SC

SEAT No._____ No. of Printed Pages : 03

[837]

SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar
M. Sc. (Physics) 1st Semester Examination
Wednesday, 1st November, 2017
Time: 02:00 pm to 05:00 pm
Subject: PS01CPHY01 [Mathematical Physics & Computer Programming]
Total Marks: 70

Note: (1) Figures to the right indicate marks.
(2) Symbols have their traditional meaning.

Q:1 **Attempt all of the following Multiple choice type questions. [01 mark each]** [08]

(1) A linear combination of a set of vectors, $v_1=1$, $v_2=x$ and $v_3=x^3$ will be
(a) $a+bx+cx^3$ (c) $1+x+x^3$
(b) $bx+cx^3$ (d) x^4

(2) The eigen values of matrix $\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$ are
(a) 1,2 (c) 1,1
(b) 0,2 (d) 1,0

(3) Analytic function is
(a) single valued (c) bounded
(b) differentiable (d) all of these

(4) If $u = x^2 - y^2$, then corresponding analytic function is
(a) $z^3 + c$ (c) $z^2 + c$
(b) $z^4 + c$ (d) $z + c$

(5) If $f_1(t)$ and $f_2(t)$ are two functions having Fourier transforms $g_1(\omega)$ and $g_2(\omega)$ then the Fourier transform of $f_1(t)+f_2(t)$ is
(a) $g_1(\omega).g_2(\omega)$ (c) $g_1(\omega) \cdot g_2(\omega) \cdot e^{i\omega t}$
(b) $g_1(\omega)+g_2(\omega)$ (d) $g_1(\omega) \cdot g_2(\omega) \cdot e^{-i\omega t}$

(6) The number of generators of $S\,U(x)$ is
(a) 2^{n+1} (c) n^2+1
(b) 2^n (d) n^2-1

(7) Which of the following is a valid real constant
(a) 67,200.98 (c) -0.567
(b) 1 (d) -1/2

(8) The correct answer for the following expression is,
REAL:: a=2.5,b=2.5
a/2.5/b
(a) 1.0 (c) 0
(b) 0.25 (d) 0.4

Q:2 **Answer any 7 of the following 9 questions briefly. [02 marks each]** [14]

1 Show that Eigen values of a Hermitian operator are real.
2 Explain outer product and contraction of tensors.
3 What are linearly independent vectors and unitary operators?
4 Define complex number and give its geometrical representation.
5 Is $f(z) = z^*$ analytic?
6 Giving a proper illustration explain group multiplication table.
7 Describe Parseval's relation.
8 Explain FORMAT specifications using any two examples.
9 Give the general structure of a FORTRAN program.

Q:3 (a) Define linear vector space. Explain scalar product and triangle inequality. [6]

(b) Define the Christoffel symbol of the first and second kind. Define the covariant derivatives of a contravariant and covariant tensor of rank one. [6]

OR

(b) Write a note on dual vectors and Cauchy-Schwarz inequality. [6]

Q:4 (a) Using Cauchy's second integral theorem show that the nth order derivative of an analytic function is given as $f^{(n)}(z_0) = \frac{n!}{2\pi i}\oint_c \frac{f(z)}{(z-z_0)^{n+1}} dz$ [6]

(b) Evaluate $\int_0^\infty \frac{dx}{(1+x^2)^2}$ [6]

OR

(b) Obtain Green's function for the boundary value problem defined by $\left(\frac{d^2y}{dx^2}\right) + \omega^2 y = f(x)$ with y(0)=0 and y(L)=0. [6]

Q:5 (a) Define Fourier transform. What are its applications? Discuss how it can be used to resolve a finite pulse into sinusoidal waves. [6]

(b) Define Laplace transform. Discuss the application of Laplace transform in the study of a damped harmonic oscillator. [6]

OR

(b) Explain (i) Fourier transform of derivatives (ii) convolution theorem. [6]

Q:6 (a) Write a note on DO loops. Write a FORTRAN90 program to compute the sum of integers 1 to 10 using DO loop. [6]

(b) Write a note on subroutines. [6]

OR

(b) Using suitable illustration, explain in detail the IF-ELSEIF construct. [6]

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SEAT No._____ No. of Printed Pages : 02

[76]

SARDAR PATEL UNIVERSITY

M. Sc. (Physics) (I[st] Semester) Examination

Day: Friday, Date: 03/11/2017, Time: 02:00 p.m. to 05:00 p.m.

Course No. PS01CPHY02 (Classical and Statistical Mechanics)

CBCS (choice based credit system)

Important Note: Signs have their usual meaning

Q.1: Eight multiple choice questions (MCQ) carry one mark each.

Q.2: Short answer questions carry two marks each (attempt any seven out of nine)

Q.3 to Q.6: Long answer questions carry 12 marks each.

Total Marks: 70

Q1 (i) The equation of constraint in case of a particle moving on or outside the surface of a sphere of radius 'r' is given by $x^2 + y^2 + z^2 \geq r^2$. Name the type of constraint _____

(a) non-holonomic (b) holonomic (c) independent (d) dependent

(ii) If Lagrangian L is written with respect to any one coordinate say q_k as $\frac{\partial L}{\partial q_k} = 0$, then q_k is a _____ coordinate.

(a) configuration (b) cyclic

(c) cartesian (d) confirmation

(iii) Any point in a *configuration space* is known as _____.

(a) system-point (b) hodograph-point

(c) momentum-point (d) locus-point

(iv) Write the correct relation between Hamilton H and Lagrangian L _____. Where T – kinetic energy.

(a) L = 2H - T (b) H = 2T – L

(c) L = 2T – L (d) H = 2L – T

(v) As a system of bosons undergo BEC state, its fugacity approches to.

(a) infinity (b) one

(c) zero (d) one half

(vi) The ensemble average of a physical quantity G is computed using the density matrix $\hat{\rho}$,

(a) $GTr(\hat{\rho})$ (b) $Tr(\hat{\rho}\hat{G})$ (c) $\hat{G}/Tr(\hat{\rho})$ (d) $Tr(\hat{\rho})/G$

(vii) Trace of density matrix should be.

(a) One (b) Zero (c) Complex number (d) none

(viii) The stability of white dwarf stars are understood as its gravitational pressure balances with

(a) centripetal force (b) electron degeneracy pressure

(c) neutron degeneracy pressure (d) centrifugal force of its mother galaxy

Q2 (i) What are constraints? Discuss different types of constraints.

(ii) Define stable and unstable equilibrium with illustration and examples. How they are differentiated.

(iii) Explain Hamilton's principle.

(iv) What are the characteristics of a chaotic motion?

(v) Prove that Poissons bracket $[u, q_j] = -\frac{\partial u}{\partial p_j}$ and $[u, p_j] = \frac{\partial u}{\partial q_j}$.

(vi) Define phase transition. Explain P - V diagram of pure state.

(vii) Explain stability of white dwarf stars and neutron stars.

(viii) Define fugacity of gas. Explain properties of the fugacity for Boson gas.

(ix) Define density operator? How a pure state is defined in terms of the density operator?

Q3 (a) Solve the harmonic oscillator problem using canonical transformation. The given generating function for the harmonic oscillator is $\mathbf{F_1 = \frac{1}{2} m\omega q^2 cotQ.}$ 6

(b) Derive Lagrangian's eqution of motion for a conservative holonomic system from D'Alembert's principle. 6

OR

(b) What is gauge and canonical transformation? Derive a relation between new and old coordinates, momenta and Hamiltonian function. What are generating functions? 6

Q4 (a) Discuss small oscillations, stable and unstable equilibrium. Derive the equation of Lagrangian for the small oscillations near its equilibrium position. 6

(b) Show that the eigenvectors corresponding to the two distinct eigen frequencies are orthogonal. Explain the meaning of orthogonality. 6

OR

(b) Discuss the theory of the free vibrations of linear triatomic molecule with necessary mathematical equations. 6

Q5 (a) Determine the density matrix in the momentum representation for a free particle. 6

(b) Show that the specific heat of a degenerate ideal Bose gas varies as $T^{3/2}$ near absolute zero. 6

OR

(b) Prove that white dwarf stars in equilibrium must have a mass less than the Chandrashekhar limit. 6

Q6 (a) Consider a real gas system and derive the virial equation of state. Derive the second virial coefficient explicitly. 6

(b) Derive Boltzmann transport equation. 6

OR

(b) Discuss the theory of Ising model in one dimension. 6

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(163) SEAT No._____

No. of Printed Pages: 02

SARDAR PATEL UNIVERSITY

M.Sc. (PHYSICS) I[st] Semester Examination

Tuesday, 7[th] November; 2017 02:00 pm to 05:00 pm

Course No.: PS01CPHY03: Atomic, Molecular and Laser Physics

All questions are compulsory.

Total Marks:70

Q.1 Multiple choice questions. **(8)**

(i) For three level laser system, _____ gives necessary mathematical condition for population inversion between level 1 and 2.

(a) $T_{32} = T_{21}$ (b) $T_{32} > T_{21}$ (c) $T_{32} < T_{21}$ (d) $T_{32} > T_{31}$

(ii) The eigenvalue of *permutation* or *interchange* operator is _____.

(a) +1 (b) -1 (c) ±1 (d) 0

(iii) Life time for cavity photon in a given lasing system depends on _____.

(a) internal absorption (b) leakage through window (mirror-2)

(c) scattering (d) all of the above

(iv) _____ gas is used to increase the efficiency of the CO_2 gas laser.

(a) He (b) N_2 (c) O_2 (d) NH_3

(v) The lowest possible value for *radial quantum number* is _____.

(a) 1 (b) -1 (c) 0 (d) -2

(vi) In the case of H-atom "centrifugal barrier potential" varies as _____.

(a) $\frac{1}{r}$ (b) $\frac{1}{r^2}$ (c) $\frac{1}{r^3}$ (d) r^2

(vii) Most probable decay mechanism of $2S_{½}$ is _____.

(a) non-radiative transition (b) one-photon spontaneous radiation

(c) two-photon emission (d) completely forbidden

(viii) Which of the following does not fall in the microwave region?

(a) ESR (b) hyperfine structure (c) Lamb shift (d) Lyman–α line

Q.2 Short answer questions.(Attempt any seven) **(14)**

(a) "Rydberg atoms can be treated as hydrogenic atoms" – why?

(b) With usual notation, prove that for two electron system $S_z\chi_1(1,2) = \chi_1(1,2)$.

(c) Write two assumptions involved in Thomas-Fermi model for many-electron atom.

(d) Why normal optical sources do not emit stimulated light?

(e) Write acronym of LASER and MASER.

(f) Give difference between Rayleigh and Raman scattering.

(g) For the case of homonuclear diatomic molecule, explain the symbol $X^1\Sigma_g^+$.

(P.T.O.)

(h) Define CARS.

(i) Give difference between stimulated and hyperRaman effects?

P.T.O.

Q.3(a) Starting with $\left[\frac{d^2}{d\rho^2} - \frac{l(l+1)}{\rho^2} + \frac{\lambda}{\rho} - \frac{1}{4}\right] u_{E,l}(\rho) = 0$, where $\rho = \left(-\frac{8\mu E}{\hbar^2}\right)^{-\frac{1}{2}} r$ and $\lambda = \frac{Ze^2}{4\pi\epsilon_0 \hbar}\left(-\frac{\mu}{2E}\right)^{-\frac{1}{2}}$, for bound state (E < 0) of H-atom; derive expression for discrete energy eigenvalues (E_n). Discuss important outcome of it. (6)

(b) Write detailed note on Lamb shift experiment. (6)

OR

(b) Name different contributions to total Hamiltonian. Give expression for total or corrected energy ($E_{n,j}$). Draw and discuss in detail *fine structure* energy level diagram for H-atom. (6)

Q.4(a) Taking an example of H_2^+ ion discuss in detail about LCAO method. (6)

(b) Derive $\frac{d^2\chi(x)}{dx^2(x)} - \frac{1}{\sqrt{x}}[\chi(x)]^{\frac{3}{2}} = 0$ using Thomas–Fermi theory for many-electron atoms. Write at least one limitation of the theory. (6)

OR

(b) Based on Born-Oppenheimer approximation, derive an equation for total energy ($E_{s,v,j}$) for diatomic molecule. Discuss the use of Morse potential in determining $E_{s,v,j}$. (6)

Q.5(a) Derive necessary equations to show how variation of Laser power takes place around threshold condition. (6)

(b) For three-level laser system, obtain the condition for population inversion and derive an expression for threshold pump power. (6)

OR

(b) Using an expression $\Gamma_{12} = \frac{1}{2\epsilon_0}\frac{\mathcal{D}_{21}^2}{\hbar^2}\int u(\omega)\left\{\frac{\sin[(\omega_{21}-\omega)/2]t}{(\omega_{21}-\omega)/2}\right\}^2 d\omega$ for transition probability and assuming $u(\omega)$ varies slowly, obtain expressions for Einstein coefficients B_{12} and A. (6)

Q.6(a) Discuss in detail about semiconductor laser. (6)

(b) Write the basic principle of laser. Discuss the working of He-Ne laser with the help of suitable diagram. What makes the combination of He and Ne gas to produce favorable condition for stimulated emission? (6)

OR

(b) Write note on *free electron laser*. Also mention its chief advantages. (6)

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SEAT No._____ No. of Printed Pages : 03

[847]

SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar
M. Sc. (Physics) 1st Semester Examination
Wednesday, 1st November, 2017
Time: 02:00 pm to 05:00 pm
Subject: PS01CPHY21 [Mathematical Physics]

Total Marks: 70

Note: (1) Figures to the right indicate marks.
(2) Symbols have their traditional meaning.

Q:1 **Attempt all of the following Multiple choice type questions. [01 mark each]** [08]

(1) $\langle\phi|\psi\rangle^* =$

(a) $\langle\psi|\phi\rangle$
(b) $\langle\psi|\phi\rangle^*$
(c) $\langle\psi^*|\phi^*\rangle$
(d) 1

(2) The eigen values of matrix $\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$ are

(a) 1,1
(b) 1,0
(c) 1,2
(d) 0,2

(3) If $u = x^2 - y^2$, then corresponding analytic function is

(a) $z + c$
(b) $z^2 + c$
(c) $z^3 + c$
(d) $z^4 + c$

(4) If c is a circle $|z - z_0| = r$, $\int_c \frac{dz}{z - z_0}$ will be equal to

(a) $2\pi i$
(b) 0
(c) $-2\pi i$
(d) $3\pi i$

(5) The Laplace transform is a

(a) linear operator
(b) non linear operator
(c) Laplacian operator
(d) Eigen operator

(6) Laplace transform $\pounds\{\delta(t)\}$ is equal to

(a) s^2
(b) 1
(c) s
(d) 0

(7) The number of different components for a symmetric tensor is

(a) N^2
(b) N
(c) $N(N+1)/2$
(d) $N^2 - 1$

(8) The number of generators of $SU(x)$ is

(a) 2^{n+1}
(b) 2^n
(c) $n^2 + 1$
(d) $n^2 - 1$

Q:2 **Answer any 7 of the following 9 questions briefly. [02 marks each]** [14]

1 Define Hilbert space.
2 Show that a vector $|a\rangle$ multiplied by number 0 gives $|0\rangle$.
3 Define (i) simply connected region (ii) essential singularity.
4 Show that zz^* and $z+z^*$ are real quantities.
5 Define analytic function. Write Laurent series.
6 Describe the RLC analogy.
7 Explain Parseval's relation.
8 What is quotient rule?
9 Explain contraction of tensors.

Q:3 (a) Define linear vector space. Explain scalar product. [6]

(b) Write notes on (i) dual vectors (ii) unitary operator. [6]

OR

(b) (i) Show that Eigen values of a Hermitian operator are real. [6]
(ii) Explain self adjointness.

Q:4 (a) State and prove Cauchy-Riemann conditions. Is $f(z)=z^*$ analytic? [6]

(b) Write a note on Mapping. [6]

OR

(b) If $f(z)$ is single valued and analytic throughout a simply connected region R, and if c is any closed contour interior to R and enclosing z_0, then show that $f(z_0)=\frac{1}{2\pi i}\oint_c \frac{f(z)}{(z-z_0)}dz$. Evaluate $\oint_c \frac{z^2+2z}{z-4}dz$ over a contour path enclosing the pole $z_0=4$. [6]

Q:5 (a) Find the solution of a damped oscillator described through the differential Equation $mx''(t)+bx'(t)+kx(t)=0$ subjected to the initial condition $x(0)=x_0$, $x'(0)=0$ [6]

(b) Define Fourier transform. Show how a finite pulse can be resolved into sinusoidal waves using Fourier transform. [6]

OR

(b) Write notes on (i) convolution theorem (ii) Fourier transform of derivatives. [6]

Q:6 (a) Write a note on group its representation and character. Giving an example discuss the group multiplication table. [6]

(b) Write notes on (i) Christoffel symbol (ii) covariant derivative. [6]

OR

(b) Write notes on (i) metric tensor (ii) geodetic equation. [6]

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SC

SEAT No._____ No. of Printed Pages : 02

[77]

SARDAR PATEL UNIVERSITY

M. Sc. (Physics) (I[st] Semester) Examination

Day: Friday, Date: 03/11/2017, Time: 02:00 p.m. to 05:00 p.m.

Course No. PS01CPHY22 (Atomic & Molecular Spectroscopy and Statistical Mechanics)

CBCS (choice based credit system)

Important Note: Q.1: Eight multiple choice questions (MCQ) carry one mark each.
Q.2: Short answer questions carry two marks each (attempt any seven out of nine)
Q.3 to Q.6: Long answer questions carry 12 marks each.

Total Marks: 70

Q1 (i) The binding energy (E_n) for H-atom is given by; (n = 1, 2, 3, -------- α)
(a) $-13.6/n^2$ (b) $13.6/n$ (c) n^2 (d) $13.6/n^2$

(ii) The energy level shift without splitting is known as;
(a) hyperfine shift (b) isotopic shift
(c) fine structure (d) Lamb shift

(iii) Ortho helium does not have _____ state
(a) 1^3s (b) 2^3s
(c) 2^3p (d) 3^3s

(iv) Raman lines at wave number _____ is always more intense.
(a) $\nu_o + \nu_M$ (b) $\nu_o - \nu_M$
(c) $\nu_o + 2\nu_M$ (d) ν_o

(v) Threshold pump power for three level laser system is given by _____.
(a) $T_{21}T_{32}/T_{32} - T_{21}$ (b) $T_{32} - T_{21}$
(c) $T_{21}T_{32}$ (d) $T_{32} - T_{21}/T_{21}T_{32}$

(vi) The end point of liquid-vapour curve of P – V diagram for pure state is known as _____ point.
(a) triple (b) critical (c) condensation (d) none

(vii) White dwarf stars in equilibrium must have mass less than.
(a) 1.44M (b) $1M_o$ (c) $0.44M_o$ (d) $2.44M_o$

(viii) Specific heat of Boson gas at low temperature varies as.
(a) T (b) $T^{1.5}$ (c) T^2 (d) T^3

Q2 (i) Draw fine structure energy level diagram for H-atom.

(ii) Explain auto-ionization in He-atom

(iii) "Two level system is not suitable for laser action". Explain.

(iv) What is undulator?

(v) Obtain ratio of Einstein coefficient using classical theory.

(vi) Write the Hamitonian for the Ising-1D model of circular spin chain and discuss limitations of the model.

(vii) Define order parameter. How does it vary for 1[st] order and 2[nd] order phase transition?

(viii) Write three properties of density matrix.

(ix) What is the difference between symmetric and asymmetric phase?

Q3 (a) Derive time independent three dimensional Schrodinger equation for H-atom. 6

(b) What is lamb shift? Describe how experimentally lamb shift could be detected. 6

OR

(b) Derive Thomas-Fermi equation for many electron atoms. 6

Q4 (a) Explain: (i) Stimulated Raman effect. 6
(ii) Hyper Raman effect.
(iii) Coherent antistokes Raman scattering.

(b) Write a detail note on spin flip laser. 6

OR

(b) Describe construction and working of CO_2 laser. 6

Q5 (a) Obtain density matrix for a free particle in coordinate space. 6

(b) Derive thermodynamic properties for degenerate Fermi gas. 6

OR

(b) Discuss cluster expansion for a classical gas and derive second virial coefficient. 6

Q6 (a) Discuss Landau's theory of second order phase transition and show that the specific heat is discontinuous at the transition point. 6

(b) Write a detail note on critical exponents and their scaling relations. 6

OR

(b) What is Boltzmann H- theorem? Prove $dH/dt \leq 0$. 6

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5C

(164) SEAT No._____ No. of Printed Pages : 02

SARDAR PATEL UNIVERSITY

M.Sc. (PHYSICS) I[st] Semester Examination

Tuesday, 7th November, 2017 2:00 pm to 5:00 pm

Course No.: PS01CPHY23: Analog and Digital Electronics

All questions are compulsory.

Total Marks:70

Q.1 Multiple choice questions. **(8)**

(i) In a four layers SCR device, other than anode and cathode layers which layer connection is taken out as a gate terminal?
(a) junction of any two semiconductor layers **(b)** n- type layer
(c) p- type layer **(d)** gate is not there

(ii) The reverse recovery time of a diode arises due to the _____;
(a) minority carriers in the depletion-region
(b) minority carriers in the n- & p-regions
(c) majority carriers in the n- & p-regions
(d) majority carriers in the depletion-region

(iii) In a series noise clipper made from Si diode, if noise of 0.9V amplitude is to be removed than what should be the dead zone;
(a) greater than 0.9V **(b)** less than 0.9V **(c)** equal to 0V **(d)** None

(iv) In the LED, the region in which the light is produced is _____;
(a) in bottom and top metal contacts **(b)** in p- region
(c) in n- region **(d)** none of them

(v) Which of the following is a cyclic or unit distance code?
(a) 8421 **(b)** Gray code **(c)** Excess-3 code **(d)** ASCII code

(vi) X-NOR gate is used as a coincidence gate in _____circuit.
(a) Decoder **(b)** DAC **(c)** Comparator **(d)** Multiplexer

(vii) A certain binary counter circuit uses eight Flip-Flops. What will be the modulus of this counter?
(a) 16 **(b)** 32 **(c)** 512 **(d)** 256

(viii) The counter type ADC is also known as a _____ADC
(a) Tracking type **(b)** Flash type
(c) Successive approximation type **(d)** Digital Ramp type

Q.2 Short answer questions.(Attempt any seven) **(14)**

(a) Why is phototransistor more sensitive than photodiode? Explain with equations.

(b) Discuss the working action of diode as a switch.

(c) Why OPAMP is also known as differential amplifier?

(d) What is the difference between comparator and Schmitt trigger?

(e) What are sequential codes?

(f) Differentiate between serial and parallel counters and write their advantages and limitations.

(g) Define propagation delay time and glitch in a counter circuit.

P.T.O.

(h) What are Analog to Digital converters? Mention few of their applications.

(i) Give classification of semiconductor memory.

Q.3(a) What is solar cell? Discuss its construction and working with neat diagram. Derive the equations leading to shifting of I-V characteristics into fourth quadrant. (6)

(b) What are clamper circuits? Discuss in details the positive and negative clamper circuit. Draw a clamper circuit with its input-output waveform to clamp output at approximately +4V maximum. (6)

OR

(b) Why is UJT known as uni-junction transistor? Describe in detail the construction and working of UJT. Derive the equation of intrinsic stand-off ratio and peak voltage. (6)

Q.4(a) Draw circuit diagram of Schmitt trigger and discuss its working. Derive the equations for LTP and UTP. (6)

(b) Draw a block diagram of IC-555 and label its terminals. Discuss its working in detail. What is the importance of pin-4? (6)

OR

(b) Draw the block diagram of voltage control oscillator using IC-741 and explain its working. (6)

Q.5(a) What are weighted and non-weighted codes? Discuss any two BCD codes in detail. (6)

(b) Explain working of a full adder circuit with the help of a logic diagram and truth table. (6)

OR

(b) Sketch the logic diagram of a four-bit synchronous up/down counter and explain its working. (6)

Q.6(a) Define resolution and accuracy of a D to A converter. Also find the percentage resolution of a 10 bit DAC. What will be the full-scale output voltage if it has the step size of 50 mV? (6)

(b) Explain basic principle of DAC and discuss the weighted resistor type DAC in detail. Mention its disadvantage over R-2R ladder type DAC. (6)

OR

(b) With the help of neat circuit diagram and output waveform, discuss the counter type A/D converter. Why does the conversion time increase with the value of the analog input voltage in this ADC? (6)

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(187) SEAT No._____ No. of Printed Pages : 3

SARDAR PATEL UNIVERSITY

M. Sc. (Physics), 1st Semester Examination

9th November 2017, Thursday

Time: 02:00 PM TO 05:00 PM

Subject: Element of Solid State Physics, Paper No. PS01EPHY01

Important Note :

Q.1 : Multiple choice questions (MCQ) carries one mark each.
Q.2 : Short questions carries two marks each (attempt any seven out of nine)
Q.3 to Q.6 : Long questions carries 12 marks each.

Max Marks: 70

Que 1 **Write correct answer for each of the following MCQs.** **[08]**

1 Unit cell of FCC structure is

a) Primitive
b) Non- primitive
c) May be primitive or non-primitive
d) None of these

2 In an BCC lattice, the no. of points per unit cell is

a) 4
b) 2
c) 1
d) 3

3 The no. of Bravais lattice in three dimension are

a) 7
b) 9
c) 14
d) 8

4 If Vg and Vp be the phase velocity and group velocity of lattice wave, then in the long wavelength side,

a) $Vg > Vp$
b) $Vg = Vp$
c) $Vg < Vp$
d) $Vg = Vp = \alpha$

5 If e_{xx}, e_{yy} and e_{zz} are linear strain components, then dilation is given by

a) $e_{xx} + e_{yy} + e_{zz}$
b) $(e_{xx} + e_{yy} + e_{zz})^2$
c) $e_{xx} - e_{yy} - e_{zz}$
d) $(e_{xx} + e_{yy} + e_{zz})^3$

6 An isotropic elastic cubic crystal has _____ constants.

a) 2
b) 3
c) 6
d) 9

7 The dipole moment per unit volume of a solid is called

a) Polarization of the solid
b) permittivity of the solid
c) electrostatic moment
d) permeability of the solid

8 Above the Curie temperature, the ferromagnetic material becomes _____ material.

a) Antiferro magnetic
b) ferri-magnetic
c) paramagnetic
d) canted antiferromargnetic

Que 2 **Write answers of any seven questions.** **[14]**

1 Prove that $2/m = i$.

2 Write down the total no. of crystal system, Bravais lattice, point group and space group.

(P.T.O)

(1)

3 Differentiate between
(i) roto reflection and roto inversion
(ii) Screw and rotation axes

4 Write down the co-ordinates for the points per unit cell of SC, BCC and FCC structures.

5 Distinguish between intrinsic and extrinsic semiconductors with suitable examples.

6 Explain elastic stiffness constants of a cubic crystal.

7 What is effective mass? Describe effective masses in semiconductor.

8 Using necessary diagram, explain direct and indirect band gap in semiconductor.

9 Show that wave vector of hole (k_h) is opposite sign to that of wave vector of an electron (k_e).

Que 3 **[a]** (i) Write down all the crystal system giving details of their lattice parameters. **[06]**
(ii) Differentiate between Miller indices and Miller Bravais indices with proper example.

[b] Give the account of microscopic symmetry elements, mention the total no. of screw and glide possible. Display 2_1 and 4_2 screw and 'C' glide. **[06]**

OR

[b] Obtain the transformation matrix for the following two sets of planes observed for two different systems: **[06]**

	(hkl)	(HKL)
1.	(310)	(450)
2.	(410)	(560)
3.	(001)	(001)

Que 4 **[a]** (i) Define symmetry, symmetry element and symmetry operation. **[06]**
(ii) Show that the planes ($1\ \bar{1}\ 0$), ($1\ \bar{2}\ 1$) and ($\bar{3}\ 1\ 2$) belongs to zone axis [111].

[b] Show that for one –dimensional mono-atomic lattice, the phase velocity is equal to the group velocity at low temperature. **[06]**

OR

[b] What do you mean by quantization of lattice vibration? Discuss in brief a method for measurement of phonon dispersion in elastic neutron scattering. **[06]**

Que 5 **[a]** Derive wave equation for elastic waves in a cubic crystal. Solve it for longitudinal and shear waves moving in the [100] direction. **[06]**

[b] What is Hall effect? Discuss the physical origin of this effect using necessary diagram and obtain the expression to determine Hall coefficient for electron and hole. Also mention applications of Hall effect. **[06]**

OR

[b] Show that the longitudinal and shear wave velocities in [111] direction in cubic crystal are: **[06]**

$$V_L = \sqrt{\frac{[C_{11} + 2C_{12} + 4C_{44}]}{3\rho}}, \quad V_S = \sqrt{\frac{[C_{11} - C_{12} + C_{44}]}{3\rho}}$$

Que 6 **[a]** Derive an expression for the local electric field acting an atom. Explain the terms, depolarization field and Lorentz field. **[06]**

[b] Define electronic polarizability. Discuss the classical theory electronic polarizability and obtain the corresponding dispersion relation. **[06]**

OR

[b] What is magnetization? With help of necessary diagram explain cooling by isentropic demagnetization. **[06]**

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SARDAR PATEL UNIVERSITY

M. Sc. (Physics), 1st Semester Examination

9th November 2017, Thursday

Time: 02:00 PM TO 05:00 PM

Subject: Element of Solid State Physics and Error Analysis, Paper No. PS01EPHY21

Important Note :

Q.1 : Multiple choice questions (MCQ) carries one mark each.

Q.2 : Short questions carries two marks each (attempt any seven out of nine)

Q.3 to Q.6 : Long questions carries 12 marks each.

Max Marks: 70

Que 1 **Write correct answer for each of the following MCQs.** **[08]**

1 The (111) and (222) planes in a lattice are

a) Perpendicular to each other b) Parallel to each other

c) Inclined at 60° to each other d) None of these

2 In a primitive unit cell, the number of lattice point per unit cell is

a) 2 b) 5

c) 6 d) 1

3 The co-ordination number of an SC structure is

a) 6 b) 12

c) 8 d) 4

4 The forbidden frequency band of solid disappears at $k = \pm \pi/2a$, if ____ where m and M are the mass of light and heavy atom respectively.

a) $m > M$ b) $m < M$

c) $m = M$ d) $m M = 1$

5 The elastic energy density is given by :

a) 1/2(stress × strain) b) (stress × strain)

c) 2(stress × strain) d) 1/(stress × strain)

6 In case of wave propagating in [100] direction, the ratio of the velocity and transverse wave velocity is

a) C_{11}/C_{44} b) C_{44}/C_{11}

c) $(C_{11}/C_{44})^{1/2}$ d) $(C_{44}/C_{11})^{1/2}$

7 The density of carriers in a pure semiconductor is proportional to :

a) $\exp(-E_g/k_BT)$ b) $\exp(+2E_g/k_BT)$

c) $\exp(+E_g/k_BT)$ d) $\exp(-E_g/2k_BT)$

8 The equation for the hyperbolic type curve is :

a) 1/(ax - b) b) (ax + b)

c) (ax - b) d) 1/(ax + b)

Que 2 **Write answers of any seven questions.** **[14]**

1 Write about Miller Indices and Bravais lattice.

2 Display SC, BCC and FCC unit cell. What is the number of points per unit cell in these lattices?

3 Define coordination no. and nearest neighbor distance and write down the coordination no. and nearest neighbor distance for SC, BCC and FCC structures.

4 Differentiate between

(i) roto-reflection and roto-inversion

(ii) Screw and Glide

5 Calculate the intrinsic concentration of charge carriers of Ge at 300K. Given that $m_e^* = 0.12m_0$, $m_h^* = 0.28m_0$, E_g of Ge = 0.67eV $m_0 = 9.1 \times 10^{-31}$kg, k=1.38 x 10^{-23} J/^{0}K, h=6.625 x 10^{-34} J s

6 What are N-process and U-process as applied to lattice vibration.

7 Describe in brief intrinsic and extrinsic semiconductors.

8 Define: Histogram, class mark, class frequency and frequency of polygon.

9 Prove that arithmetic mean is the best estimated true value of data.

Que 3 [a] Define Symmetry, Symmetry element and Symmetry operation. Summarize all the possible macroscopic symmetry operation giving proper illustration and discuss about these operation. [06]

[b] (i) Define planes of form and planes of zone. Do the following planes belong to same zone axes, if so what is zone axes. [06]

$(\bar{1}\,1\,0)$, $(\bar{3}\,1\,1)$ and $(1\,\bar{3}\,2)$

(ii) Obtain the packing fraction for BCC, FCC and HCP structure.

OR

[b] (i) Obtain the Transformation matrix for FCC to SC (Rhombohedral) and SC to FCC structure. [06]

(ii) Write about the crystal structure of CsCl and NaCl giving the coordinate of the atom.

Que 4 [a] What do you mean by lattice vibration and phonon? Obtain the dispersion relation for one dimensional mono atomic lattice. [06]

[b] (i) Convert the following space groups into its point group [06]

P 21/c, $P2_12_12_1$, Pbca, Cc

(ii) Write down the equivalent points for the following

a) mirror 'm' perpendicular to a axis

b) Screw axis parallel to b axis

(iii) Draw the stereogram for $2, \tilde{2}, \bar{2}$

OR

[b] Obtain the necessary relation to explain the origin of acoustical and optical branch in linear diatomic lattice. Why these branches are named so? **[06]**

Que 5 [a] Draw schematic diagram of experimental set up used to determine elastic stiffness constants and describe its working procedure in detail. **[06]**

[b] For elastic stiffness constant, prove that **[06]**

$$C_{44} = \frac{1}{S_{44}} \text{ and } C_{11} - C_{12} = \frac{1}{S_{11} - S_{12}}$$

OR

[b] Show that, when crystal is under hydrostatic pressure, the energy per unit volume can be expressed as: **[06]**

$$u = \frac{1}{2}\frac{(C_{11} + 2C_{12})}{3} v^2$$

where Δv is the change in volume and Bulk modulus (B) of solid is :

$$B = \frac{1}{3}(C_{11} + 2C_{12})$$

Que 6 [a] Define Gaussian distribution and describe properties of this distribution. Also determine the mean value of the Gaussian distribution. **[06]**

[b] Obtain the expression for the best estimate of uncertainty and prove that $X = \bar{X}_n + U_n$. The breaking strength of 10 steel wire were tested in tones on testing machine is : **[06]**

4.3	4.5	4.7	4.2	4.5
4.6	4.4	4.6	4.9	4.5

Calculate:

a. The mean value of breaking strength.
b. Mean deviation.
c. Standard deviation.
d. Best estimate precision.
e. Internal standard error or best estimated uncertainty
f. The breaking strength of wire.

OR

[b] Describe linear least square fitting method in detail. **[06]**

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