U.G. 4th Semester Examination - 2021

PHYSICS

[PROGRAMME]

Course Code : PHY-G-CC-T-4(A-D)

Full Marks : 20 Time : 1 Hour

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer all the questions from selected Option.

OPTION-A

PHY-G-CC-T-4A

(Quantum Mechanics)

1. Answer any **five** questions : 1×5=5

   a) What is Gyromagnetic ratio?

   b) What do you mean by expectation value?

   c) Why the quantum mechanical operators are Hermitian operator?

   d) Show that Scrödinger equation is a normal consequence of conservation of energy principle.

   e) What are the conditions that a function can be the wave function of a quantum system?

   f) What is zero-point energy?

   g) Write down the time dependent Scrödinger equation.

   h) What do you mean by the degenerate states of a physical system?

2. Answer any **one** question : 5×1=5

   a) What is box normalization? Explain Anomalous Zeeman effect showing a net diagram of transition between the split energy levels with required selection rules. 2+3

   b) Derive the eigen value and eigen functions of the operator $\left(x+\frac{d}{dx}\right)$. Show that the eigen values form a continuous spectrum. 4+1

   c) Solve the time dependent part of wave function using a time dependent Scrödinger equation. What is stationary state? 4+1

3. Answer any **one** question : 10×1=10

   a) Write down the expression of Scrödinger equation for Hydrogen atom in spherical polar coordinate. Using separation of variable solve the azimuthal angle (ϕ) dependent solution. What

is the outcome of Stern-Gerlach experiment? Write the form of energy eigen values and ground state energy eigen function of such oscillator. 2+3+3+2

b) A free particle is moving in X-direction within a confined region $0 \le x \le L$, write the Scrödinger equation for the system. Determine the energy eigen value and eigen function of the system. Show that the energy eigen values are discrete. What will be the energy eigen values if the particle is free in three dimension? 2+3+3+2

c) What is space quantization? What is Bohr magneton? What is its value? What is J-J and L-S coupling interaction? Sketch the normal Zeeman transition of sodium D_2 line $3\,^2P_{\frac{3}{2}} \rightarrow 3\,^2S_{\frac{1}{2}}$. 2+1+1+3+3

OPTION-B

PHY-G-CC-T-4B

(Solid State Physics)

1. Answer any **five** questions : 1×5=5

   a) What is Type I and Type II superconductivity?

   b) State the limitations of Einstein's Law of specific heat of solids.

   c) Explain the translation vector in a crystal system.

   d) Draw the (230) plane for a simple cubic system.

   e) Explain how can you identify the type of semiconductor by Hall effect experiment.

   f) What is the unit cell of a crystal system?

   g) What is Phonon?

   h) What is Ferromagnetic domain?

2. Answer any **one** question : 5×1=5

   a) Explain the effective mass of an electron in presence of electric field in Brillouin Zone. What is the isotope effect in a Superconductor? 3+2

   b) Calculate the number of atoms per cell for a simple cubic crystal system. Define Moniclinic crystal system. 3+2

c) What is the origin of Paramagnetism? Calculate the average value of magnetic moment vector for a paramagnetic system subjected to external field H. 2+3

3. Answer any **one** question : 10×1=10

a) What are the differences between amorphous and crystalline materials? Explain how the Basis and Lattice generate crystal structure. Does the choice of unit cell is unique? Explain how does a quartz crystal used as piezoelectric material. What is electrostrictive effect? 2+2+2+2+2

b) Write down the expression of force equation for a monatomic lattice chain along x-direction. Derive the relation between angular frequency and wave-vector for such system. Draw the dispersion curve for such system. How does the dispersion curve differ in diatomic one dimensional system? What happens in the curve if both atoms in that diatomic system have same mass? 2+3+2+2+1

c) State Dulong-Petit's Law. What is the drawback of the law? How Einstein has solved the problem explain with mathematical deductions. State the how Debye propose the solution of Einstein equation for deduction of specific heat of solids. 2+2+5+1

OPTION-C

PHY-G-CC-T-4C

(Electromagnetic Theory)

1. Answer any **five** questions : 1×5=5

a) What is relaxation time in case of electromagnetic wave propagation?

b) What is retarded plate?

c) What do you mean by displacement current?

d) Using the Maxwell's equation derive the expression of wave equation in a dielectric medium.

e) State Biot's Law of rotatory polarization.

f) State the Poynting theorem.

g) What is Plasma frequency?

h) What is negative and positive crystal?

2. Answer any **one** question : 5×1=5

a) What is Babinet compensator? What is TE and TM mode of wave guide? 1+2+2

b) What is Poynting vector? Show that average energy density in a harmonic electromagnetic field is $\langle u \rangle = \frac{1}{4}\mathrm{Re}\left[\vec{E}\vec{D}^{*} + \vec{H}\vec{B}^{*}\right]$ 2+3

c) State the Brewster's law. Using Fresnel's formula of refraction of an electromagnetic wave, establish the Brewster's Law. Draw a neat diagram how a plane polarised light can be generated using this law. 2+2+1

3. Answer any **one** question : 10×1=10

a) Discuss the action of a Nicole prism as a polariser. Calculate the thickness of a quarter wave plate for sodium light of wavelength 5893Å. Given refractive index of ordinary and extraordinary waves are 1.5442 and 1.5533, respectively. A plane polarised electromagnetic wave is incident in the interface of a two dielectric medium having refractive index μ_1 and μ_2, find the relation between angle of incident and angle of refraction. 2+3+5

b) What is optic axis? Using the concept of resolution of a linear optical vibration into two circularly polarised vibration derive the expression of phase difference in terms of difference of refractive indices of left and right circularly polarised light. Explain the basic principle of a Laurent half-shade polarimeter. A 20 cm long tube containing sugar solution gives a rotation of 11° of the plane of vibration of a plane polarised light. If the specific rotation of sugar be $66^{o}\ dm^{-1}.g^{-1}.cm^{-3}$, calculate the strength of the solution. 2+4+2+2

c) Write the expression of four Maxwell's equation stating the significance of each of them. Derive the wave equation from it in a conducting medium. Show that the electric field amplitude is spatially attenuated. What is skin depth? 2+3+3+2

OPTION-D

PHY-G-CC-T-4D

(Statistical Mechanics)

1. Answer any **five** questions : 1×5=5

a) What are the properties of liquid Helium?

b) What is Fermi energy?

c) State and explain the basic postulate of equal a priory theory.

d) Define Micro-canonical and Grand-canonical ensemble.

e) What is the difference between macroscopic and microscopic states?

f) State the limitations of Wines displacement law.

g) Write the expression of FD distribution function.

h) What is entropy of a statistical system under thermal equilibrium?

2. Answer any **one** question : 5×1=5

a) Why the electron in a white dwarf star is considered as degenerate? Using First law of thermodynamics show that the product of wavelength of emitted radiation varies inversely to the absolute temperature. 2+3

b) What is ideal gas? Assuming the free particle concept of an ideal gas derive the expression of equation of state of such gas. 1+4

c) Show that the value of Fermi energy is $E_F = \frac{h^2}{2m}\left(\frac{3N}{8\pi}\right)^{\frac{2}{3}}$. The molar mass of Li is 0.00694 and its density 0.53×10^3. Calculate the Fermi energy and Fermi temperature of electron. 3+2

3. Answer any **one** question : 10×1=10

a) Show that the amount of radiation emitted from a black body at absolute temperature T_1 surrounded by another black body at absolute temperature T_2 is $Q = \sigma\left(T_1^4 - T_2^4\right)$. σ is a constant. Using First law of thermodynamics show that the product of wavelength of emitted radiation

varies inversely to the absolute temperature of the body. State the limitations of Rayleigh-Jeans Law. What is Chandrasekhar limit? 4+2+2+2

b) Calculate the probability that a small system be in energy state E resides in a big micro-canonical ensemble having energy E_0 under equilibrium, established by energy exchange only. Assuming the partition function (Z) of a canonical ensemble as a function of β and energy E, show that the entropy of the system becomes $S = k\left(\ln Z + \beta\langle E\rangle\right)$. T=equilibrium absolute temperature and $\beta = \frac{1}{KT}$. Express the Helmoltz free energy of a canonical system in terms of partition function and temperature. 4+3+3

c) Derive the expression of number of bosons (using grand canonical ensemble concept) present in a particular energy state E_s. What conclusion can you draw about the minimum energy of a boson from the expression? Show that for an ideal Bose gas the product of its pressure (P) and volume (V) related to mean energy (E) by $PV = \frac{3}{2}E$. Explain qualitatively the phenomena of B-E condensation. 3+1+4+2

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