UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: I (Solid State Physics-II) **MAX. MARKS: 50**

NOTE: Attempt any FOUR questions, in all by selecting at least ONE question from each section.

Q.1(a) Derive the energy expression for the electron in one dimensional potential box and discuss the important conclusions from this equation.

(b) State Fermi Dirac distribution function and describe how it is affected by change in temperature. Use graphs to illustrate your answer. **(6.5+6)**

Q.2 (a) Show that the effective mass of an electron in a crystal depends on the curvature of energy band. Discuss the physical basis for the effective mass of an electron in a crystal.

(b) What is cyclotron resonance and how it can be measured experimentally.

(c) Plot the distribution of probability 'p' in the lattice for ψ^{-2} and ψ^{+2} and for a pure travelling wave. **(6.5+3+3)**

Q.3 (a) What is Hall effect? Give an elementary theory of it. Mention its important uses.

(b) Plot the optical absorption curves for the direct and indirect gap materials.

(c) State Wiedman Franz law and also write down the expression for Lorentz number.

(6.5+3+3)

Q.4 (a) Using **Langevin's** classical treatment, show that the orbital motion of the electron gives rise to to a diamagnetic susceptibility under the influence of a magnetic field '**B**'.

(b) Explain the origin of the paramagnetic behavior of the conduction electrons of a metal and drive an expression for the Pauli spin magnetization of the conduction electron. **(6.5+6)**

Section-II

Q.5 (a) What are intrinsic semiconductors ? Drive an expression for intrinsic carrier concentration in a semiconductor.

(b) How is conductivity of a semiconductor affected by doping? Show that the Fermi energy level in the band picture shifts either towards conduction band edge or valence band edge depending on the type of doping **(6+ 6.5)**

Q.6 (a) How is abrupt p-n junction defined? Draw schematic diagrams specifically showing the relative positions of band edges and Fermi level for p-n junction in thermal equilibrium.

(b) Starting with the Poison's differential equation and assuming an abrupt p-n junction show that $N_d d_n$-$N_a d_p$ where x= -dp and x=dn. Also find the length of depletion region on n and p sides. **(3+ 9.5)**

Q.7 Write notes on the following. **(6.5+ 6)**

(a) Electrical conduction in metals

(b) origin of energy gap

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: II (Statistical Physics) **MAX. MARKS: 50**

NOTE: Attempt FOUR questions, in all by selecting at least ONE question from each section. Try to be focused and give only precise answers, of the asked questions.

Section-I

Q.1.

(a) Define these terms in your own words:
Phase Space (μ-Γ), Micro-Macro states, Ergodic Surface and theorem. (4)

(b) What is the basic difference in the definition of calculating the average from ordinary method and then by Ensemble method. Define the elements of an ensemble along with the proof of the relation for Ensemble average? (4)

(c) A nuclear bomb at the instant of explosion may be approximated to a blackbody of radius 0.3m with a surface temperature of 10^7 K. Show that the bomb emits a power of 6.4×10^{20} W. (4.5)

Q.2.

(a) Show that the particles tend to move from a region of higher μ to a region of lower μ as the system approaches equilibrium for the case of particle equilibrium? (3)

(b) Why is the quantity $h/(2\pi MkT)^{1/2}$ identified with a wavelength? (2)

(c) Illustrate with a simple example that entropy is a measure of the "randomness" of a system. (2)

(d) If the temperature difference between the source and surroundings is small then show that the Stefan's law reduces to Newton's law of cooling. (2.5)

(e) Consider a system which consists of two compartments A and B. The temperature of the compartment B is greater than that of compartment A. Calculate the expression for the change in entropy of the total isolated system under the given condition. (3)

Q.3.

(a) The Maxwell's distribution for velocities of molecules is given by

$$N(v)dv = 2\pi N(m/2\pi kT)^{3/2} v^2 \exp(-mv^2/2kT)dv$$

Calculate the value of $< 1/v >$. (3)

(b) Consider an ideal gas consisting of "n" number of molecules enclosed in cylinder having volume V. Calculate the most probable velocity of molecules on the basis of Maxwell velocity distribution. (3)

(c) Graphically illustrate the temperature dependence of velocity distribution function. (3)

(d) Obtain the equation $Tds = C_p dT - TV\alpha dp$ (3.5)

Q.4.

Write notes on the following: (6, 6.5)

(a) Gibb's paradox: it's meaning, its origin and how it is removed.

(b) The properties of photons in thermal equilibrium with matter or of a photon gas in a constant temperature enclosure.

PTO

Section-II

Q.5.

(a) Define the basic criteria to analyze which type of statistics to be applied on what type of a system? Define De-Broglie thermal wavelength in this regard. Also classify between the classical and quantum statistics with respect to Degeneracy Temperature? (5)

(b) How is the equation of the symmetry of wave functions related to the basic distinction between Fermi-Dirac and Bose-Einstein systems? (3.5)

(c) Classify the following between Bosons and Fermions and state the criterion which statistics has been applied for this classification:

- ❖ Hardrons, Gauge-Bosons, Ar-Atoms, Xe-Atoms.
- ❖ Pions, Neutrino, Anti-neutrino, Spin zero particles. (4)

Q.6.

Consider a photon gas enclosed in a volume V and in equilibrium at temperature T.

(a) Derive a formula for the density of states $G(\upsilon)$ and hence find an expression for the total number of photons in terms of frequency υ. What value of chemical potential is used in this calculation and why? (4)

(b) Show that the total energy density is proportional to the fourth power of temperature T. (4)

(c) Calculate the solar constant: that is the radiation power received by 1 m^2 of earth's surface. (Assume the sun's radius $R_S = 7 \times 10^8$ m, the earth sun distance $r = 1.5 \times 10^{11}$ m, the earth's radius $R_E = 6.4 \times 10^6$ m, sun's surface temperature, $T_S = 5{,}800$ K and Stefan-Boltzmann constant is $\sigma = 5.7 \times 10^{-8}$ $W/m^2\text{-}K^4$. (4.5)

Q.7.

(a) Show that the orbit of a linear simple harmonic oscillator in phase space is an ellipse.

(b) The volume of a perfect gas of N atoms is doubled. And the energy is being held constant. What is the change of entropy? What this entropy change actually means. Illustrate your answer by providing necessary physical interpretation?

(c) Show that $C_v = KT \frac{\partial^2}{\partial T^2} \{T.\log(z)\}$

(4, 4.5, 4)

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: III (Relativity & Cosmology)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

NOTE: Attempt FOUR questions selecting at least ONE from each section.

Section-I

Q1.(a) Derive Lorentz transformations by assuming that the transformations are equivalent to the rotation in Minkowski space. Also deduce the inverse Lorentz transformation equations.
(b) Derive the relativistic velocity composition law using Lorentz transformation matrix.
(c) Write down importance of K-factor? [6.5,4,2]

Q2.(a) The kinetic energy of a non-relativistic particle reads $T = \frac{p^2}{2m_o}$, where $p = m_o v$ is the momentum of the particle. Find a similar expression for the relativistic kinetic energy.
(b) A neutron with kinetic energy of 1.00 BeV strikes a proton which is vibrating about a fixed point in such a way that its maximum kinetic energy is100 MeV. What are the maximum and minimum values of the relative velocities of the two particles? Assuming that the rest mass energies of neutron and proton are equal and of magnitude 940 MeV.
(c) The total energy of the particle is exactly twice of its rest energy. Calculate its speed? [5.5,5,2]

Q3.(a) A stationary atom of proper mass m_o is struck by a photon of frequency f and recoils. If the atom absorbs the photon, what are speed and mass of the recoiling particle? [5.5]
(b) Explain Doppler effect of light and show that the observed frequency ν of light emitted by a moving source is $\nu = \frac{\nu_o}{\gamma\left(1 - \frac{v}{c}\cos\theta\right)}$, where v is the velocity of the source and θ is the angle at which the light is emitted. [5]
(c) Why we need four dimensional space in Special Relativity? [2]

Section-II

Q4. (a) What is a metric? Transform $ds^2 = dx^2 + dy^2 + dz^2$ into spherical polar coordinates.
(b) Prove that the Christoffel symbol Γ^a_{bc} is not a tensor.
(c) Show that in Cartesian system there is no distinction between contravariant and covariant components of a vector. [6.5,4,2]

Q5. (a) For the Christoffel symbol of second kind, show that

$$\Gamma^{\lambda}_{\mu\gamma} = \frac{1}{2} g^{\nu\lambda}\left(\partial_\gamma g_{\mu\nu} + \partial_\mu g_{\nu\gamma} + \partial_\nu g_{\gamma\mu}\right) \quad [5.5]$$

(b) Compute the components of Riemann Curvature Tensor $R^{\theta}_{\phi\theta\phi}$ and $R^{\theta}_{\phi\phi\theta}$ for a unit 2-sphere $ds^2 = d\theta^2 + \sin^2\theta\, d\varphi^2$ [4]
(c) Show that $\Gamma_{abc} + \Gamma_{bca} = \frac{\partial g_{ab}}{\partial x^c}$. [3]

Q6.(a) If $G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R$ is the Einstein tensor. Show that the contraction of the Bianchiidentity implies $\nabla_\mu G^{\mu}_{\nu} = 0$. [6.5]
(b) Write down vacuum field equations and describe them briefly. [4]
(c) State principle of minimal gravitational coupling in relativity. [2]

Q7.(a) What is critical density of universe. Show that the critical density is given by:

$$\rho_c = \frac{3H^2}{8\pi G} \quad [5.5]$$

(b) Write briefly on the following: [7]
(i) Space-time curvature (ii) Nucleosynthesis

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: IV (Computational Physics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

NOTE: Attempt FOUR questions in all selecting at least ONE from each section.

Section-I

Q.1 (08 ½ +4)

The temperature values per day for two cities A and B are given in the table. Write program to determine: (i) number of times the temperature of A is greater than that of B with day (ii) temp. of B equal to that of A with day (iii) temp. of A & B > 60 with days (iv) find out the day with two temperatures are very close or apart from each other and (v) find average temperature per day and per week.

Day	1	2	3	4	5	6
A	60	56.2	63	64	58	60.2
B	54.6	56.2	64	60	59	60.2

Write C++ program to calculate and print equivalent capacitance of n capacitances connected in parallel.

Q.2. (8+4 ½)

Write C++ program which reads in a number as decimal number and convert it into binary number. Implement your program for 10 iterations

Write MATLAB program calculate and print table of number 7.

Q.3. (6+6 ½)

Write C++ program to print the following series and sum:

$$S = \frac{1}{10}\sum_{i=1}^{10} xi$$

Write C++ program to calculate and print odd numbers in the list of numbers from 1 to 33. Also calculate sum of the numbers.

Section-II

Q.4.
A (06 ½ +6)

What are random numbers? Write syntax for random number generation in MATLAB. Write MATLAB program to plot graph for a particle describing Brownian motion. Also calculate total and average distances traced by the particle. Draw approximate output graph with proper labels.

B

Write MATLAB program to determine corresponding force (f) values for the given acceleration and mass values as give in the table. Also calculate total force, minimum mass and average acceleration values.

m (mass)	3	4	2.1	8.7	14.6
a(acceleration)	0.25	0.53	0.47	0.53	0.74

PTO

<table>
<tr><td>Q.5. (A)</td><td>Write MATLAB program for the Growth of Current in a simple RL-circuit using Euler's Method with initial conditions: r=10Ω, L=5H, initial time 0, time step 0.1, maximum time 2.5sec., initial current 0 and voltage v=4 volts. Print and plot current against time values. Draw estimate graphs with proper labels. How you can convert the same program for the decay of current in the circuit?</td><td>8+4 ½</td></tr>
<tr><td>(B)</td><td>Write MATLAB to plot 'x' against f(x) values using supbplot such that: x = [0 10], y(x) = sin(x).</td><td></td></tr>
<tr><td>Q.6. (A)</td><td>Write down the MATLAB syntax with example for: min(), trapz(), expand() and bar().</td><td>8+ 4 ½</td></tr>
<tr><td>(B)</td><td>Write MATLAB program calculate and print factorial of a number using two different methods.</td><td></td></tr>
<tr><td>Q.7. (A)</td><td>The acceleration of a spherical body experiencing air drag is given by $a = g - k v^2$ where $k = c \pi \rho r^2 / 2$ m with the conditions: g = 9.8 m/sec^2, c=0.46 (drag constant), ρ= 1.2 kg/m3, r=1m, v=0 m/sec, h= 0.1 sec and tmax=2.5sec. Write MATLAB program to plot and print time, position, velocity and acceleration values. Also draw estimate output graphs with proper curve labels, x & y labels and title</td><td>8+ 4 ½</td></tr>
<tr><td>(B)</td><td>Write MATLAB program to determine corresponding current and power values such that the voltage and resistance values are given in the table.
<table>
<tr><td>V (voltage)</td><td>5.4</td><td>4.3</td><td>2.4</td><td>8.7</td><td>3.2</td></tr>
<tr><td>R(resistance)</td><td>4.5</td><td>3.7</td><td>3.3</td><td>3.5</td><td>4.6</td></tr>
</table></td><td></td></tr>
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UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: V (Classical Electrodynamics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FIVE questions, at least TWO questions from each section. All questions carry equal marks.

Section-I

Q.1. (a) Express a potential distribution produced by a specified distribution of charge in terms of its electric dipole moments. 15

(b) Show that the force acting on a dipole placed in an external field is $(\boldsymbol{p}\cdot\nabla)\boldsymbol{E}_{ext}$. 5

Q.2. (a) What are Zonal harmonics? Describe briefly. 5

(b) Find the potential for a conducting sphere in a uniform electric field. 15

Q.3. (a) Describe briefly the Biot-Savart law. 6

(b) If we have two current carrying circuits 1 and 2, find following expression for the force $\boldsymbol{F_2}$ exerted on circuit 2 due to circuit 1: 14

$$\boldsymbol{F}_2 = \frac{\mu_0 I_1 I_2}{4\pi}\oint_{c1}\oint_{c2}\frac{d\boldsymbol{l}_2\times[d\boldsymbol{l}_1\times(\boldsymbol{r}_2-\boldsymbol{r}_1)]}{|\boldsymbol{r}_2-\boldsymbol{r}_1|^3}$$

Q.4. (a) Discuss briefly the magnetic vector and scalar potentials. 10

(b) Find an expression for magnetic vector potential $\boldsymbol{A}$. 10

Q.5. (a) Show that magnetic induction due to a magnetized distribution of matter is given by $\boldsymbol{B}(\boldsymbol{r}) = -\mu_o\nabla\varphi^*(r) + \mu_o\boldsymbol{M}(\boldsymbol{r})$, where $\varphi^*(r)$ is magnetic scalar potential. 14

(b) With the help of an expression for $\varphi^*(r)$ due to magnetized material, express magnetic pole density ρ_M and surface density of magnetic pole strength σ_M. 6

Section-II

Q.6. (a) Define phase velocity. What is plane wave and the plane wave solution? 6

(b) Discuss plane monochromatic waves in non-conducting media. 14

Q.7. (a) What is skin depth? Prove that for poor and good conductors, the skin depth is $\frac{2}{g}\sqrt{\frac{\varepsilon}{\mu}}$ and $\sqrt{\frac{2}{\mu\omega g}}$ respectively, where g is the conductivity. 16

(b) Find frequency at which skin depth in sea water is one meter, we take $g = 4.3$ S/m and $\mu = \mu_o$. 4

Q.8. (a) Find an expression of Debye length in a plasma. 10

(b) Discuss polarization of EM waves. 10

Q.9. Discuss briefly only two topics. 10,10

(a) p.n. junction laser (b) Ohm's law and conductivity

(c) Magnetic susceptibility and permeability (d) Plasma oscillations

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Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: VI (Nuclear Physics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: *Attempt any FOUR questions selecting at least one from each section. All questions carry equal marks. Please read question carefully and answer accordingly.*

Question 1: **Section I** (15 + 5 + 5 = 25)

(a): What is Semiempirical mass formula? Derive its expression. Also discuss the utility of this formula.

(b): Calculate the contribution of Coulomb energy and surface energy terms for $^{238}_{92}U$ nucleus.

(c): Explain the nuclear reaction method to determine the masses of unstable nuclei.

Question 2: (12 + 13 = 25)

(a): Explain in detail principle, working and construction of Scintillation Counter.

(b): What is a synchrotron? Give constructional details of a proton synchrotron. Explain its working and theory.

Section II

Question 3: (12 + 13 = 25)

(a): How does collective model combine the liquid-drop model and shell model to explain the magnetic dipole moment and electric quadrupole moment of nuclei?

(b): In a β-decay process, in the *allowed* approximation, the partial decay rate for electrons and neutrinos with the proper momenta is:

$$d\lambda = Ap^2q^2dp$$

where p and q are momenta of emitted electron (positron) and antineutrino (neutrino), respectively, and A is constant including all factors independent of p and q. Use this expression to calculate momentum, $N(p)$, and energy, $N(T_e)$, distributions of the emitted electrons. Draw the expected shape of these distributions and also draw the Fermi-Kurie plot.

Questio 4: (13 + 12 = 25)

(a): How does the n-p interaction in the singlet and triplet states differ? Explain in the view of n-p scattering cross-section for low energy neutrons.

(b): What is alpha decay? Why does it occur? Find the expressions for the Q-value and kinetic energy of alpha particle in an alpha-decay process.

Question 5: **Section III** (10 + 10 + 5 = 25)

(a): Explain the deutron induced and neutron induced reactions in detail.

(b): What is threshold energy of a nuclear reaction? Derive the expression to calculate the values of threshold energy.

(c): The Q-value of the ^{23}Na(n, α)^{20}F reaction is -5.4MeV. Determine the threshold energy of the neutrons for this reaction. (Given: m(n) = 1.0086amu, $m(^{23}\text{Na})$ = 22.9909amu)

Question 6: (13 + 12 = 25)

(a): Discuss in detail about the energy required to start a fission process of ^{235}U and ^{238}U. Also explain how much energy is released in a fission process and where does it go? **(b):** What are different ways to detect neutrons of different energies? Discuss slow neutron's detection through charged particle production in nuclear reactions.

Question 7: (10 + 15 = 25)

(a): Classify neutrons with respect to their energy. List different neutron sources explaining one in detail.

(b): Why the thermonuclear reactions may be the only source of energy in sun? Discuss in detail the p-p and CNO solar fusion cycles.

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: VII (Solid State Physics-I)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FOUR questions, in all. All questions carry equal marks. Try to be focused and give only precise answers, of the asked questions.

Ques. No. 1 (12, 6, 7)

(a) Define Independent and Free Electron Approximation? Solve out a simple calculation in order to observe the behavior of Free Electron Gas in three dimensions. Also prove the degeneracy in energy eigen states for the case of (1,2,3) plane and draw this plane and other analogy planes in E-K diagram?

(b) Describe the motion of electrons in the periodic potential? Also prove that the energy of the particle is no longer a simple function of **k** but depends on the form of potential $\mathbf{U_k(r)}$? *(Hint: Take help from the concept of Vg)*

(c) Show that $\pi/6$ of the available volume is occupied by hard spheres in contact in a simple cubic arrangement.

Ques. No. 2 (12, 4, 4, 5)

(a) Write in detail about the plane wave concept of APW and OPW? Explain and plot both of these plane waves in all regions of the isolated atoms for the case of periodic solid? Carry out a detailed calculation on OPW method and define the term of integral operator (V_R) and effective potential?

(b) Name any four basic phenomenon's related to the interaction of X-Rays with the periodic crystal. Discuss the phenomenon of Diffraction in detail with the help of an example?

(c) How the idea of Von Laue formalism leads us to develop a new concept of Reciprocal Lattice?

(d) Calculate the separations of the sets of planes which produce strong x-ray diffractions beams at angles 4° and 8° in the first order, given that the x-ray wavelength is 0.1 nm.

Ques. No. 3 (12, 6, 7)

(a) What is meant by Raman Effect? Discuss quantum theory of Raman Effect in detail? Show with the help of figures the schematic transition in this process regarding the Stokes and Anti-Stokes line? Is there any calculation we required for intensity ratio?

(b) What is the basic difference between Rayleigh scattering and Raman scattering? What is the theory of Classical Raman Effect? Illustrate the example of CO_2 for Infrared active and Raman active bending stretch?

(c) At what angle will a diffracted beam emerge from the (111) planes of a face centered cubic crystal of unit cell length 0.4 nm? Assume diffraction occurs in the first order and that the x-ray wavelength is 0.3 nm.

Ques. No. 4 (12, 7, 6)

(a) What do you know about the Jospheson Superconducting Tunnelling Effect? Describe the process for the formation of junction? And write AC Jospheson effect in detail for the calculation of parameter $\hbar/e$?

(P.T.O.)

(b) What do you know about the effect of magnetic field on the superconductivity? Plot that point in graph where the threshold magnetic field at critical temperature goes to zero? Also plot the entropy change region for SC and NC separately?

(c) Lead is a fcc with lattice constant 4.94 Å. Lead melts when the average amplitude of its atomic vibrations is 0.46 Å. Assuming that for lead the Young's modulus is 1.6×10^{10} N/m^2, find the melting point of lead.

Ques. No. 5 (12, 7, 6)

(a) Define Phonons? What do you know about infrared phonons? Carry out a detailed calculation in order to get the relationship for the frequency dependent dielectric constant of a material when a photon interacts with TO-Phonon. Also plot and explain this relation. What information do you get about Reststrahlen band?

(b) The static and high frequency dielectric constant of NaCl are ε_{st}=5.9 and ε_{∞}=2.25 respectively, and the TO phonon frequency is 4.9THz. Calculate the upper and lower limit of reststrahlen band.

(c) In order to obtain the dielectric coefficient of any lightly damped system, Prove that the given relationship is valid:

$$\varepsilon_r(\omega) = \varepsilon_{\infty}\left(\frac{\omega_L^2-\omega^2}{\omega_T^2-\omega^2}\right)$$

Ques. No. 6 (6, 6, 7, 6)

(a) Write down the atomic radii r in terms of the lattice constant a, for (a) Simple cubic structure (b) FCC structure (c) BCC structure (d) Diamond structure.

(b) In the historical experiment of Davisson and Germer electrons of 54 eV at normal incidence on a crystal showed a peak at reflection angle $\theta r = 40^0$. At what energy neutrons would also show a peak at $\theta r = 40^0$ for the same order.

(c) Take the Fermi energy of silver to be 5.52 eV.

I. Find the corresponding velocity of conduction electron.

II. If the resistivity of silver at room temperature is 1.62×10^{-8} Ωm estimate the average time between collisions.

III. Determine the mean free path. Assume the number of conduction electrons as 5.86×10^{28} m^{-3}.

(d) Find the drift velocity of electron subjected to an electric field of 20 Vm^{-1} given that the inter-collision time is 10^{-14} sec.

Ques. No. 7 (12.5, 12.5)

Write notes on any TWO of the followings:

I. Entropy and Specific heat of Superconductors.

II. Persistence of super-current and single particle tunneling.

III. Effective mass.

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Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: VIII (Solid State Physics-II)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FOUR questions. All questions carry equal marks.

Q.1 (a) Give details of the Hamiltonian of electron-phonon interactions.
(b) What is Knight shift? Write an explanatory note. **(12.5+12.5)**

Q.2 (a) Derive Boltzmann transport equation in relaxation time approximation.
(b) Apply Boltzmann equation to find the conductivity equation. **(12.5+12.5)**

Q.3 (a) Explain various significant material properties, which are exhibited by semiconductors.
(b) How does the shape affect the ferromagnetic resonance frequency? **(12.5+12.5)**

Q.4 (a) Derive an expression that can fairly describe the susceptibility variations in the paramagnetic region above the Curie point.
(b) How does the saturation magnetization vary at different temperatures? Also elaborate its behavior at absolute zero. **(5+20)**

Q.5 (a) What is Nuclear Magnetic Resonance? Describe its applications.
(b) Determine the dispersion relation for spin waves in one dimension with nearest-neighbor interactions. **(10+15)**

Q.6 (a) Describe classical model for specific heat and give experimental facts about its failure.
(b) Discuss Einstein's model of specific heat for different temperature ranges. **(12.5+12.5)**

Q.7 Write notes on any two of the followings:
(a) The polarons
(b) Interactions between conduction electrons
(c) Microscopic theory of frequency dependent dielectric constant
(12.5+12.5)

Section III

Question 5: $(12 + 8 + 5 = 25)$

(a): Solve the Dirac equation and interpret all its four solutions.

(b): Show that if we assume the Dirac particle to be spinless then for that particle angular momentum is not conserved.

(c): Develop Klein-Gordon equation using relativistic expression of energy and write it in covariant form.

Question 6: $(10 + 10 + 5 = 25)$

(a): Show that Schroedinger wave equation is not invariant under Lorentz transformations.

(b): The covariant form of the transition amplitude, T_{fi}, from an initial state i to final state f is given by

$$T_{fi} = -i \int dx^4 \phi_f^*(x) V(x) \phi_i(x)$$

use this expression to derive Fermi's Golden rule.

(c): What kind of particles do obey Dirac equation? How did Dirac interpret negative energy solutions in his Hole theory?

Question 7: $(12 + 10 + 3 = 25)$

(a): For a proper infinitesimal Lorentz transformation

$$\Lambda_\mu^\nu = \delta_\mu^\nu + \epsilon_\mu^\nu,$$

show that an S which satisfies $S^{-1}\gamma^\nu S = \Lambda_\mu^\nu \gamma^\mu$ is

$$S = 1 - \frac{i}{4}\sigma_{\mu\nu}\epsilon^{\mu\nu}$$

and hence show that

$$S^{-1} = \gamma^0 S^\dagger \gamma^0$$

(b): Show that in the ultrarelativistic limit, an eigenstate of a helicity operator will also become eigenstate of the chirality operator and vice versa.

(c): Show that $(\sigma^{\mu\nu})^\dagger = \gamma^0 \sigma^{\mu\nu} \gamma^0$.

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: X (Particle Physics-II)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FIVE questions selecting at least ONE from each section.

Section I

Q1. For the elastic scattering process, Show that

$$\sigma_{el} = \frac{4\pi}{k^2}(2l+1)\frac{\frac{\Gamma^2}{4}}{(E_R - E)^2 + \frac{\Gamma^2}{4}} \qquad (20)$$

Q2. (a). Define differential scattering cross section and discuss the factors on which it depends

(b). Write down the expression for the differential cross section for a general scattering process and obtain total cross section

(8+12)

Q3. (a) Define Mandelstam variables and show that for a two body scattering process

$$s + t + u = \sum_{i=1}^{4} m_i^2$$

(b) What are the energies of particles $1, 2, 3, 4$ in terms of Mandelstam variables.

(10+10)

Section II

Q4. Discuss standard model in detail. Explain its significance in Particle Physics.

(20)

Q5. (a). Write down the general transformation for the group $SU(3)$ and also write down its generators in matrix form. What are structure constants.

(b). Solve the following commutators

$$[T_3, T_2],$$
$$[T_2, T_7] \qquad (12+8)$$

Q6. By using Klein Gordon equation, obtain the expression for four-vector current j^μ for a spinless electron in an electromagnetic field A^μ.

(20)

Section III

Q7. Prove the following trace theorems

(a). $\mathrm{Tr}(abc) = 0$
(b). $\mathrm{Tr}(abcd) = 4\left[(a.b)(c.d) - (a.c)(b.d) + (a.d)(b.c)\right]$
(c). $\mathrm{Tr}(\gamma_5 ab) = 0$
(d). $\gamma^\mu \gamma_\mu = 4$

(20)

Q8. Starting with the Feynman diagram obtain the following expression for $e^- \mu^-$ scattering

$$|\bar{\mathcal{M}}|^2 = \frac{e^4}{q^4} L_e^{\mu\nu} L_{\mu\nu}^{muon},$$

write down the expressions for $L_e^{\mu\nu}$ and $L_{\mu\nu}^{muon}$.

(20)

Q9. (a) Draw Feynman diagrams for $e^- e^+$ scattering.

(b) Show that for $e^- e^+$ at very high energies

$$\sigma = \frac{4\pi\alpha^2}{3s} \qquad (6+14)$$

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: XIII (opt-iv) [Advance Electronics]

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FIVE questions, All questions carry equal marks.

Q.1 a) Explain the construction and working of Differential Amplifier. [14]

b) Write the ideal characteristics of OP-Amp. Explain the use of OP- AMP as Summing Amplifier. [6]

Q.2 a) Describe the R-2R ladder network for the D/A Conversion? [12]

b) Determine the out-put voltage for a 5-bit R-2R ladder network, when the digital input is 10101, where logical 0 stands for 0 V and logical 1 for 5 V. [8]

Q.3 a) Describe the working of J-K master slave Flip Flop. [10]

b) An alarm system to be used in conjunction with an automated bottling system is needed in a milk bottling plant. A conveyor belt carries empty bottles which are to be filled with milk. The alarm should sound if any of the following conditions occur. [10]

i) The milk tank is empty and bottles are on the conveyor belt.

ii) There are no bottles on the conveyor belt and there is milk in the tank.

iii) There is milk in the tank, bottles are on the conveyor belt and the electric power is off.

iv) There is no milk in the tank, no bottles and no power.

Write its truth table, its Boolean function and design the circuit using NAND gate.

Q.4 a) Design a logic circuit for BCD to Gray and Gray to BCD. [16]

b) Draw the logic circuits of AND, OR, NOT and NOR by using NAND gate. [4]

Q.5 a) Define the Multiplexer, De-Multiplexer and Comparator. [6]

b) Draw the circuit for Eight Bit Multiplexer. How many selector switches will be used? [14]

Q.6 a) What is the difference between the A-Synchronous and Synchronous Counter? [4]

b) Design a Mod-7 Synchronous counter using J-K Flip Flops. [16]

Q.7 State the types of ROM. What is RAM? What is the difference between DRAM and SRAM? [20]

Q.8 a) What is a Microwave? What are its advantages and its applications? [8]

b) Draw the block diagram and working of super heterodyne receiver. [12]

Q.9 Write short note on any two of the following: [10+10]

a) Microprocessor

b) Klystron Amplifier

c) ALU

UNIVERSITY OF THE PUNJAB

Part-II A/2017
Examination:- M.A./M.Sc.

Roll No. .....

Subject: Physics
PAPER: IX (Particle Physics-I)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FOUR questions selecting at least ONE from each section. All questions carry equal marks. Please read question carefully and answer accordingly.

Section I

Question 1: (12 + 7 + 6 = 25)

(a): Describe Quark Model in detail. How can we have so many hadrons with only three quarks and their antiparticles? Can two hadrons have same combination of quarks?

(b): Write a note on discovery of Kaons. Also explain why are they called strange particles?

(c): Write down conservation laws in electromagnetic, strong and weak interactions.

Question 2: (10 + 15 = 25)

(a): Give the classification of particles and elementary particles in high energy Physics. Give their examples. Also mention the types of interactions in which they participate.

(b): Describe in detail the differences between QED and QCD. Also explain the phenomena of asymptotic freedom and quark confinement in QCD.

Section II

Question 3: (12 + 7 + 6 = 25)

(a): What is C-parity? Discuss the conditions a state should satisfy to be an eigen state of C-parity operator. What is the difference between C-parity and G-parity? Explain this difference with an example.

(b): Show that

$$J_{\pm}|j,m>=[j(j+1)-m(m\pm 1)]^{1/2}|j,m\pm 1>$$

where $|j,m>$ are eigen-states of J^2 and J_z with eigen values $j(j+1)$ and m, respectively.

(c): Show that the induce operator of time reversal is anti-unitary.

Question 4: (12 + 8 + 5 = 25)

(a): Show that the four Maxwell equations are equivalent to the following field equation:

$$\Box^2 A^{\mu}-\partial^{\mu}(\partial_{\nu}A^{\nu})=J^{\mu}$$

(b): Show that **E**, **B** and the field equation in part (a) of this question remain invariant under the following gauge transformation.

$$A^{\mu}(x)\rightarrow A^{\mu}(x)+\partial^{\mu}f(x)$$

(c): For a spin-1/2 particle, the state vector is defined by $|s,m_s>$. Use the eigen value equations for operators S^2 and S_z to find their matrix representation.

P.T.O.

Section III

Question 5: $(12 + 8 + 5 = 25)$

(a): Solve the Dirac equation and interpret all its four solutions.

(b): Show that if we assume the Dirac particle to be spinless then for that particle angular momentum is not conserved.

(c): Develop Klein-Gordon equation using relativistic expression of energy and write it in covariant form.

Question 6: $(10 + 10 + 5 = 25)$

(a): Show that Schroedinger wave equation is not invariant under Lorentz transformations.

(b): The covariant form of the transition amplitude, T_{fi}, from an initial state i to final state f is given by

$$T_{fi} = -i \int dx^4 \phi_f^*(x) V(x) \phi_i(x)$$

use this expression to derive Fermi's Golden rule.

(c): What kind of particles do obey Dirac equation? How did Dirac interpret negative energy solutions in his Hole theory?

Question 7: $(12 + 10 + 3 = 25)$

(a): For a proper infinitesimal Lorentz transformation

$$\Lambda_\mu^\nu = \delta_\mu^\nu + \epsilon_\mu^\nu,$$

show that an S which satisfies $S^{-1}\gamma^\nu S = \Lambda_\mu^\nu \gamma^\mu$ is

$$S = 1 - \frac{i}{4}\sigma_{\mu\nu}\epsilon^{\mu\nu}$$

and hence show that

$$S^{-1} = \gamma^0 S^\dagger \gamma^0$$

(b): Show that in the ultrarelativistic limit, an eigenstate of a helicity operator will also become eigenstate of the chirality operator and vice versa.

(c): Show that $(\sigma^{\mu\nu})^\dagger = \gamma^0 \sigma^{\mu\nu} \gamma^0$.