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[3722]-21

M. Sc.

PHYSICS

PHY UT - 601 : Electrodynamics

(Old Course) (2005 Pattern) (Sem. - II)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory. Attempt any four questions from the remaining.***
2) ***Draw neat labelled diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and calculator is allowed.***

Q1) Attempt any four of the following :

a) Calculate the frequency at which the skin-depth in sea water is 1m.

Given : $\mu = \mu_0 = 4\pi \times 10^{-7}$ Wb/A-m and $b = 4.3\frac{mho}{m}$. **[4]**

b) If the average distance between the sun and earth is 1.5×10^{11} m, find the average solar energy incident on the earth.

Given P = 3.8×10^{26}W. **[4]**

c) Find the velocity at which the mass of the particle is double it's rest mass. Given C = 3×10^8 m/s. **[4]**

d) Given the e.m. wave $\vec{E} = \hat{i}E_0 \cos w\left(\sqrt{\in \mu}\, z - t\right) + jE_0 \sin w\left(\sqrt{\in \mu}\, z - t\right)$, where E_0 is constant. Find the corresponding magnetic field. **[4]**

e) Write Maxwell's equation in differential and integral forms. **[4]**

f) Write and explain the expression for force describing magnetic interaction between two current loops. **[4]**

Q2) a) Obtain Faraday's law of induction for a stationary medium. Hence show that for moving medium it is expressed as -

$\vec{\nabla} \times \left(\vec{E}' - \vec{u} \times \vec{B}\right) = \frac{-\partial \vec{B}}{\partial t}$, where $\vec{E}'$ is the field observed by a moving observer and $\vec{u}$ is the velocity of the motion of the medium. **[8]**

P.T.O.

b) Prove that the space interval $x^2 + y^2 + z^2$ is not invariant under Lorentz transformations, while the combined space-time interval $x^2 + y^2 + z^2 - c^2t^2$ is Lorentz invariant. **[8]**

Q3) a) Explain Michelson-Morley experiment with reference to the special theory of relativity. Derive the necessary formula for the fringe shift and comment on the result. **[8]**

b) The magnetic field intensity $\vec{B}$ at a point is given by $\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\frac{\vec{j}\times\vec{r}}{r^3}\,d\tau$.

show that $\left(\vec{\nabla}\times\vec{B}\right) = \mu_0\vec{j}$. **[8]**

Q4) a) A plane e.m. wave is incident obliquely on an interface between the two non-conducting dielectric media. Obtain expressions for Fresnell's equations if the electric field vectors are perpendicular to the plane of incidence. **[8]**

b) Explain the term Hertz Potential and show that it obeys inhomogenous wave equation. Obtain the electric and magnetic fields in terms of Hertz potential $\vec{Z}$. **[8]**

Q5) a) What is a linear quadrupole? Derive the expression for potential at a distant point due to a small linear quadrupole. **[8]**

b) Explain the term e.m. field tenser and hence derive the expression for this field tenser $F_{\mu\upsilon}$. **[8]**

Q6) a) State and prove Poynting's theorem resulting to the flow of energy at a point in space in an electromagnetic field. **[8]**

b) Solve the inhomogeneous wave equation :

$\Box^2 \psi(x_\alpha, t) = -g(x_\alpha, t)$ by Fourier analysis.

Use Dirac-delta function $G\left(x_\alpha, x'_\alpha\right)$ to obtain the solution. **[8]**

Q7) a) Two identical bodies move towards each other, the speed of each being 0.9C. What is their speed relative to each other? **[4]**

b) Find the phase velocity of a plane e.m. wave at a frequency of 10 GHz in polyethelene material.

Given : $\mu \simeq \mu_0 = 4\pi \times 10^{-7}$ Wb/A-m, $\in_r = 2.3$,

$\in_0 = 8.85 \times 10^{-12} C^2/N\text{-}m^2$ and

$b = 2.56 \times 10^{-4}$ mho/m. **[4]**

c) Explain the term 'Four Vector Potential'. **[4]**

d) Describe and explain the Minkiowski's space-time diagram. **[4]**

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[3722]-23

M. Sc.

PHYSICS

PHY UT - 603 : Statistical Mechanics in Physics

(Old Course) (2005 Pattern) (Sem. - II)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory. Attempt any four of the remaining questions.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and electronic pocket calculator is allowed.***

Constants :	1)	Boltzman constant	k_B	=	1.38×10^{-23} J/K.
	2)	Planck's constant	h	=	6.623×10^{-34} Js.
	3)	Avogadro's number	N	=	6.023×10^{23} cgs units.
	4)	Mass of electron	m_s	=	9.1×10^{-31} kg.
	5)	Velocity of light	C	=	3×10^{8} m/s.
	6)	Gas constant	R	=	8.314 J/mole/°K.

Q1) Attempt any four of the following :

a) The energy levels of harmonic oscillator are given by $E_n = \left(n + \frac{1}{2}\right)\hbar\omega$.

Find the ratio of probability of the harmonic oscillator being in the first excited state to the probability of it being in the ground state. **[4]**

b) For Helium gas at room temperature (300°K) and atmospheric pressure; calculate N/V. **[4]**

c) Energy states of a particle moving in a rigid cubical box is given by

$$n_x^2 + n_y^2 + n_z^2 = \frac{2ml^2E}{\pi^2\hbar^2} = 14.$$

Determine the number of microstates accessible to the particle. **[4]**

d) If $\overline{F} = \overline{E} - TS = - kTluZ$

Show that $E = \frac{\partial(\beta F)}{\partial\beta}$. **[4]**

e) A particle of unit mass is executing simple harmonic motion. Determine its trajectory in phase space. **[4]**

f) State and explain the concept of equal-a-priori probability. **[4]**

Q2) a) For canonical ensembles show that the probability of finding the system in a particular microstate '*r*' having energy E_r is given by $P_r = \frac{e^{-\beta E_r}}{\sum_r e^{-\beta E_r}}$. **[8]**

b) Show that the fluctuation in number of particles in a system in grand canonical ensembles is given by $\overline{(\Delta N)^2} = KT\left(\frac{\partial \overline{N}}{\partial \mu}\right)$. **[8]**

Q3) a) Obtain the partition function of a photon gas. Hence derive Planck's radiation formula. **[8]**

b) State and prove equipartition theorem. **[8]**

Q4) a) What is Gibb's paradox? How is it resolved? **[8]**

b) Write the partition function for Bose-Einstein statistics and hence obtain B.E. distribution in the form $\overline{n}_r = \frac{1}{e^{\beta(E_r - \mu)} - 1}$

Where μ is chemical potential. **[8]**

Q5) a) Obtain Maxwell's velocity distribution and hence show that the ratio of root mean square velocity υ_{rms} to mean velocity $\overline{\upsilon}$ to the most probable velocity $\tilde{\upsilon}$ is given by $\upsilon_{rms} : \overline{\upsilon} : \tilde{\upsilon} \cong \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$. **[10]**

b) According to Pauli's paramagnetism, show that paramagnetic susceptibility is independent of temperature but strongly dependent on the density of the gas. **[6]**

Q6) a) Obtain the expression for mean energy of fermions at $T = O°K$. **[6]**

b) Show that for classical monoatomic ideal gas having N particles contained in volume V, the number of states $\Omega(E)$ of the system in the energy range E and $E + \delta E$ is given by $\Omega(E) = BV^N E^{3N/2}$

Where B is constant independent of V & E. **[10]**

Q7) a) Write a short note on "Statistical Ensembles". **[4]**

b) Compare the basic postulates of B.E. and F.D. statistics. **[4]**

c) Use canonical distribution to obtain the mean energy $(\overline{E})$. **[4]**

d) Explain the concept of microstate and macrostates. **[4]**

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[3722]-24

M. Sc.

PHYSICS

PHY UT - 604 : Quantum Mechanics II

(Old Course) (2005 Pattern) (Sem. - II)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory.***
2) ***Attempt any four from remaining.***
3) ***Draw neat diagrams wherever necessary.***
4) ***Figures to the right indicate full marks.***
5) ***Use of Mathematical tables and calculators are allowed.***

Q1) Attempt any four from following :

a) Find the Eigen values of exchange operator P_{12} for identical particles. **[4]**

b) Discuss validity conditions of W.K.B. approximation. **[4]**

c) Show that the total energies in Laboratory and centre of mass system is related by $T_{cm} = \frac{m_2}{m_1 + m_2} T_{Lab}$. **[4]**

d) Discuss the selection rule for electric dipole approximation. **[4]**

e) What is perturbation? Develop first order perturbation equations for stationary states. **[4]**

f) Discuss role of symmetry in quantum mechanics. **[4]**

Q2) a) Obtain Slator's determinant for system of N electrons. **[8]**

b) Explain the term differential cross section. Show that differential cross section is directly proportional to scattering amplitude. **[8]**

Q3) a) Using variation method obtain an expression for ground state of hydrogen atom. **[8]**

b) Prove that

$$\sigma_{total} = \frac{4\pi}{k} \ \mathrm{I}_m \ f(0)$$

Where $f(0)$ is imaginary part of the forward scattering amplitude. **[8]**

Q4) a) What do you mean by partial waves? Obtain the partial wave shift δ_l for scattering from square well potential. **[8]**

b) Develop time dependent perturbation theory to obtain first order correction to amplitude $a_f^{(1)}(t)$. **[8]**

Q5) a) Compare classical and quantum mechanical treatment for scattering of identical particles. **[8]**

b) Using WKB approximation, obtain the transmission coefficient for α particle. **[8]**

Q6) a) Obtain first order equation of time independent perturbation theory. Consider a doubly denerate level and show that the perturbation removes degeneracy. **[8]**

b) Deduce the expression for scattering amplitude using Born approximation for Yukawa Potential. **[8]**

Q7) a) Explain principle of variation method. Show that it leads to better estimation. **[4]**

b) What are symmetric and antisymmetric wave functions? **[4]**

c) Describe vectors and pseudovectors in terms of intrinsic parity. **[4]**

d) Discuss the centre of mass and laboratory frame of reference with respect to scattering cross section. **[4]**

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[3722]-31
M. Sc.
PHYSICS
PHY UT - 701 : Solid State Physics
(Old Course) (Sem. - III)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory and solve any four questions from the remaining.***
2) ***Draw neat labelled diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic table and pocket calculator is allowed.***

Given : Rest mass of the electron = 9.109×10^{-31} kg.
Charge on the electron = 1.602×10^{-19} coulomb.
Planck's constant = 6.026×10^{-34} J-s.
Boltzmann constant = 1.3805×10^{-23} J.K^{-1}.
Avogadro's number = 6.0225×10^{26} (kilo mole)$^{-1}$.
Bohr magneton = 9.27×10^{-24} A-m^2.
Permeability of free space = $4\pi \times 10^{-7}$ Henry/m.
Permittivity of free space = 8.85×10^{-12} C^2/N-m^2.

Q1) Attempt any four of the following : **[16]**

a) Find the energies of the six lowest energy levels of a particle in a cubical box which of the levels are degenerate?

b) Draw neat diagrams showing construction of the first two Brillouin sones in a two dimensional square lattice.

c) If all the molecular dipoles in a 1.0 cm. radius water drop are pointed in the same direction, calculate the intensity of polarization. Dipole moment of the water molecule is 6×10^{-30} c-m.

d) Calculate the critical current which can flow through a long thin superconducting wire of aluminium of diameter 10^{-3} m. The critical magnetic field for aluminium is 7.9×10^3 amp./m.

e) A paramagnetic substance has 10^{28} atoms/m^3. The magnetic moment of each atom is 1.8×10^{-23} amp.m^2. Calculate the paramagnetic susceptibility at 300K.

f) State Larmor's theorem.

P.T.O.

Q2) a) Distinguish between reduced zone, extended zone and periodic zone schemes of representing energy bands. **[8]**

b) Define dielectric function of the free electron gas and derive an expression for plasma frequency. **[8]**

Q3) a) State and prove Bloch theorem for the function Ψ_K for a general potential at general value of K. **[8]**

b) Write a note on ferroelectricity and ferroelectric crystals with reference to Batioz. **[8]**

Q4) a) Derive London equation for superconducting state and obtain an expression for penetration depth. **[8]**

b) Explain the quantum theory of paramagnetism and obtain curie law. Discuss the behaviour of rare earth ions. **[8]**

Q5) a) Describe the assumptions of BCS theory of superconductivity. **[8]**

b) Describe the Weiss molecular theory of ferromagnetism with reference to Curie point. Hence derive Curie-Weiss law. **[8]**

Q6) a) Explain the origin of dimagnetism in a free atom. Derive Langevin's theory and derive an expression for diamagnetic susceptibility. **[8]**

b) Discuss the term Anisotropy energy with reference to magnetisation. **[4]**

c) What is meant by hystersis in magnetic materials? **[4]**

Q7) a) An insulator must have an even number of valence electrons per atom. Comment. **[4]**

b) Explain Meissner effect in superconductivity. **[4]**

c) Discuss the domain structure in ferromagnetic materials. **[4]**

d) Explain how Fermi surface can be constructed in two dimensions. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 2**

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[3722]-41

M. Sc.

PHYSICS

PHY UT - 801 : Nuclear Physics

(Old Course) (2005 Pattern) (Sem. - IV)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory. Attempt any four questions from the remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and pocket calculator is allowed.***

Q1) Attempt <u>any four</u> of the following :

a) What is distance of closest approach of a 2 MeV proton to a gold nucleus? How does this distance compare with for a deuteron and α particle of the same energy?

(Given : Z = 79, z = 1, $e = 1.6 \times 10^{-19}$ C, $4\pi \in_0 = \frac{1}{9 \times 10^{+9}}$) **[4]**

b) Calculate the total cross-section for n-p scattering at neutron energy 2 MeV (lab).
(Given : $a_t = 5.38$ F, $a_s = -23.7$ F, $r_{ot} = 1.70$ F and $r_{os} = 2.40$ F,

$\hbar = 1.054 \times 10^{-34}$ Js, M = 1.6748×10^{-27} kg). **[4]**

c) Calculate total angular momentum I, magnetic moment and Quadropole moment Q, also state parity of ${}_8O^{17}$ using shell model. **[4]**

d) State the assumptions of Fermi theory of Beta decay. **[4]**

e) Explain pair production in case of absorption of Gamma Rays. **[4]**

f) Which of the following reactions are allowed or forbidden under the conservation of strongess, conservation of baryan number and conservation of charge.

i) $\pi^+ + n \longrightarrow \wedge^0 + K^+$

ii) $\pi^- + p \longrightarrow \pi^0 + \wedge^0$ **[4]**

P.T.O.

Q2) a) State basic components of mass spectroscope. With necessary diagrams explain the working of Bainbridge and Jordan mass spectrograph state its advantages. **[10]**

b) Discuss the violation of parity conservations in beta decay. **[6]**

Q3) a) Show that the stoping power does not depend on the mass of particle but is a only function of its velocity and charge. **[8]**

b) Discuss various aspects of collective model of nucleus. **[8]**

Q4) a) In case of gamma decay; explain multipole radiations and state selection rules. **[8]**

b) State three categories of semiconductor junction type detector and explain any one in detail. **[8]**

Q5) a) Explain neutron-proton scattering at low energy. Find expressions for

i) Scattering length

ii) Phase-shift and

iii) Total scattering cross-section. **[12]**

b) In case of elementary particles, explain terms

i) Conservation of isopin and

ii) Conservation of strangeness. **[4]**

Q6) a) Write a note on : Quark theory of elementary particles. **[6]**

b) Discuss collective nuclear mode. **[6]**

c) Why the study of *p-p* scattering is capable of much higher accuracy than *n-p* scattering? **[4]**

Q7) a) Explain coherent scattering of slow neutrons. **[6]**

b) Describe the principle and working of microtron. **[6]**

c) Enlist the evidences for the existance of magic numbers. **[4]**

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P880

[3722]-101

M. Sc.

PHYSICS

PHY UTN - 501 : Classical Mechanics

(New Course) (Sem. - I)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory and solve any four questions from the remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic table and electronic pocket calculator is allowed.***

Q1) Attempt <u>any four</u> of the following :

a) Obtain the equation of motion of a Atwood's machine by using Lagrangian method. **[4]**

b) Describe the Hamiltonian and Hamilton's equation of motion for a charged particle moving in an electromagnetic field. **[4]**

c) Two particles of masses m_1 and m_2 are located on a frictionless double inclined plane and connected by an inextensible string passing over a smooth peg. Use D'Alembert's principle to show equation of motion is $(m_1 + m_2)\ \ddot{r}_1 = (m_1\sin\theta_1 - m_2\sin\theta_2)g$ **[4]**

d) A particle is constrained to move along the inner surface of a fixed hemispherical bowl. Calculate the number of degrees of freedom. **[4]**

e) A bead moves on a circular wire. Specify the type of constraint and constraint force. **[4]**

f) Prove that generating function $F = \Sigma\ q_i\, p_i$ generates the identity transformation. **[4]**

Q2) a) What is Focault's pendulum? A vertical rod PQ is rotating with constant angular velocity $\vec{\omega}$. An inextensible light spring of length 'l' has one end attached at R of the rod while the other end S has mass 'm'. Find the tension in the string. **[8]**

b) Show that $Q = lu\dfrac{\sin p}{q}$, $P = q\cot p$ are canonical. Find corresponding F_1 and F_2. **[8]**

Q3) a) Prove that under canonical transformation (q, p) to (Q, P)

$[F, G]_{q,p} = [\overline{F}, \overline{G}]_{Q,P}$ **[8]**

b) Show that $Q = \sqrt{2q}\, e^t \cos p$ and $P = \sqrt{2q}\, e^{-t} \sin p$ are canonical. **[8]**

Q4) a) Evaluate the Poisson's brackets.

i) $[L_x, x]$

ii) $[L_x, p_x]$ **[8]**

b) Explain variational principle. Apply variational principle to find the equation of one dimensional oscillator. **[8]**

Q5) a) Compare Newtonian, Lagrangian and Hamiltonian formulation and discuss the advantages and disadvantages of each. **[8]**

b) State and prove Viral theorem. **[8]**

Q6) a) Write down the Lagrange's equation of motion for a particle of mass m falling freely under gravity near the surface of earth. **[8]**

b) Obtain the Hamiltonian and equation of motion for a projectile near the surface of the earth. **[8]**

Q7) a) A bullet is fixed horizontally in the north direction with a velocity of 500 m/sec at 30° N latitude. Calculate the horizontal component of Coriolis acceleration and the consequent deflection of the bullet as it hit a target 250 meters away. Also determine the vertical displacement of the bullet due to gravity. If the mass of the bullet is 10 gm. Find the Coriolis force. **[8]**

b) Explain artificial satellite. **[4]**

c) Draw phase space diagram for **[4]**

i) Damped and Undamped harmonic oscillator.

ii) A stone thrown vertically up in the field of uniform gravity.

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P881

[3722]-102

M. Sc.

PHYSICS

PHY UTN - 502 : Electronics

(New Course) (Sem. - I)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory. Attempt any four questions from the remaining.***
2) ***Figures to the right indicate maximum marks.***
3) ***Draw neat diagrams wherever necessary.***
4) ***Use of logarithmic tables and calculator is allowed.***

Q1) Attempt any four of the following :

a) State atleast four parameters of Op.Amp. and explain any two in detail. **[4]**

b) Design a wide band reject filter having f_h = 400 Hz and f_l = 2 kHz with pass band gain as 2. Choose C = 0.1 μF. **[4]**

c) Design a 5V regulated power supply using LM317. Assume value of $R_1 = 240\ \Omega$ and $I_{adj} = 100\ \mu A$. **[4]**

d) What is 7490 IC? Design a divide-by-20 counter using ICs 7490. **[4]**

e) Design a function generator using IC 8038 to generate wave form of frequency of 5 kHz. Assume duty cycle is 50%. **[4]**

f) Draw logic diagram of 2 line to 1 line multiplexer and explain its working. **[4]**

Q2) a) Given the logic equation $Y = ABC + B\overline{C}D + \overline{A}BC$ make a truth table. Simplify using Karnaugh-map and sketch the necessary logic diagram. **[8]**

b) Draw the circuit diagram of Instrumentation Amplifier using Op.Amp. and explain its working. Explain how gain can be adjusted using single resistance. **[8]**

Q3) a) Draw the block diagram of counter type ADC and explain its working in detail. What is the resolution of an 8 bit ADC whose max. input voltage range is 10V. **[8]**

P.T.O.

b) Draw the functional diagram of IC 7495 and explain its working with reference to the operations SISO and PIPO. **[8]**

Q4) a) What is a monostable multivibrator? Explain the working of monostable multivibrator IC 74121 with necessary functional table. Design a monostable multivibrator using IC 74121 to generate a pulse of 5 m sec. **[8]**

b) Explain in detail working of 4-bit R-2R DAC with necessary circuit diagram. State and explain atleast 2 - characteristics of DAC. **[8]**

Q5) a) Explain the basic operating principle of a PLLIC565 with necessary block diagram. Give expression for

i) free running frequency

ii) lock range

iii) capture range.

Discuss any one application of PLL in detail. **[8]**

b) Draw the circuit of a full-wave precision rectifier using Op.Amp. and explain how it gives the average value. **[4]**

c) Explain the concept of DC to DC converter with suitable diagram. **[4]**

Q6) a) Write the count sequence of a 4 bit BCD and binary up-counter. Draw the logic diagram of 4 bit up/down counter using ff′s and explain its working. **[8]**

b) Explain the concept of current limit in case of IC 723. Design a 5V regulator with current limit of 1 Amp. using IC 723 and with external current boost transistor. **[8]**

Q7) Write short note on any four of the following : **[16]**

a) Optical fiber communication.

b) Satellite communication.

c) VCO.

d) Switching Regulator.

e) UPS and Invertors.

f) Sample and hold circuit.

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Total No. of Questions : 7] **[Total No. of Pages : 3**

P882

[3722]-103

M. Sc.

PHYSICS

PHY UTN - 503 : Methods of Mathematical Physics

(New Course) (2008 Pattern)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory. Attempt any four questions from the remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic table and pocket calculator is allowed.***

Q1) Attempt any four of the following : **[16]**

a) What are spherical harmonics? State the orthogonality condition satisfied by them.

b) Let W be the subspace of R^4 generated by {(1, –2, 5, –3), (2, 3, 1, –4), (3, 8, –3, –5)}. Find the basis and dimensions of W.

c) Prove Schwartz inequality for vectors in an inner product space.

d) State and prove Parseval's identity for Fourier series F(x).

e) Find the Laplace transform of the function

$$f(t)=\begin{cases} =\cos\left(t-\dfrac{2\pi}{3}\right), & t>\dfrac{2\pi}{3} \\ =0 & ,\ t<\dfrac{2\pi}{3} \end{cases}$$

f) Show that the function $f(z) = z^2$ is an analytic function of z.

P.T.O.

Q2) a) State Cauchy's integral formula and prove that

$$f(z_0)=\frac{1}{2\pi i}\int_c \frac{f(z)}{z-z_0}dz\,. \qquad \textbf{[8]}$$

b) Expand $f(x)$ in the form of Fourier series

where $f(x) = 0 \quad 0 < x < L$

$= 1 \quad L < x < 2L$ **[8]**

Q3) a) Solve $x''(t)+4x'(t)+4x(t)=4e^{-2t}$ using Laplace transform

Given : $x(0) = -1 \qquad x'(0)=4$ **[8]**

b) Use the calculus of residue to prove

$$\int_0^{2\pi}\frac{d\theta}{2+\cos\theta}=\frac{2\pi}{\sqrt{3}} \qquad \textbf{[8]}$$

Q4) a) Find the eigenvalues and the corresponding orthonormal eigenvectors of the given matrix.

$$A=\begin{bmatrix}1 & 0 & 1\\ 0 & 1 & 0\\ 1 & 0 & 1\end{bmatrix} \qquad \textbf{[8]}$$

b) Using Gram-Schmidt orthogonalization procedure construct first three Legendre polynomials.

$u_n(x) = x^n$ for $-1 \le x \le 1$ and n = 0, 1, 2 .... and the density function $w(x) = 1$. **[8]**

Q5) a) Obtain the orthogenality for Hermite polynomials

$$\int_{-\infty}^{\infty} H_n(x)H_m(x)e^{-x^2}dx = 2^n n!\sqrt{\pi}\,\delta mn \qquad \textbf{[8]}$$

b) Let U & W be the subspaces of R^4 generated by

U $\equiv$ {(1, 1, 0, –1), (1, 2, 3, 0), (2, 3, 3, –1)} and

W $\equiv$ {(1, 2, 2, –2), (2, 3, 2, –3), (1, 3, 4, –3)}.

Obtain

i) $\dim(U + W)$ ii) $\dim(U \cap W)$ **[8]**

Q6) a) Find $L^{-1}\left\{\dfrac{2s^2-4}{(s+1)\,(s-2)\,(s-3)}\right\}$ **[8]**

b) Obtain an expression for the integral representation of Bessel function

$$J_n(x) = \frac{1}{\pi}\int_0^{\pi} \cos(n\theta - x\sin\theta)\,d\theta$$ **[8]**

Q7) a) Let V = R^3. If W = {(a, b, c) : a $\geq$ 0}. then prove that W is not subspace of V. **[4]**

b) Prove for Laguerre polynomial

$(1 + 2n - x)\, L_n(x) = n^2\, L_{n-1}(x) + L_{n+1}(x)$. **[4]**

c) Find the Fourier cosine transform of $f(x) = e^{-2x} + 4e^{-3x}$. **[4]**

d) Expand $\dfrac{1}{(z-1)\,(z-2)}$ in a form of Taylor series for $|z| < 1$. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 3**

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[3722]-104

M. Sc.

PHYSICS

PHY UTN - 504 : Quantum Mechanics - I

(New Course) (Sem. - I)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory.***
2) ***Attempt any four from the remaining.***
3) ***Figures to the right indicate full marks.***
4) ***Draw neat diagrams wherever necessary.***
5) ***Use of Mathematical tables and pocket calculator is allowed.***

Q1) Attempt any four of the following : **[16]**

a) The spectral density of a matter wave-packet is in the form of a symmetrical exponential as : $\phi(k) = Ae^{-\pi|k|}$

Find the form of wave function $\psi(x)$.

b) The x-component of a linear momentum P_x is classically expressed as $P_x = m\frac{dx}{dt}$. By using Schroedinger equation, show that

$$\langle P_x \rangle = \int_{-\infty}^{+\infty} \Psi^*(x,t)\left(\frac{\hbar}{i}\frac{\partial}{\partial x}\right)\Psi(x,t)\,dx\ .$$

c) Define :

i) adjoint of an operator $\hat{A}$

ii) Hermitian operator and

Show that $(\hat{A}\,\hat{B})^{+} = \hat{B}^{+}\,\hat{A}^{+}$

d) Explain unitary operator. Show that the norm of a state functions do not changes under unitary transformation.

e) In three dimension, the ground state wave-function of hydrogen atom is $\Psi(x)=\left(\frac{1}{\pi a_0^3}\right)^{\frac{1}{2}} e^{-r/a_0}$ where a_0 is Bhor radius. Then show that the probability in momentum space is : $C(p)=\frac{1}{\pi}\left(\frac{2a_0}{\hbar}\right)^{\frac{3}{2}} \frac{1}{\left[\left(p^2 a_0^2/\hbar^2\right)+1\right]^2}$

f) The operators for angular momentum are : $J_+ = J_x + iJ_y$ and $J_- = J_x - iJ_y$

Show that : (i) $[J_+, J_-] = 2\hbar J_z$ and (ii) $[J_z, J_-] = -\hbar J_-$

Q2) a) A particle of mass m is moving in potential well :

$V(x) = V_0$ for $x < -a$

$= O$ for $-a < x < a$

$= V_0$ for $x > a$

When energy of a particle $E < V_0$; then show that there exists at least one bound state. **[8]**

b) Obtain Clebsch-Gordan coefficients for a system of two non-interacting particles with angular momenta : $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. **[8]**

Q3) a) Using ladder operator method, obtain the energy eigen values and eigen functions of a one dimensional harmonic oscillator. **[10]**

b) What are observables? Using expansion postulate show that **[6]**

i) Eigen functions belonging to discrete eigen-values are normalizable.

ii) Eigen functions belonging to contineous eigen values are of infinite norm.

Q4) a) Obtain the eigen value spectrum of L^2 and L_z operators. **[8]**

b) Describe Schroedinger and Heigenberg pictures regarding the evolution of a system with time. **[8]**

Q5) a) What is spin angular momentum and spin space of a particle having spin S. For spin = $\frac{1}{2}$ particles; explain Pauli spin matrices and show that

i) $\sigma_x^2 + \sigma_y^2 + \sigma_z^2 = 3$ and ii) $\sigma_x \sigma_y = i\sigma_z$ **[8]**

b) Apply the evolution equation of Heigenberg's picture, to construct the position operator $\hat{x}(t)$ and momentum operator $\hat{p}(t)$ for harmonic oscillator. **[8]**

Q6) a) When the unitary transformation is induced by rotation of co-ordinate system then show that **[8]**

i) $\left(\frac{L_z}{\hbar}\right)$ plays the role of the generator of infinitesimal rotation

ii) $\langle x | \Psi' \rangle = \langle x | e^{i\theta \bar{n}.\bar{L}/\hbar} | \Psi \rangle$.

b) Explain completeness property and prove the closure relation. **[8]**

Q7) a) Define projection operator. Show that the sum of all the projection operators leaves any state vector $|\Psi\rangle$ unchanged. **[4]**

b) Obtain matrices for J_x and J_y when $j = \frac{1}{2}$. **[4]**

c) In Dirac formulation of Quantum Mechanics; explain the terms : **[4]**

i) State vectors

ii) Hilbert space

d) Use Dirac notation to prove that the Eigen values of Hermitian operator are real. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 3**

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M. Sc.

PHYSICS

PHY UTN - 601 : Electrodynamics

(New Course) (2008 Pattern) (Sem. - II)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) *Question No. 1 is compulsory and solve any four questions from the remaining.*
2) *Draw neat labelled diagram wherever necessary.*
3) *Figures to the right indicates full marks.*
4) *Use of logarithmic tables and pocket calculator is allowed.*

Q1) Attempt <u>any four</u> of the following :

a) Calculate the intrinsic impedance of an e.m. wave travelling through free space.

Given for free space : $\mu \simeq \mu_0 = 4\pi \times 10^{-7}$ Wb/A-m

and $\in\ = \in_0 = 8.85 \times 10^{-12}$ $C^2/N\text{-}m^2$. **[4]**

b) Find the ratio of skin depth in copper at 1KHz to that at 100 MHz. **[4]**

c) Two identical bodies move towards each other, the speed of each being 0.9C. Find their speed to each other. **[4]**

d) Calculate the magnitude of Poynting's vector at the surface of the sun. Given : Power radiated by sun is 3.8×10^{26} Watt and radius of the sun is 7×10^8 m. **[4]**

e) Calculate the rest mass energy of an electron in eV if it's rest mass is equal to 9.1×10^{-31} kg. **[4]**

f) Show that the ratio of electrostatic and magnetostatic energy densities $\left(\frac{u_e}{u_m}\right)$ is equal to unity. **[4]**

P.T.O.

Q2) a) Show that the Maxwell's equations in a charge free region lead to

$$\nabla^2 \vec{E} - \frac{KKm}{C^2}\frac{\partial^2 \vec{E}}{\partial t^2} - \mu b \frac{\partial \vec{E}}{\partial t} = 0$$

Explain which term is predominant in metals. **[8]**

b) The magnetic field intensity $\vec{B}$ at a point is given by $\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\int \frac{\vec{j}\times\vec{r}}{r^3}\, d\tau$.

Show that Curl $\vec{B} = \mu_0 \vec{j}$. **[8]**

Q3) a) Explain the term 'multipole moments'. Derive an expression for potential at a distant point using multipole expansion for a localized charge distribution in free-space. **[8]**

b) Show that the operator :

$\Box^2 \equiv \nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2}$ is invariant under Lorentz transformations where as

$\nabla^2 \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$ is not Lorentz invariant. **[8]**

Q4) a) If a medium is moving with a velocity $\vec{u}$, then show that the Faraday's law has the form $\vec{\nabla} \times \left(\vec{E}' - \vec{u} \times \vec{B}\right) = \frac{-\partial \vec{B}}{\partial t}$. **[8]**

b) Describe Michelson-Morley experiment with reference to the special theory of relativity. Derive the necessary formula for the fringe shift and comment on the result. **[8]**

Q5) a) Starting from Maxwell's equations, derive inhomogenous wave equations in terms of scalar potential ϕ and vector potential $\vec{A}$. Hence explain Lorentz's and coulomb's gauges. **[8]**

b) Prove the relativistic addition theorem for velocities :

$u_x = \dfrac{u'_x + v}{1 + \dfrac{u'_x v}{c^2}}$ where $u'_x = \dfrac{dx'}{dt'}$ and $u_x = \dfrac{dx}{dt}$.

Hence show that any velocity added relativistically to 'c' gives resultant velocity 'c', which is Lorentz invariant. **[8]**

Q6) a) Explain the term e.m. field tensor. Hence derive an expression for e.m. field tensor $F_{\mu\upsilon}$. **[8]**

b) Describe the term Hertz potential and show that it obeys inhomogenous wave equation. Obtain the electric and magnetic fields in terms of Hertz potential $\vec{Z}$. **[8]**

Q7) a) Calculate the electric field associated with a LASER beam having energy density $10^6 J/cm^3$. **[4]**

b) Explain Minkowski's space-time diagram. **[4]**

c) Write the expression for force describing magnetic interaction between two current loops and explain it. **[4]**

d) Describe the term 'Four Vector Potential'. **[4]**

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M. Sc.

PHYSICS

PHY UTN - 603 : Statistical Mechanics in Physics

(New Course) (2008 Pattern) (Sem. - II)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) *Question No. 1 is compulsory. Attempt any four of the remaining questions.*
2) *Draw neat diagram wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and electronic pocket calculator is allowed.*

Constants :	1)	Boltzmann constant	k_B	=	1.38×10^{-23} J/K.
	2)	Planck's constant	h	=	6.623×10^{-34} Js.
	3)	Avogadro's number	N	=	6.023×10^{23} cgs units.
	4)	Mass of electron	m_e	=	9.1×10^{-31} kg.
	5)	Charge on electron	e	=	1.6×10^{-19} C
	6)	Velocity of light	C	=	3×10^{8} m/s.

Q1) Attempt any four of the following :

a) Prove the following relation : **[4]**

$$S = -k\sum_r p_r \ln p_z$$

b) Show that mean square deviation for the number of particles distributed according to grand canonical distribution is given by

$$\overline{(\Delta N)^2} = KT\frac{\partial \overline{N}}{\partial \mu}$$ **[4]**

P.T.O.

c) A simple harmonic one dimensional oscillator has energy level given by $E_n = \left(n + \frac{1}{2}\right)\hbar\omega$ where 'ω' is the characteristic angular frequency of the oscillator and 'n' is the quantum number, assures the possible integral values $n = 0, 1, 2$ .... Suppose that such an oscillator is in thermal contact with a heat reservoir then find the ratio of the probability of the oscillator being in the first excited state to the probability of its being in the ground state. **[4]**

d) The molar mass of Lithium is 0.00694 and its density is 0.53×10^6 kg/m^3. Calculate the Fermi energy of electron. **[4]**

e) Prove the following relation : **[4]**

$$\overline{P} = KT \frac{\partial \ln Z}{\partial V}$$

f) Prove the following relation : **[4]**

$$\left[\frac{\overline{(\Delta E)^2}}{(\overline{E})^2}\right]^{1/2} = \left[\frac{2}{3N}\right]^{1/2}$$

Q2) a) For canonical ensemble, show that probability of finding the system in a particular microstate 'r' having energy E_r is given by

$$P_r = \frac{e^{-\beta E_r}}{\sum_r e^{-\beta E_r}}$$ **[8]**

b) Explain, what do you mean by Bose-Einstein condensation. **[8]**

Q3) a) Show that, when $T << \theta_r$

$$(C_\vartheta)_{rot} = 12NK\left(\frac{\theta_r}{T}\right)^2 e^{-\frac{2\theta_r}{T}}$$

where θ_r = The rotational characteristic temperature in the lowest approximation. **[8]**

b) State the partition function for M. B. Statistics and show that the quantum distribution function for M. B. Statistics

$$\bar{n}_s = \frac{Ne^{-\beta\epsilon_s}}{\sum_s e^{-\beta\epsilon_s}}$$ **[8]**

Q4) a) Show that for photon gas, the mean pressure is related to its mean energy by the relation $\bar{P} = \frac{1}{3}\frac{\bar{E}}{V}$. **[8]**

b) Show that specific heat of strongly degenerate Fermi gas is given by $C_V = \frac{\pi^2}{2} R \frac{T}{T_F}$. **[8]**

Q5) a) Compare the basic postulates of M. B., B. E. and F. D. Statistics. Hence, comment about the probabilities of particles coming together according to B. E. and F. D. Statistics. **[8]**

b) Discuss the phenomenon of sharpness of probability distribution in statistical thermodynamics. **[8]**

Q6) a) Using Canonical distribution, obtain the law of atmosphere. **[8]**

b) State and prove Liouville's theorem. **[8]**

Q7) a) Show that for classical monoatomic ideal gas having particles contained in volume V. The number of states $\Omega(E)$ for the system in the energy range E & $E + \delta E$ is given by

$\Omega(E) = BV^N E^{3N/2}$ **[8]**

b) What is Gibb's paradox? How it is resolved? **[8]**

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Total No. of Questions : 7] [Total No. of Pages : 3

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M. Sc.

PHYSICS

PHY2 UTN - 604 : Quantum Mechanics - II

(New Course) (2008 Pattern) (Sem. - II)

Time : 3 Hours] *[Max. Marks : 80*

Instructions to the candidates :

1) ***Question No. 1 is compulsory. Solve <u>any four</u> questions from remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of Logarithmic tables and calculator is allowed.***

Q1) Attempt <u>any four</u> of the following :

a) Explain the conditions of the validity of W. K. B. approximation. **[4]**

b) What is perturbation? Develope the first and second order perturbation equations for stationary states. **[4]**

c) Find the energy levels and eigen functions of Hamiltonian

$$H = \begin{bmatrix} 1+\in & \in \\ \in & -1+\in \end{bmatrix}$$ where $\in \ll 1$, corrected upto first order in $\in$ by using perturbation theory. **[4]**

d) The scattering amplitude by partial wave analysis is :

$$f(\theta)=\frac{1}{k}\sum_{l=0}^{\infty}(2l+1)\exp(i\delta_l)\sin\delta_l\, P_l(\cos\theta)$$ where symbols have their usual meaning.

Hence obtain optical theorem. **[4]**

e) Show that the angle of scattering in Laboratory frame (θ_L) and in the centre of mass frame (θ_C) are related by :

$$\tan\theta_L = \left[\frac{\sin\theta_C}{\frac{m_1}{m_2}+\cos\theta_C}\right]$$ **[4]**

f) Explain the terms : **[4]**

i) Identical particles and

ii) Symmetric and Antisymmetric wave functions.

Q2) a) Apply non-degenerate time independent perturbation theory to find

i) first order change in energy and

ii) second order change in energy. **[8]**

b) Evaluate the scattering amplitude and differential cross-section for Yukawa potential $V(r)=\dfrac{V_0 \exp(-\alpha r)}{r}$ where V_0 and α are constant use Born approximation. **[8]**

Q3) a) In time dependent perturbation theory, the first order transition amplitude is $a_f^{(1)} = (i\hbar)^{-1} \int_0^t H'_{fi} \, (t)' \, e^{iw} fi^{t'} \, dt'$. Hence obtain Fermi-Golden rule for constant perturbation. **[8]**

b) Obtain the Slater determinant for N-identical particles and explain the Pauli exclusive principle. **[8]**

Q4) a) By using Green's function technique, obtain the expression for the scattering amplitude. **[8]**

b) What is stark effect in hydrogen atom? Show that

i) in the ground state, it is absent

ii) in first order excited level of hydrogen atom :

$$\begin{bmatrix} 0 & -3eFa & 0 & 0 \\ -3eFa & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} a_{0,0} \\ a_{1,0} \\ a_{1,1} \\ a_{1,-1} \end{bmatrix} = W^{(1)} \begin{bmatrix} a_{0,0} \\ a_{1,0} \\ a_{1,1} \\ a_{1,-1} \end{bmatrix}$$

where F = external electric field.

(Given : $\phi_{100} = \dfrac{1}{\sqrt{\pi a_0^2}} e^{-r/a_0}$; $\phi_{200} = \dfrac{1}{4\sqrt{2\pi a_0^3}} \left(2 - \dfrac{r}{a_0}\right) e^{-r/2a_0}$

and $\phi_{210} = \dfrac{1}{4 \, . \sqrt{2\pi a_0^3}} \dfrac{r}{a_0} e^{-r/2a_0} \cos\theta$) **[8]**

Q5) a) Describe the variation method used to estimate ground state energy and apply it to find ground state energy of a one-dimensional harmonic oscillator when trial wave-function is $\psi = Ae^{-\alpha x^2}$. **[10]**

b) Using partial wave analysis, obtain the expression for phase shift of s-wave scattering from hard sphere ($V(r) = \infty$ for $o \le r \le a$ and $V(r) = 0$ for $r > a$). Show that in low energy limit, the total scattering cross-section is $4\pi a^2$. **[6]**

Q6) a) Explain the First Born approximation. Show that for spherically symmetric scattering centre, the Born approximation amplitude is

$f_B(\theta) = \frac{-1}{K}\int_0^\infty r\, sin\, Kr\ U(r)\, dr.$ Hence for the Coulomb screen potential

$V(r) = \frac{-Ze^2}{r} e^{-\alpha r}$; find the Born approximation amplitude $f_B(\theta)$. **[8]**

b) Write down the connecting formulae in W. K. B. approximation, hence obtain Bohr-Sommerfeld quantum rule. **[8]**

Q7) a) The anharmonic Hamiltonian of oscillator is $H = \frac{p^2}{2m} + \frac{1}{2} m\omega^2 x^2 + bx^3$.

Show that the second order correction to ground state energy is $\left(\frac{-11\, b^2\hbar^2}{8\, m^3\omega^4}\right)$. (Given : $a\, u_n = \sqrt{n}\ u_{n-1}$ and $a^+ u_{n-1} = \sqrt{n}\ u_n$) **[4]**

b) Define exchange operator P_{12} for identical particles and show that it commutes with Hamiltonian H(1, 2). **[4]**

c) With necessary diagram, explain scattering event and define differential as well as total scattering cross-section. **[4]**

d) Explain the dipole approximation. Which of the following transitions are allowed : **[4]**

i) $1s \longrightarrow 2s$

ii) $2p \longrightarrow 3d$ and

iii) $3s \longrightarrow 5d$.

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Total No. of Questions : 7] **[Total No. of Pages : 2**

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M. Sc.

PHYSICS

PHY UTN - 701 : Solid State Physics

(New Course) (Sem. - III)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) ***Question No. 1 is compulsory. Attempt any four questions from the remaining.***
2) ***Draw neat labelled diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and pocket calculator is allowed.***

Given :

Rest mass of electron	=	9.109×10^{-31} kg.
Charge of electron	=	1.6021×10^{-19} C.
Planck's constant	=	6.626×10^{-34} J-S.
Boltzmann constant	=	1.3805×10^{-23} JK^{-1}.
Avogadro's number	=	6.0225×10^{26} $(\text{Kilomole})^{-1}$.
Bohr Magneton	=	9.27×10^{-24} $A\text{-}m^2$.
Permeability of free space	=	$4\pi \times 10^{-7}$ Henry/m.
Permittivity of free space	=	8.85×10^{-12} $C^2/N\text{-}m^2$.

Q1) Attempt <u>any four</u> of the following : **[16]**

a) Show that for Kronig-Penny model with P<<1, the energy of the lowest band at K = 0 is $E = \frac{\hbar^2 p}{ma^2}$.

b) Electrical resistivity of Cu at R.T. is 1.6×10^{-8} Ωm. If Wiedemann-Franz law applies to this material, find the electronic contribution of thermal conductivity of Cu at 27°C.

c) For a simple square lattice, calculate K.E. of free electron at the corner and at the mid point of the side face of the 1st Brillouin zone. How are these two values related?

d) A superconducting material has a critical temperature of 3.7 K in zero magnetic field and a critical field of 0.0306 Tesla at zero K. Find the critical field.

e) A paramagnetic material has 10^{28} atoms/m^3. The magnetic moment of each atom is 1.8×10^{-23} $A\text{-}m^2$. Calculate the paramagnetic susceptibility at 300 K.

P.T.O.

f) The magnetic field strength in Cu is 10^6A/m. If the magnetic susceptibility of Cu is – (0.8×10^{-5}), calculate magnetization and flux density.

Q2) a) Derive an expression for energy of free electron in 1-dimensional linear solid of length L. Define Fermi energy. **[8]**

b) State Bloch function $\psi_k(x)$ and prove it for degenerate $\psi_k(x)$. **[8]**

Q3) a) With the help of diagrams explain the concept of reduced, extended and periodic zone schemes used for the representation of energy bands. **[8]**

b) For an atom placed at general lattice site, derive an expression for local electric field E_{local}. Explain each term in the expression. **[8]**

Q4) a) Give an account of Weiss theory of ferromagnetism and show from the plot of Langevin's function, spontaneous magnetization exists below the Curie temperature and vanishes above the Curie temperature. **[8]**

b) Derive London equation for superconducting state and obtain an expression for the penetration depth. **[8]**

Q5) a) Explain Antiferromagnetism with reference to the Neel temperature and susceptibility. Hence describe ferrimagnetism. **[8]**

b) Describe the assumptions of BCS theory of superconductivity. **[8]**

Q6) a) Discuss the origin of diamagnetism in a free atom. Obtain Langevin's diamagnetism equation for the diamagnetic susceptibility. **[8]**

b) Describe Josephson superconducting tunneling. **[4]**

c) Distinguish between type - I and type - II superconductors. **[4]**

Q7) a) Explain the concept of hole based on band structure of solid. **[4]**

b) Write a note on Fermi-Dirac statistics. Explain it's temperature dependence with the help of neat diagram. **[4]**

c) Calculate the critical current which can flow through a long thin superconducting wire of Al of diameter 1 mm. The critical magnetic field for Al is 8×10^3A/m. **[4]**

d) Describe the term 'Bloch wall' with reference to magnetism. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 3**

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[3722]-401

M. Sc.

PHYSICS

PHY UTN - 801 : Nuclear Physics

(New Course) (2008 Pattern) (Sem. - IV)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates :

1) *Question No. 1 is compulsory. Attempt any four questions from the remaining.*
2) *Draw neat diagrams wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and pocket calculator is allowed.*

Q1) Attempt <u>any four</u> of the following :

a) Evaluate the maximum energy shift that can be observed for a body whose quadropole moment is Q. **[4]**

b) For a graphite $\sigma_a = 0.003$ barn, $L_m = 54$ cm, $\tau_o = 364$ cm^2 and for Uranium $\sigma_a = 698$ barn and $\eta = 2.08$. (Given p = 1 & $\in$ = 1)

Calculate thermal utilization factor, k_∞ and thermal diffusion length for the mixture. **[4]**

c) Obtain selection rules for magnetic multipole radiations in case of gamma-decay for electric and magnetic dipole, quadrople. **[4]**

d) Compute the maximum energy of the Compton recoil electrons resulting from the absorption in Al of 2.19 MeV γ-ray.

(rest mass of electron $m_0 = 9.1091 \times 10^{-31}$ kg) **[4]**

e) Which of the following reactions are allowed and forbidden under the conservation of strangeness, conservation of baryon number and conservation of charge. **[4]**

i) $\pi^+ + n \rightarrow \overline{k^0} + \Sigma^+$ &

ii) $\pi^- + p \rightarrow \pi^0 + \wedge^0$

f) Calculate the total cross-section for *n-p* scattering at neutron energy 2MeV in lab system. (Given : $a_t = 5.38$F, $a_s = -23.7$F, $r_{ot} = 1.7$F and $r_{os} = 2.4$F & M = 1.6748×10^{-27} kg, $\hbar = 1.0549 \times 10^{-34}$ Js) **[4]**

P.T.O.

Q2) a) Explain principle, construction and working of a Bain bridge and Jordan Mass spectrometer used to determine the mass of nucleus. State it's advantages. **[8]**

b) By using Schroedinger equation, obtain expressions for phase-shift and scattering cross-section in case of low energy *n-p* scattering. **[8]**

Q3) a) Describe Gamow theory of alpha particle decay and show that :

$$T = \exp\left[-\frac{2\sqrt{2m}}{\hbar^2}\int_{R}^{r_1}\left[v(r)-E\right]^{\frac{1}{2}}dr\right] \quad \textbf{[8]}$$

b) In case of nuclear fission reactors, explain chain reaction with uranium and obtain four-factor formula. **[8]**

Q4) a) With suitable diagrams, describe the working of Van-de-Graff accelerator and explain the action of accelerating tube. **[8]**

b) Give the classification of elementary particle interactions and explain each in brief. **[8]**

Q5) a) In case of interaction of radiations with matter, describe **[8]**

i) stopping power and

ii) range for electrons

b) Describe the construction of microton and obtain the expressions for

i) change in period and

ii) output kinetic energy **[8]**

Q6) a) In case of elementary particles, explain : **[8]**

i) Conservation of baryon number

ii) Conservation of Isospin

iii) Conservation of hypercharge and

iv) Conservation of strangeness.

b) Explain construction and working of proportional counter. Mentions it's applications. **[8]**

Q7) a) Explain coherent scattering of slow neutrons by Ortho and Para hydrogen molecules and explain the spin of neutron. **[6]**

b) Describe the reactor design with reference to **[10]**

i) Fuel

ii) Moderators and reflectors

iii) Reactor coolants

iv) Control materials and

v) Reactor shielding

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