Total No. of Questions : 7]

SEAT No. :

P384

[Total No. of Pages : 3

[4224] - 101
M.Sc.
PHYSICS
PHY UTN - 501 : Classical Mechanics
(2008 Pattern) (Sem. - I)

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

Instructions to the candidates :

1) ***Question No. 1 is compulsory and 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 calculator is allowed.***

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

a) If $\{p_i, q_i\}$, $\{q_i, p_i\}$ are the Lagranges brackets and $[p_i, p_j]$, $[q_i, p_j]$ are the Poisson brackets then prove the following identity

$$\sum_{i=1}^{n}\{p_i, q_j\}[p_i, p_j] + \sum_{i=1}^{n}\{q_i, q_j\}[q_i, p_j] = 0 \cdot$$ **[4]**

b) Two heavy particles of weights W_1 and W_2 connected by a light inextensible string and hang over a fixed smooth circular cylinder of radius R, the axis of which is horizontal. Find the condition of equilibrium of the system by applying the principle of virtual work. **[4]**

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

d) The Lagrangian of a problem is $L = \frac{1}{2} m\,(\dot{r}^2 + r^2\,\dot{\theta}^2) + V(r)$. Identify the cyclic coordinate and the corresponding conservation law for the problem. **[4]**

e) Describe the Hamiltonian and Hamiltonian equations for a simple pendulum. **[4]**

f) A particle sliding down on an inclined plane under the influence of gravity. Specify the types of constraints. **[4]**

P.T.O.

Q2) a) The system S' is rotating relative to system S having the same origin and assumed to be fixed in space. The angular velocity of the time S' relative to S is given by $\vec{w} = 2t\hat{i}' + t^2\hat{j}' + 8\hat{k}'$, where t is the time. The position vector of the particle at the instant t relative to the system S' is given by $r = t^2\, \hat{i}' - 6t\, \hat{j}' - 4t^3\, \hat{k}'$. Find :

i) The apparent velocity.

ii) The true velocity.

iii) The Coriolis acceleration at $t = 1$. **[8]**

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

Q3) a) Find the values of α and β so that the equations. **[8]**

$Q = q^\alpha \cos \beta p$, $\qquad$ $P = q^\alpha \sin \beta p$

represents a canonical transformation. Also find the generating function F_3 for this case.

b) If the transformation equation between two sets of coordinates are $P = 2\,(1 + q^{1/2} \cos p)q^{1/2}$, $\qquad Q = \log\,(1 + q^{1/2} \cos p)$, then show that

i) The transformation is canonical.

ii) The generating function of this transformation is $F_3 = -\,(e^Q - 1)^2 \tan p$. **[8]**

Q4) a) Using Euler - Lagrange differential equation, prove that if f does not depend on x explicitly then $f - y' \dfrac{\partial f}{\partial y'}$ = constant. **[8]**

b) What is Focault's Pendulum? Obtain an equation of motion for such a pendulum. **[8]**

Q5) a) Show that invariance of Poisson bracket with respect to canonical transformation $[Q_k, P_i]_{q,p} = [Q_k, P_i]_{Q,P} = \delta_{kl}$. **[8]**

b) A particle describes a circular orbit under the influence of an attractive central force directed towards a point on the circle. show that the force varies as the inverse fifth power of the distance. **[8]**

Q6) a) A charged particle is moving under the influence of point nucleus. Find the orbit of the particle and the periodic time in the case of an elliptical orbit. **[8]**

b) A particle is constrained to move in a plane under the influence of an attractive towards the origin proportional to the distant from it and also of a force perpendicular to the radius vector inversly proportional to the distance of the particle from the origin in anticlockwise direction. Find the Lagrangian. **[8]**

Q7) a) Discuss the stability of orbit under central force. Hence, show that the circular orbit is stable if n + 3 > 0 where '*n*' is an integer. **[8]**

b) Explain Geosynchronous orbit and Geostationary orbit. Write use of artificial satellite. **[4]**

c) What are configuration space and phase space. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P385

[Total No. of Pages : 2

[4224] - 102
M.Sc.
PHYSICS
PHY UTN - 502 : ELECTRONICS
(2008 Pattern) (Semester - 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) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic table and calculator is allowed.***

Q1) Attempt any four of the following :

a) Design second order, Butterworth low pass filter for f_h = 5 kHz. **[4]**

b) Define following terms used for OPAMP : **[4]**

i) Slew rate
ii) Unity gain bandwidth
iii) Gain error factor
iv) CMRR

c) Design a regulated power supply using IC LM317 to obtain output voltage variable from +2V to +20V. **[4]**

d) Draw block diagram of DC-DC converter. Explain its operation. **[4]**

e) State the requirements to be fullfilled by components used in sample-hold circuit. **[4]**

f) What is PLL? Draw its block diagram. Define its capture range and locking range. **[4]**

Q2) a) Design a combinational logic circuit which multiplies 3-bit binary number by 2 by using k-map. **[8]**

b) What is programmable logic array (PLA)? State its advantages. How it can be used to generate following outputs. **[8]**

$F_1 = \Sigma$ m (4, 5, 7), $F_2 = \Sigma$ m (3, 5, 7)

Q3) a) What is precision rectifier? Explain the operation of full wave precision rectifier. **[6]**

b) Explain the concept of foldback current limiting. How it can be implemented for low-voltage regulator using IC 723. **[6]**

c) Design astable multivibrator using IC 555 to generate a squarewave of frequency 10 kHz and duty cycle of 60%. **[4]**

Q4) a) Draw circuit diagram of twin-T type active band-reject filter. Derive an expression for its transfer function, bandwidth and quality factor. **[8]**

b) What is VCO? Explain its working. Design VCO using IC 566 to generate a waveform with frequency adjustable from 2 kHz to 10 kHz. (Given V_{cc} = 10V). **[8]**

Q5) a) State characteristics of instrumentation amplifier. Draw circuit diagram of instrumentation amplifier using three OPAMPS. Derive expression for its output voltage. **[8]**

b) Design 2-bit flash ADC. Draw its complete circuit diagram. **[8]**

Q6) a) Draw internal block diagram of IC 8038. Explain its operation. How it can be used to generate waves of 10 kHz frequency. **[8]**

b) What is decade counter? State its applications. How 7490 IC's can be used to construct MOD-3g counter? **[8]**

Q7) Write short notes on <u>any four</u> of the following : **[16]**

a) Successive approximation ADC.

b) Satellite communication.

c) Universal shift register IC 74 95.

d) High-Q band-pass filter using OPAMP.

e) Switch mode power supply.

f) One shot multivibrator IC 74 121.

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Total No. of Questions : 7]

SEAT No. :

P386

[Total No. of Pages : 3

[4224] - 103
M.Sc.
PHYSICS
PHY UTN - 503 : Mathematical Methods in Physics
(2008 Pattern) (Semester - 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) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and pocket calculators is allowed.***

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

a) Let the vector space V ≡ R^3. Show that W is a subspace of V where W = $\{(a, b, c) : a + b + c = 0\}$.

b) Determine whether the following polynomials in $p(t)$ are linearly dependent or independent.

$u = t^3 + 2t^2 - 2t + 1$

$v = t^3 + 3t^2 - t + 4$

$w = 2t^3 + t^2 - 7t - 7$

c) Define Dirac delta function. Obtain Fourier transform of Dirac δ function.

d) Use the calculus of residue to prove $\int_0^{2\pi} \frac{d\theta}{2+\cos\theta} = \frac{2\pi}{\sqrt{3}}$.

e) For Bessel's function show that $\frac{d}{dx}\left[x^n J_n(x)\right] = x^n J_{n-1}(x)$.

f) Define the associated legendre function $p_n^m(x)$. Write parity and orthogonality relations for $p_n^m(x)$.

P.T.O.

Q2) a) Let D be the differential operator $D(f) = \frac{df}{dt}$. Find the matrix of D in the following bases.

i) $\{e^t, e^{2t}, te^{2t}\}$

ii) $\{1, t, \sin 3t, \cos 3t\}$. **[8]**

b) For Legendre polynomials prove the recurrence relations. **[8]**

$(2n + 1)\, x\, p_n(x) = (n + 1)\, p_{n+1}(x) + n\, p_{n-1}(x)$ and $p'_{n+1}(x) = (2n + 1)\, p_n(x) + p'_{n-1}(x)$.

Q3) a) Use Schmidt orthogonalization procedure to construct the first three Hermite polynomials $H_0(x)$, $H_1(x)$ and $H_2(x)$

$u_n(x) = x^n$ $n = 0, 1, 2$ ------ $-\infty < x < \infty$, $w(x) = e^{-x^2}$.

Use the normalization condition.

$\int_{-\infty}^{\infty} H_m(x) H_n(x) w(x)\, dx = \delta_{mn}\, 2^m . m!, \pi^{1/2}$. **[10]**

b) State and prove Laurent's theorem. **[6]**

Q4) a) Develop Fourier series for the function. **[8]**

$f(x) = 0$ when $-\pi \le x \le 0$.

$= \frac{\pi x}{4}$ when $0 \le x \le \pi$.

b) Solve the differential equation using Laplace transform.

$X''(t) + 4X'(t) + 4X(t) = 4e^{-2t}$.

Where $X(0) = -1$ $X'(0) = 4$. **[8]**

Q5) a) Prove by centour integration $\int_0^{\infty} \frac{\sin mx}{x} dx = \frac{\pi}{2}$. **[8]**

b) Show that eigenvalues of Hermitian matrix are real and the eigenvectors are orthonormal. **[8]**

Q6) a) Find the eigenvalues and orthonormal eigenvectors of $\begin{pmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{pmatrix}$. **[8]**

b) Define vector space. Write all eight axioms to be satisfied to define a vector space. **[8]**

Q7) a) Using Schwartz inequality, show that $\delta(x, y) \leq \delta(x, z) + \delta(z, y)$ where $\delta(x, y)$ denotes distance bet x and y. **[4]**

b) Find the Taylor series of $\log z$ at $z = -i + i$. **[4]**

c) Consider two bases of R^2, $E = \{e_1, e_2\} = [(1, 0), (0, 1)]$ and $S = \{u_1, u_2\} = [(1, 3), (1, 4)]$. Find the change of basis matrix P from E to S. **[4]**

d) State and prove Parseval's identity for fourier series. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P387

[Total No. of Pages : 2

[4224] - 104
M.Sc.
PHYSICS
PHY UTN - 504 : Quantum Mechanics - I
(2008 Pattern) (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) *Draw neat diagrams wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table and calculator is allowed.*

Q1) Attempt any four of the followings :

a) If A and B are two operators which commute with their commutator [A, B], prove that $[A, B^n] = n\, B^{n-1} [A, B]$. **[4]**

b) Normalize the wave function in the region
$-\infty < x < \infty$ $\psi(x) = A\, e^{-x^2/2a^2 + ikx}$. **[4]**

c) Show that the function $L_+ \psi_m$ will be an eigen-function of L_z belonging to an eigenvalue $(m + 1)\hbar$. **[4]**

d) For $j = 1/2$, obtain the matrix J_y. **[4]**

e) The ground state eigen function for harmonic oscillator is $\psi(x) = \left(\frac{\alpha}{\sqrt{\pi}}\right)^{1/2} e^{-\alpha^2 x^2/2}$. Obtain uncertainty in position Δx. **[4]**

f) Show that the pauli spin matrices satisfy the commutation relation $[\sigma^2, \sigma_z] = 0$. **[4]**

Q2) a) Establish Schrödinger equation for a linear harmonic oscillator and solve it to obtain eigenvalues and eigen functions. **[8]**

b) An arbitrary wave function $|\psi\rangle$ is written in terms of complete set of eigen functions $|a\rangle$ such as $|\psi\rangle = \sum_a C_a |a\rangle$. Using expansion define a projection operator $\hat{p}_a$. Show that for any function of $f(\hat{A})$ of an operator we can write $f(\hat{A}) = \sum_a f(a)\, \hat{p}_a$. **[8]**

P.T.O.

Q3) a) Explain unitary transformations. Show that **[8]**

i) Operator equations remain unchanged in form under unitary transformation.

ii) A Hermitian operator retains its Hermitian character under unitary transformation.

b) Using as a basis the eigenvectors $|\,jm\,\rangle$ of J^2 and J_z, obtain the matrix representation of the angular momentum operators J_x, J_y, and J_z. **[8]**

Q4) a) Describe Heisenberg picture. Show that $\frac{d}{dt}A_H = \frac{i}{\hbar}[H, A_H] + \frac{\partial A_H}{\partial t}$. **[8]**

b) By using $\alpha = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\beta = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$ as basis, obtain the matrix representation for S_x, S_y and S_z for spin $\frac{1}{2}$. Show that $S_x^2 = S_y^2 = S_z^2 = \frac{\hbar^2}{4}$. **[8]**

Q5) a) Explain completeness and closure property. Show that in the Dirac notation the closure relation can be written as $\sum_n |\psi_n\rangle\langle\psi_n| = I$. **[8]**

b) Obtain commutation relation for L_x, L_y, L_z, the components of angular momentum operator. Show that L^2 commutes with any of the three components. **[8]**

Q6) a) What are Dirac's bra and ket vectors. With respect to these vectors, define Hilbert space. Write expressions for the norm and scalar product in this space and define the basis of Hilbert Space. **[8]**

b) Using ladder operators obtain energy eigenvalues of one dimensional harmonic oscillator. **[8]**

Q7) a) Show that angular momentum operator is a generator of rotational motion. **[4]**

b) Show that $(\hat{x}\,\hat{p}_x)^2 \neq \hat{x}^2\hat{p}_x^2$. **[4]**

c) If A is anti-Hermitian, show that e^A is unitary. **[4]**

d) If ψ_1 and ψ_2 are eigen functions of an operator then prove that their linear combination is also a eigen function of the same operator. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P388

[Total No. of Pages : 3

[4224] - 201
M.Sc.
PHYSICS
PHY UTN - 601 : Electrodynamics
(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 diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and pocket calculator is allowed.***

Q1) Attempt any four of the following :

a) Determine the skin-depth for copper at 1 MHz.
Given : $\mu \simeq \mu_0 = 4\pi \times 10^{-7}$ Wb/A-m and $\sigma = 5.8 \times 10^7$ mho/m. **[4]**

b) The earth receives about 1300 watt/m^2 radiant energy from the sun. Assuming the normal incidence, calculate magnitude of electric field vector in sun light. Given : $\in_0 = 8.85 \times 10^{-12} \dfrac{c^2}{\mathrm{N}-m^2}$ and $\mu_0 = 4\pi \times 10^{-7} \dfrac{\mathrm{W}b}{\mathrm{A}-m}$. **[4]**

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

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

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

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

Q2) a) If a medium is moving with a velocity $\vec{u}$, then show that the Faraday's law has the form $\vec{\nabla} \times \left(\vec{E}' - \vec{u} \times \vec{B}\right) = \dfrac{-\partial \vec{B}}{\partial t}$. **[8]**

b) Prove the relativistic addition theorem for velocities : **[8]**

$$ux = \frac{ux' + v}{l + \frac{u'xv}{c^2}} \text{ where } ux' = \frac{dx'}{dt'} \text{ and } ux = \frac{dx}{dt}.$$

Hence show that any velocity added relativistically to '*c*' gives resultant velocity '*c*', which is Worentz invariant.

Q3) a) Starting from Maxwell's equations, derive inhomogeneous wave equations in terms of scalar potential ϕ and vector potential $\vec{A}$. Hence explain Worentz's and Coulomb's gauges. **[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 $(\vec{\nabla}\times\vec{B}) = \mu_0 \vec{j}$. **[8]**

Q4) a) What is a linear quadrupole? Derive an expression for potential at a distant point due to a small linear quadrupole. **[8]**

b) Show that the operators - **[8]**

$\Box^2 \equiv \nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$ is invariant under Worentz 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 Worentz invariant.

Q5) a) 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]**

b) What is Hertz potential? Show that electric and magnetic fields can be expressed in terms of Hertz potential as $\vec{E} = \vec{\nabla}\times(\vec{\nabla}\times\vec{z})$ and $\vec{B} = \frac{1}{c^2}\frac{\partial}{\partial t}(\vec{\nabla}\times\vec{z})$, where $\vec{z}$ is the Hertz potential. **[8]**

Q6) a) Using the concept of e.m. energy, show that power transferred to the e.m. field through the motion of charge in volume *v* is given by : **[8]**

$$-\int_v (\vec{j}.\vec{E})dv = \frac{d}{dt}\int_v \frac{1}{2}(\vec{E}.\vec{D} + \vec{B}.\vec{H})dv + \int_{c.s.} (\vec{E}\times\vec{H}).\vec{ds}.$$

Explain the significance of each term.

b) Explain the term e.m. field tensor. Hence obtain an expression for e.m. field tensor $F\mu\gamma$. **[8]**

Q7) a) Explain Minkowski's space-time diagram. **[4]**

b) Describe the concept of vocuum displacement current. Hence write the expression for modified Ampere's law. **[4]**

c) Show that the ratio of electrostatic and magnetic energy densities $\left(\frac{ue}{um}\right)$ is equal to unity. **[4]**

d) A radiator approximates to an electric dipole of length 250m at a frequency of 60 kHz. Assuming that current is maintained over the length, evaluate the radiation resistance of the radiator. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P389

[Total No. of Pages : 2

[4224] - 202

M.Sc.

PHYSICS

PHY UTN - 602 : Atoms, Molecules and Solids

(2008 Pattern) (Semester - II)

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

Instructions to the candidates :

1) *Question No. 1 is compulsory. Solve any four questions of the remaining.*
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.*

Given

Rest mass of electron	=	9.109×10^{-31} kg
Charge on electron	=	1.6021×10^{-19} coulomb
Plank's constant	=	6.626×10^{-34} Js
Boltzmann constant	=	1.38054×10^{-23} Jk^{-1}
Avogadro's number	=	6.02252×10^{26} (k mole)$^{-1}$
Bohr Magneton	=	9.27×10^{-24} amp - m^2
1 ev	=	1.6021×10^{-19} J

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

a) If the Debye temperature of a solid is 2000K, what will be its specific heat at temperature 27ºC.

b) Calculate the magnetic field required to get a transition frequency 60 MHz for fluorine : Given $g_N = 5.255$ $\mu_N = 5.05$ 1×10^{-27} JT^{-1}.

c) The value of *xe* for lower and upper states of C_2 are 0.00711 and 0.00919 respectively. Find the number of levels in the upper and lower states.

d) A NMR signal for compound is found to be 180 Hz down. Word from rms peak using a spectrometer operating at 60 MHz. Calculate shift in ppm.

e) Find Lande g factor for $3D_3$ state.

P.T.O.

f) The Debye temperature of diamond is 1850ºK. Calculate the highest lattice frequency as per Debye theory. Also calculate the specific heat per kilomole for diamond at 20ºK.

Q2) a) Explain the theory of geometrical structure factor and derive expression for fcc lattice. **[8]**

b) Explain the principle of electron spin resonance (ESR) ESR is observed in atomic hydrogen with an instrument operating at 9.5 GHz. If the 'g' value for the electron in hydrogen atom is 2.0026, what is the magnetic field applied. **[8]**

Q3) a) Explain the interpretation of quantum numbers n, l, m_l and m_s for electron atoms. **[8]**

b) Explain briefly the information one can get from the vibrational analysis of an electronic vibration spectra. **[8]**

Q4) a) Derive an expression for concentration of vaccencies in a crystalline solid as a function of temperature. **[8]**

b) Define dissociation energy for a diatomic molecule. Obtain an expression for υ_{max} corresponding to the dissociation energy. **[8]**

Q5) a) Explain band origin and band head in relation to rotational fine structure of electronic vibrational spectra. **[8]**

b) Derive the dispersion relation for a linear diatomic lattice and explain origin of optical mode and acoustic mode. **[8]**

Q6) a) What are the limitations of classical theory of specific heat? Derive expression for the specific heat of solids on the basis of Einstein's model. **[8]**

b) State and explain Franke-Condonn principle. **[8]**

Q7) a) Point out essential difference between atomic spectra and molecular spectra. **[4]**

b) Write short note on screw dislocation. **[4]**

c) What is meant by width of spectral line? **[4]**

d) The Miller indices of some planes are (222) (111) (212) (303). Find which of the above reflections are possible in bcc and fcc structure. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P390

[Total No. of Pages : 3

[4224] - 203

M.Sc.

PHYSICS

PHY UTN - 603 : Statistical Mechanics in Physics

(2008 Pattern) (Semester - 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. Boltzmann constant $K_B = 1.38 \times 10^{-23}$ J/K
2. Gas constant R = 1.987 cal/deg/mole
3. Plank's constant h = 6.625×10^{-34} J - Sec
4. Avogadro's Number N = 6.023×10^{23}/gm-mole

Q1) Attempt any four of the following :

a) A damped harmonic oscillator is described by the equation $m\frac{d^2x}{dt^2}+R\frac{dx}{dt}+kx=0$. Determine the phase trajectory of the oscillator. **[4]**

b) The table given below shows the energy parameters and accessible states for two systems 1 and 2. **[4]**

System 1	System 2
E_1 = 2, 3, 4 units	E_2 = 5, 6, 7 units
Ω_1 = 5, 25, 75	Ω_2 = 100, 150, 200

The systems are kept in contact and undergo thermal interaction only. Obtain the distribution for 9 units of energy in the equilibrium state.

c) Show that the dispersion in enthalpy (H) in a canonical ensemble is given by $\overline{(\Delta H)^2} = KT^2 C_p$. **[4]**

d) The partition function for monoatomic ideal gas of N identical particles is $Z = V^N \left(\frac{2\pi mkT}{h^2}\right)^{3N/2}$. Hence show that molar specific heat $C_v = \frac{3}{2}R$. **[4]**

e) For a mole of Ar at NTP calculate **[4]**

i) Translational partion function.

ii) Kinetic energy of a gas and

iii) Molar heat capacity at constant pressure assuming the ideal behaviour.

(Given : Gas constant R = 82.05 atm/deg/mole)
Mass of Ar = 40 amu

f) Calculate mean energy of fermions at ok. **[4]**

Q2) a) Two macroscopic systems A and A' are in thermal interaction with each other forming a combined system $\overset{o}{A}$. Show that S = k ln Ω (E). Where Ω (E) are accessible microstates of system A. **[8]**

b) Show that when T << θ_r where θ_r is the rotational characteristic temperature in the lowest approximation.

$$(C_v)_{rot} = 12NK\left(\frac{\theta_r}{T}\right)^2 e^{-\theta_r N/T}$$ **[8]**

Q3) a) State the expression for quantum distribution function $\overline{n_r}$ and obtain F-D distribution in the form $\overline{n_r} = \frac{1}{e^{\beta(\epsilon_r - \mu)} + 1}$ where μ is chemical potential.

Hence obtain the dispersion relation $\overline{(\Delta n_r)^2} = \overline{nr}\left(1 - \overline{n_r}\right)$. **[8]**

b) Calculate the mean values $\overline{E}, \overline{E^2}, \overline{(\Delta E)^2}$ and $\overline{p}$ for canonical ensemble in terms of partition function. **[8]**

Q4) a) Obtain Maxwell velocity distribution and hence show that root mean square speed V_{rms} to the mean speed $\overline{V}$ and to the most probable speed $\tilde{V}$ is given by **[8]**

$$V_{rms} : \overline{V} : \tilde{V} = \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$$

b) Show that $PV = \frac{2}{3}E$ is satisfied by a gas of free monoatomic particles irrespective of statistics it obeys. **[8]**

Q5) a) Show that the value of the single particle momentum corresponding to the Fermi energy which is referred as Fermi momentum is given by

$$p_f = h\left(\frac{3N}{4\pi(2s+1)V}\right)^{1/3}.$$ **[8]**

b) Explain Gibb's paradox. How it can be resolved by the concept of indistinguishability of the particles. **[8]**

Q6) a) Obtain the Einstein derivation of Plank's law of radiation given by **[8]**

$$\rho(v_{12}) = \frac{8\pi h v^3}{c^3}\frac{1}{e^{hv/KT}-1}$$

b) Consider a system consisting of two particles each of which can be in any one of three quantum states of respective energies O, $\in$ and $3\in$. The system is in contact with a heat reservoir at absolute temperature T.

i) Write an expression for the partition function Z if the particles obey classical M.B. statistics and

ii) What is z if the particles obey F.D. statistics. **[8]**

Q7) a) In classical monoatomic ideal gas, the number of states Ω (E) for the system in the energy range E and E + δE is given by Ω (E) = $BV^{N}E^{3N/2}$ using this relation obtain the expression for entropy
$S = C_V \ln T + R \ln V + C$.
Hence show that entropy for an adiabatic process is zero. **[8]**

b) i) Given that single particle partition function for 1 - D harmonic oscillator is $z = \left[2\sin h\left(\frac{\hbar w}{2KT}\right)\right]^{-1}$. Obtain the expression for average energy of oscillator and show that at high temperature limit it is equal to KT. **[4]**

ii) An excited state of an atom is 1.38 eV above the ground state. Calculate the number of atoms in this excited state relative to the ground state at 16000k. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P391

[Total No. of Pages : 2

[4224] - 204
M.Sc.
PHYSICS
PHY UTN - 604 : Quantum Mechanics - II
(2008 Pattern) (Sem. - II)

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

Instructions to the candidates :

1) ***Question No. 1 is compulsory. 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 tables and calculators is allowed.***

Q1) Attempt any four of the following :

a) Define exchange operator. Show that eigen values of exchange operator are +1 and –1. **[4]**

b) Show that the total energies in Laboratory and centre of mass system is related by $T_{cm} = \frac{\mu}{m_1} T_{Lab}$

where μ is reduced mass. **[4]**

c) Show that there is no first order stark effect in ground state of an atom. **[4]**

d) Show that the variation method gives an upper bound to ground state of energy. **[4]**

e) Obtain condition for validity of W.K.B. approximation. **[4]**

f) Find the energy levels and eigen function 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]**

Q2) a) Using variation method, obtain ground state of hydrogen atom where the trial wave function is $\psi(r) = e^{-\alpha r}$ where α is trial parameter for variation. **[8]**

b) Explain the differential cross section and total cross section in scattering. Hence obtain the relation $\frac{d\sigma(\theta, \phi)}{d\Omega} = |f(\theta, \phi)|^2$ **[8]**

P.T.O.

Q3) a) Obtain slators determinant for system of N electrons. **[8]**

b) Prove that

$$\sigma \text{ total} = \frac{4\pi}{K} \text{Imf}(0)$$

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

Q4) a) Deduce the expression for scattering amplitude using Born approximation for Yukawa potential. **[8]**

b) Starting from perturbation equations, obtain the first order and second order energy correction in case of stationary non degenerate state. **[8]**

Q5) a) Write down connecting formula in W.K.B. approximation. Hence obtain Bohr Sommerfeld quantum rule. **[8]**

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

Q6) a) Apply time independent perturbation theory to a doubly degenerate system and show that degeneracy can be removed. **[8]**

b) Write the Fermi Golden rule for constant perturbation. Obtain expression for transition probability in case of Harmonic oscillator. **[8]**

Q7) a) Discuss selection rule for electric dipole transition. **[4]**

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

c) Discuss concept of symmetry in quantum mechanics. **[4]**

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

i) Identical particles and

ii) Symmetric and antisymmetric wave function.

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Total No. of Questions : 7]

SEAT No. :

P392

[Total No. of Pages : 3

[4224] - 301
M.Sc.
PHYSICS
PHY UTN - 701 : Solid State of Physics
(2008 Pattern) (Semester - 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) ***Figures to the right indicate full marks.***
3) ***Draw neat labelled diagram wherever necessary.***
4) ***Use of logarithmic table and pocket calculator is allowed.***

Given :

Plank's constant	=	6.626×10^{-34} J-S
Mass of electron	=	9.1×10^{-31} kg
Boltzmann constant	=	1.38×10^{-23} J/K
Avogadro's number	=	6.023×10^{26}/kmol
Permeability of free space	=	$4\pi \times 10^{-7}$ Henry/m
Charge of electron	=	1.6×10^{-19} C
Permittivity of free space	=	8.85×10^{-12} $C^2/N - m^2$
Bohr Magneton	=	9.27×10^{-24} Am^2

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

a) Calculate the energy of an electron below the fermi level at a temperature 200K for $f(E) = 0.9$ and Fermi energy $E_F = 3\ eV$.

b) Show that the wavelength associated with an electron having energy equal to the Fermi energy is given by $\lambda_f = 2\left[\frac{\pi}{3n}\right]^{1/3}$.

c) The London penetration depths for pb at 3K and 7.1K are 39.6nm and 173nm respectively. Calculate the depth at ok.

P.T.O.

d) Consider He atom in its ground state (IS). Its mean radius <r> is equal to 0.53 $\overset{o}{A}$. Density of He is 0.178kg|m^3 and atomic weight is 4 amu, calculate the diamagnetic susceptibility of He atom.

e) A material having a dielectric constant 5 is positioned with in the region between the parallel plates. Compute the polarizibility.

f) A typical magnetic field achievable with an electromagnet with iron core is about 1 tesla. Compare the magnetic interaction energy. $\mu_B B$ of an electron spin magnetic dipole moment with $K_B T$ at room temperature and show that at ordinary temperatures the approximation $\frac{K_B T}{\mu_B B} >> 1$ is valid.

Q2) a) Use the equation $m\left(\frac{d\theta}{dt}+\frac{\theta}{\hat{i}}\right)=-eE$ for the electron drift velocity υ to show that the conductivity at frequency w is $\sigma(w)=\sigma(0)\left(\frac{1+iw\hat{i}}{1+w^2\hat{i}^2}\right)$ where σ (0) = ne^2 $\hat{i}$ /m. Symbols have usual meaning. **[8]**

b) What is ferroelectric effect? Describe the spontaneous polarization in Barium titanate. **[8]**

Q3) a) Explain the paramagnetic phenomenon. Derive an expression for paramagnetic susceptibility using Langevin theory of paramagnetism. **[8]**

b) Explain the following properties of superconductors with the help of suitable diagrams : **[8]**

i) Electrical resistance.

ii) Isotope effect.

iii) Magnetic field.

iv) Meissner effect.

Q4) a) Explain the hysteresis curve on the basis of domain theory. **[8]**

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

Q5) a) Explain the classification of metals, semiconductors and insulators based on band theory. **[8]**

b) Explain the paramagnetism in rare earth ions and iron group ions on the basis of quenching of orbital angular momentum. **[8]**

Q6) a) Explain the following terms with suitable diagrams : **[8]**

i) Exchange energy. ii) Anisotropy energy

iii) Bloch wall energy.

b) i) For a simple 2-D square lattice, show that kinetic energy of a free electron at the centre of the Ist Brillouin zone is higher than that of the electron at the midpoint of a side face of a zone by a factor 2 **[4]**

ii) Calculate the number of energy states available for the electron in a cubical box of side 1cm lying below an energy of 1eV. **[4]**

Q7) a) For an atom placed at general lattice site, derive an expression for local field E local. Explain each term in the expression. **[8]**

b) i) Explain Josephson effect in super conductors. **[4]**

ii) The critical temperature, T_c for mercury with isotopic mass 199.5 is 4.185K. Calculate its critical temperature when its isotopic mass changes to 203.4. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P393

[Total No. of Pages : 2

[4224] - 401

M.Sc.

PHYSICS

PHY UTN - 801 : Nuclear Physics

(2008 Pattern) (Semester - 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 figures wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and pocket calculators is allowed.*

Q1) Attempt any four of the following :

a) In a Bainbridge and Jordon mass spectro-graph singly ionised atoms of neon-20 passed into the deflection chamber with a velocity of 10^5 m/s. They are deflected by a magnetic field of flux density 8×10^{-2} Tesla. Calculate the radius of their path. [$m_p = 1.67 \times 10^{-27}$ kg] **[4]**

b) In a certain betatron the maximum magnetic field was 4000 Guass operating at 50 cycles/sec with a stable orbit diameter of 60 inches. Calculate the average energy gained per revolution. Also, calculate the final energy of the electrons. **[4]**

c) What are ortho and para hydrogen molecules? Show that if spin of neutron is assumed to be $\frac{3}{2}$ then $\frac{\sigma \text{ortho}}{\sigma \text{para}} \approx 2$. **[4]**

d) Which of the following reactions are allowed or forbidden under the conservation of strange-ness, conservation of baryon number and conservation of charge.

i) $\pi^+ + n \longrightarrow \Lambda^o + k^+$

ii) $\pi^+ + n \longrightarrow k^o + k^+$

iii) $\pi^+ + n \longrightarrow \bar{k}^o + \Sigma^+$

iv) $\pi^+ + n \longrightarrow \pi^- + p$ **[4]**

e) Experimentally the study of p-p scattering is capable of much higher accuracy than n-p scattering. Explain. **[4]**

P.T.O.

f) State functions of **[4]**

i) Ideal moderator and

ii) The control material in nuclear reactor.

Q2) a) What is electric quadrupole moment? Obtain an expression for quadrupole interaction energy. **[8]**

b) Describe Gamow's theory of alpha decay. Hence deduce Geiger-Nuttall law. **[8]**

Q3) a) Derive Breit-Wigner single Resonance level formula. Hence deduce $\frac{1}{V}$ law of neutron scattering cross section from this formula. **[8]**

b) Outline briefly the phase-shift analysis in n-p scattering. Hence derive the expressions for **[8]**

i) Scattering cross section and

ii) Scattering amplitude.

Q4) a) Mention various methods for measuring nuclear size. Discuss how electron scattering method is used to determine the nuclear radius. **[8]**

b) Write the four factor formula for the multiplication for a steady state chain reaction and explain the significance of each factor. **[8]**

Q5) a) What do you mean by solid state reactor? Draw the labelled diagram of surface barrier detector. State any four detection characteristics of this detector. **[8]**

b) State assumptions of Fermi theory of β-decay. Find the probability of emission of electron per unit time. **[8]**

Q6) a) What is meant by high purity germanium detector (HPGe)? **[4]**

b) Explain the various conditions of criticality of nuclear reactor. **[4]**

c) What is meant by strangeness number of elementary particles. **[4]**

d) State the principle of Van.de Graff generator. Explain in brief its working. **[4]**

Q7) a) Discuss four interactions among the elementary particles. **[8]**

b) Explain the photoelectric effect and the phenomenon of pair production. **[8]**

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