomic lattice in the first Brillouin zone. (3)

5. (a) Describe qualitatively the Einstein's theory of specific heat of solids. Describe its shortcomings. (5,2)

(b) Describe how Debye improved the Einstein's theory? Discuss qualitatively Debye's theory of specific heat. (6)

(c) The Debye temperature for Aluminum is 418 K. Calculate the frequency of the highest possible lattice vibration in Aluminum. (2)

6. (a) Describe in detail n- type and p- type semiconductors. (6)

(b) Define conductivity and mobility. Obtain expressions for conductivity and mobility for a highly doped n-type semiconductor. (6)

(c) What will be the mobility of electrons in Cu if it has 9×10^{28} valence electrons per cubic meter and its conductivity is 6×10^{7} ohm ^{1}meter^{-1}? (3)

7. (a) Describe Langevin theory of paramagnetism and hence, obtain expression of magnetic susceptibility. (10)

(b) Assuming the existence of Weiss molecular field, obtain modified expression of magnetic susceptibility for a paramagnetic substance. (5)

8. (a) Obtain an expression for the local electric field at an atom in a dielectric medium. (8)

(b) Explain Meissner effect in superconductors.

(c) For a given specimen of a superconductor, th
critical fields are 1.4×10^5 A/m and 4.2 × 10
A/m respectively for 14K and 13 K. What will be
the critical field at 4.2 K?