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[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 3007

Unique Paper Code : 32221402

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. Hons Physics Core**
Repeat Paper

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. Attempt **five** questions in all.
3. **Q1** is compulsory.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.

1. Attempt any five questions : (3×5=15)

(a) Find the minimum energy of an electron confined in a one-dimensional box of size 10 nm.

P.T.O.

- (b) What is the number of photons that strike a surface of 1cm^2 in one second if the incoming light of 650nm wavelength has an intensity of 100 watts/m^2 ?
- (c) What are spontaneous and stimulated emissions? Why stimulated emission is necessary for lasing action?
- (d) The wavefunction associated with a particle is given as $\psi(x) = A \cos\left(\frac{n\pi x}{L}\right)$ in region $0 \leq x \leq L$. Find the value of normalization constant A .
- (e) The position and momentum of a 1 KeV electron are simultaneously measured, if the position is located within 0.1 nm , what is the percentage of uncertainty in momentum?
- (f) The binding energy of $^{24}\text{Mg}_{12}$ is 198.28 MeV . Find its atomic mass, (take mass of neutron to be $1.674 \times 10^{-27}\text{kg}$ and mass of proton to be $1.672 \times 10^{-27}\text{kg}$)
- (g) The half-life of ^{24}Na is 15 hours . How long will it take for 70% of sample of this nuclide to decay?
2. (a) What is photoelectric effect? Discuss the observations of the experiment illustrating photoelectric effect. How does the classical electromagnetic theory fail to explain these results?

- (b) If blue light of wavelength 460 nm impinges on a metal surface, a stopping potential of 1.1 eV is obtained. What will be the work function of the given metal? (10,5)
3. (a) State Heisenberg's uncertainty principle for position and momentum and illustrate it using gamma ray microscope thought experiment.
- (b) A photon is emitted in a process characterized by a time interval of 1.0 millisecond. What will be the inherent uncertainty in the energy and frequency of the emitted photon. (7,8)
4. (a) Obtain the time independent Schrodinger's wave equation from the time dependent Schrodinger equation.
- (b) Prove the relation $\partial P / \partial t + \nabla \cdot J = 0$, where J is the probability current density and P is the probability density. Give the physical interpretation of the equation. What are the states called for which $\nabla \cdot J = 0$. (5,10)
5. (a) A particle of mass m is confined in a one dimensional infinitely rigid box having potential

$$V(x) = \begin{cases} \infty & x < -a/2 \\ 0 & -a/2 \leq x \leq a/2 \\ \infty & x > a/2 \end{cases}$$

Find the wave function associated with the particle and its energy E .

- (b) What are quantum dot particles? How are they related with quantum mechanics? (10,5)
6. (a) On the basis of the liquid drop model of a nucleus, explain the various terms of semi-empirical mass formula for calculation of binding energy of a nucleus.
- (b) Gold $^{197}_{79}\text{Au}$ is the most ductile metal. Calculate its average radius, nuclear volume and nuclear density. (10,5)
7. (a) Discuss the variation of binding energy per nucleon with mass number, A , and hence explain the concept of (i) nuclear stability, (ii) nuclear fission, and (iii) nuclear fusion.
- (b) Consider the following decay process:



Determine the kinetic energies of the α -particles and the daughter nuclei. (10,5)

(23)

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[This question paper contains 8 printed pages.]

Your Roll No.

Sr. No. of Question Paper : 4104

Unique Paper Code : 2222012402

Name of the Paper : Solid State Physics

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

Semester : IV

Duration : 3 Hours

Maximum Marks : 90



Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** question in all.
3. Each question carry **18** marks.
4. Question No. 1 is compulsory and each part carries 3 marks.
5. Use of non-programmable scientific calculators is allowed.

P.T.O.

1. (a) Why lower branch of the dispersion curve for a linear diatomic crystal is called acoustic branch, even though the frequency associated with it is in IR (Infra-red) region?
- (b) Calculate the Hall voltage in a sample when the magnetic field of 1 Tesla is applied perpendicular to the current direction. The injected current is 300 mA and thickness of the sample is 0.4 mm. The charge carrier concentration in the sample is 10^{21} m^{-3} .
- (c) In CsCl, the Cs atoms are located at the corners of a cube and Cl at the body centre. What is the Bravais lattice for this material? Draw the Bravais lattice and identify the basis/motiff.
- (d) X-rays of wavelength $0.3 \text{ \AA}$ are allowed to fall on a crystal whose interplanar spacing for a particular set of planes is $3 \text{ \AA}$. Determine the smallest angle at which the X-rays are diffracted by the crystal.

- (e) Describe the characteristic properties of ferroelectric crystals and which symmetry element is missing in these types of crystals.
- (f) Explain the concept of the orbital magnetic dipole moment of an electron in an atom and derive an expression for it in terms of angular momentum of the electron.
2. (a) If 'a' is the lattice constant of a cubic unit cell, draw the planes which makes an intercept, in terms of 'a', along the coordinate axis as
- (i) $1/2, 1/3, \infty$
 - (ii) $-1/2, \infty, \infty$
 - (iii) What does $\langle 100 \rangle$ and $[100]$ signifies?

(5)

- (b) Silver crystallizes in fcc structure and every silver atom gives one electron to the crystal. If the interplanar separation is $2.87 \text{ \AA}$, determine density and electron concentration in it. Atomic weight of silver is 107.68 amu. (5)
- (c) Draw a square reciprocal lattice and explain the Ewald's construction and its significance? Derive vector form of the Bragg's law from the construction and explain its physical significance. (8)
3. (a) State Bloch's theorem. What is the idea behind Writing the electron wave-function as Bloch function? What are the assumptions of Kronig-Penney model? Show that for one dimensional crystal having finite length L with N number of primitive unit cells of lattice constant ' a ', the total number of allowed k -values in the first Brillouin zone is equal to the number of unit cells. (9)

(b) Discuss Meissner effect and distinguish between Type I and Type II Superconductors. (6)

(c) Calculate the effective mass of an electron near the top of the valence band in potassium crystal. The E-K relationship for the crystal is

$$E(k) = 2 - 8 \cos\left(\frac{ka}{2}\right) \text{ and lattice constant is } 5.328 \text{ \AA}. \quad (3)$$

(a) Derive an expression for the dispersion relation of a linear monoatomic crystal. The mass of the atoms is 'm' and force constant between them is 'c'. Sketch the dispersion curve within the first Brillouin zone and explain the various characteristics of the crystal dynamics. (9)

(b) Estimate the Debye temperature of Gold if its atomic weight is 197 amu, density is $1.9 \times 10^4 \text{ Kg/m}^3$ and the sound velocity in it is 2100 ms^{-1} . (5)

- (c) Determine the critical field required to destroy superconductivity at 5K in Pb whose T_c is 7.19 K and $H_c(0) = 0.0803$ T. (4)

5. (a) What is local electric field of an atom? Deduce the Lorentz relation for E_{local} inside a dielectric. (9)

- (b) Give a schematic sketch of the variation of the total polarizability of a dielectric material as a function of frequency, explaining the physical origin of the various contributions and the relative frequency ranges. (6)

- (c) A potential 12V is applied across the plates of a parallel plate capacitor having an area $6.45 \times 10^{-4} \text{m}^2$ and a plate separation of $2 \times 10^{-3} \text{m}$. If a material having a dielectric constant 5.0 is positioned within the region between the plates, compute the polarization. (3)

6. (a) Describe the classical theory of diamagnetism.

Explain the concept of Larmour precession. Derive the expression of the Larmor frequency. (9)

(b) What are ferromagnetic domains? Using the concept of domains, explain the B-H hysteresis curve. What does the area under the curve signify?

(6)

(c) A paramagnetic material has 10^{28} atoms/m³. Its susceptibility at 350K is 2.8×10^{-4} . Calculate the susceptibility at 300K. (3)

Values of Constants

$$k_B = 1.38 \times 10^{-23} \text{ JK}^{-1}$$

$$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$$

$$h = 6.63 \times 10^{-34} \text{ Js}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ Hm}^{-1}$$

$$\mu_B = 9.27 \times 10^{-24} \text{Am}^2$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{Fm}^{-1}$$

$$m_e = 9.1 \times 10^{-31} \text{kg}$$

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

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[This question paper contains 4 printed pages.]

05/6/24

Your Roll No.....

Sr. No. of Question Paper : 4142

Unique Paper Code : 2222512403

Name of the Paper : Thermal Physics and Statistical Mechanics

Name of the Course : **B.Sc. Hons.-(Physics)_NEP:
UGCF-2022_DSE (Industrial
Chemistry)**

Semester : IV

Duration : 2 Hours

Maximum Marks : 60

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 a total of **Four** Questions including Question no. 1.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.

P.T.O.



1. Attempt all parts of the question. (3×5=15)

- (a) Define the concept of temperature and the law that defines it.
- (b) A Carnot engine whose low temperature reservoir is at 7°C has an efficiency of 40%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of the high temperature reservoir be increased?
- (c) Calculate the mean free path of molecules in a chamber of 10^{-16}mm Hg pressure, assuming the molecular diameter to be 2.0 angstrom. Take the temperature of the chamber as 273 K. One gm mole of the gas occupies 22.4 liters at N.T.P. and one atmosphere is 760 mm Hg (1 atmosphere = 10^6 dynes/cm², $k_B = 1.38 \times 10^{-16}$ erg/K).
- (d) Show that Planck's law reduces to Wien's law for shorter wavelength and Rayleigh-Jeans law for longer wavelength.
- (e) Calculate the root mean square speed of a molecule of hydrogen at N.T.P. The Boltzmann's constant is 1.38×10^{-16} erg/degree and Avogadro's number is 6.0×10^{23} /gm. mol.

2. (a) Describe construction and working of Carnot's heat engine. Derive an expression for its efficiency in terms of temperatures of its heat reservoirs.

(10)

- (b) Show that the work done in isothermal process of an ideal gas from a state (P_1, V_1) to a state (P_2, V_2) is given by

$$W = RT \times 2.303 \log_{10} P_2/P_1 \quad (5)$$

3. (a) Using Maxwell's distribution function, obtain an expression for average speed (v_{av}), root means square speed (v_{rms}) and most probable speed (v_{mps}).

(10)

- (b) The melting point of a given liquid is 80°C . On melting its specific volume increases by $0.146 \text{ cm}^3\text{g}^{-1}$. Assuming its latent heat of fusion to be 35.6 cal g^{-1} , compute the change in the melting point per atmospheric pressure.

(5)

4. (a) What are the basic assumptions of Planck's theory of blackbody radiation? Derive Planck's law of blackbody radiation.

(12)

- (b) Consider a blackbody at a temperature of 6000K. Calculate the wavelength at which the maximum intensity of radiation occurs. [Given: Wien's constant = $2.898 \times 10^{-3}\text{mK}$] (3)
5. (a) Obtain an expression for thermodynamic probability and the most probable distribution function for a system obeying M.B. statistics. (9)
- (b) Find the number of microstates of a system of 2 particles and 3 states if the system obeys
- (i) M.B. statistics,
 - (ii) F.D. statistics, and
 - (iii) B.E. statistics. (6)

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SI No of QP : 4142A
Name of the Department : Department of Physics and Astrophysics
Name of Course : B.Sc. Hons. - (Physics) NEP: UGCF-2022
Name of the Paper: Analog Electronics
Semester : IV - Semester
Unique Paper Code : 2222012403
Duration : 2 hours
Max. Marks : 60 marks

Roll No.



Instructions for Candidates:

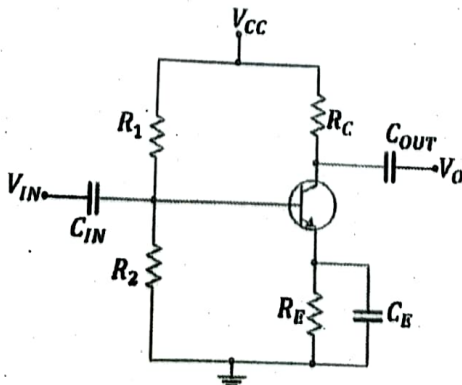
- Write your Roll No. on the top immediately on receipt of this question paper.
- Attempt any Four questions in all. Question No. 1 is compulsory.
- Simple non-programmable calculators are allowed.

1. Attempt all parts of the following:

(3X5=15)

- In a common emitter transistor configuration, the current amplification factor is 0.9. If the emitter current is 1mA and leakage current is assumed zero, determine the value of the base current for the common base configuration.
- For what voltage will the reverse current in a Germanium pn junction diode reach 80% of its saturation value at room temperature?
(Given $\eta = 1$, $k = 1.38 \times 10^{-23} \text{ J/K}$; $q = 1.6 \times 10^{-19} \text{ C}$)
- Why do we need positive feedback in designing oscillator circuits.
- Explain the role of coupling capacitor (C_C) and Emitter capacitor in (C_E) based transistor amplifier circuits.
- An Op-Amp in open loop inverting configuration is driven by a 1kHz triangular wave of 100 mV peak signal value, Draw the output waveform of the circuit with respect to this input.

2. (10,5)
- a) A transistor amplifier with voltage divider biasing circuit has the following specifications ; $V_{CC} = 22\text{V}$, $R_1 = 39\text{k}\Omega$, $R_2 = 3.9\text{k}\Omega$, $R_C = 10\text{k}\Omega$, $R_E = 1.5\text{k}\Omega$, $C_{IN} = C_{OUT} = 10\mu\text{F}$, $C_E = 50\mu\text{F}$ and $\beta = 140$. Determine the dc bias voltages and the quiescent point parameters. Also show the quiescent point on the dc load line for the circuit.



- b) Define the four h-parameters with reference to a CE transistor configuration. Explain how these parameters can be determined from the static characteristic curves of the configuration.

3.

(5,10)

- a) A sinusoidal peak-to-peak voltage of $60 \sin 100\pi t$ is applied to a full wave rectifier with load resistance of 500Ω and forward diode resistance of 50Ω . Find the maximum DC current component, rms current component, PIV of the semiconductor diode, ripple factor and rectification efficiency.

- b) Define line regulation and load regulation for a Zener diode based voltage regulator. Explain with help of a circuit diagram the working of Zener diode as a voltage regulator. Derive the relations for the minimum value of load resistance, the minimum and the maximum value of the supply voltage that can be regulated by a given Zener diode.

4.

(9,3,3)

- a) Derive the expression for the oscillation frequency of a transistor based Hartley Oscillator.

- b) A transistor based Colpitts oscillator has a frequency of oscillation $f = 100 \text{ kHz}$. If the value of two of the frequency determining components is $L = 100 \text{ mH}$ and $C_1 = 0.01 \mu\text{F}$. Determine the value of the third component.

- c) Calculate the frequency of oscillation for the transistor based RC phase shift oscillator having $R_C = 2 \text{ k}\Omega$, $R = 5 \text{ k}\Omega$ and $C = 0.01 \mu\text{F}$.

5.

(8,4,3)

- a) Explain the working of a basic differentiator circuit designed using Op-amp. Explain the problems associated with the basic circuit and how they are rectified in a practical differentiator. Explain the response curve for the circuit.

- b) Design an practical Op-amp integrator for the frequency range from 1 to 10 kHz. Choose the capacitor value as $0.1 \mu\text{F}$.

- c) Calculate the output voltage for an op-amp based inverting summing amplifier for the following sets of voltages and resistors:

(i) $V_1 = 1 \text{ V}$, $V_2 = 2 \text{ V}$, $V_3 = 3 \text{ V}$, $R_1 = 500 \text{ k}\Omega$, $R_2 = 1 \text{ M}\Omega$, $R_3 = 1 \text{ M}\Omega$ and $R_F = 1 \text{ M}\Omega$

(ii) $V_1 = -2 \text{ V}$, $V_2 = 3 \text{ V}$, $V_3 = 1 \text{ V}$, $R_1 = 200 \text{ k}\Omega$, $R_2 = 500 \text{ k}\Omega$, $R_3 = 1 \text{ M}\Omega$ and $R_F = 1 \text{ M}\Omega$