SLR-HB-1

Seat No.	

Set P

M.Sc. (Semester - I) (New) (CBCS) Examination: Oct/Nov-2022
PHYSICS (ENERGY STUDIES)
Mathematical Physics

Day & Date: Monday, 13-02-2023 Max. Marks: 80
Time: 03:00 PM To 6:00 PM

Instructions: 1) Q. Nos. 1 and. 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figure to right indicate full marks.

Q.1 A) Fill in the blanks by choosing correct alternatives given below. **10**

1) If A and B are orthogonal matrices, then the product AB is
a) Symmetric b) Antisymmetric
c) Orthogonal d) Unitary

2) What is the value of a_0 in the fourier series of t^2 in the interval $-\pi < t < \pi$?
a) 0 b) $\frac{\pi^2}{3}$
c) $\frac{\pi^2}{8}$ d) $\frac{\pi^2}{4}$

3) The solution of $(y-2)p + (z-x)9 = x - y$ is
a) $f(x+y+z) = xyz$
b) $f(x^2+y^2+z^2) = xyz$
c) $f(x^2+y^2+z^2, x^2\,y^2\,z^2) = 0$
d) $f(x+y+z) = x^2 + y^2 + z^2$

4) Laplace transform of $e^{-2t}\sin 4t$ is
a) $\frac{2}{s^2+4s+20}$ b) $\frac{s-2}{s^2+4s+20}$
c) $\frac{s-4}{s^2+4s+20}$ d) $\frac{4}{s^2+4s+20}$

5) If λ is an eigen value of a non-singular matrix A then the eigen value of A^{-1} is
a) $\frac{1}{\lambda}$ b) λ
c) $-\lambda$ d) $\frac{-1}{\lambda}$

6) For two matrices A and B, $(A+B)^-$ is equal to
a) $A^2 + B^2 + 2AB$ b) $A^2 + B^2 + AB$
c) $A^2 + B^2 + AB + BA$ d) $A^2 + B^2$

7) What is the value of integral $\oint f(z)dz$ around a circle of radius z with its centre at the origin if $f(z) = \frac{1}{(z-1)}$
a) Zero b) πi
c) $4\pi i$ d) $2\pi i$

8) Find the value of $\int_0^{2\pi} e^{\cos\theta}\cos(2\theta - \sin\theta)\,d\theta$

a) 2π b) π
c) $\frac{\pi}{2}$ d) $\frac{3\pi}{2}$

9) The eigen vectors of a Hermitian matrix are

a) Real b) Imaginary
c) Complex d) ± 1

10) A square matrix is said to be orthogonal if

a) A is singular
b) A is non-singular
c) $A^T A = 1$
d) $A = -A^T$

B) State True/False **06**

1) Inverse of unitary matrix is unitary matrix
2) Fourier transform is aa linear operator
3) Legendre polynomial of degree one i.e $P_1(x) = \partial$
4) The ODE $\frac{dy}{dx} = (x + y + 5)^2$ is separable
5) The order of matrix $A = \begin{bmatrix} 1 & 5 & 9 \\ 4 & 8 & 6 \end{bmatrix}$ is 2×3
6) The first order ODE can never be linear separable and exact at the same time

Q.2 Answer the following **16**

a) Find the eigen value of $A = \begin{pmatrix} 3 & 1 \\ 2 & 2 \end{pmatrix}$

b) Find the Fourier transform of e^{-ax^2} where $a > 0$

c) Evaluate $\oint_c \frac{1}{\sin hz}\,dz$, where C is the circle $|z| = 4$

d) Derive an expression for 2nd order homogeneous equation with consent coefficients

Q.3 Answer the following **16**

a) If $A = \begin{pmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{pmatrix}$ show that $A^2 - 4A - 5I = 0$ where I, O are the unit matrix & the null matrix of order 3 respectively use this result & find A^{-1}

b) Derive a Jacobi - Bernoulli equation and solve the equation use J.B equation $y^1 + x = \frac{y}{x}$

Q.4 Answer the following **16**

a) Evaluate $\int_0^{\infty} \frac{\cos 3\theta}{5+4\cos\theta}\,d\theta$

b) Explain the details of Parseval Theorem

Q.5 Answer the following **16**

a) Explain the first order linear differential education.

b) In square wave expand the function

$f(x) = 0; -\pi \le x \le 0$

$f(x) = 4; -0 \le x \le \pi$ Fourier

Q.6 Answer the following **16**

a) Show that the eigen value of Hermitian matrix are real?

b) Find the General solution of $x(z^2 - y^2)\frac{\partial z}{\partial y} + y\,(x^2 - z^2)\frac{\partial z}{\partial y} = z(y^2 - x^2)$

Q.7 Answer the following **16**

a) Determine whether the following equation is exact and find its solution if it is exact

$$(4x^3 + 6xy + y^2)\frac{dx}{dy} = -(3x^2 + 2xy + 2)$$

b) Write matrix A gives below as the sum of symmetric & a skew symmetric matrix $A = \begin{pmatrix} 1 & 2 & 4 \\ -2 & 5 & 3 \\ -1 & 6 & 3 \end{pmatrix}$

SLR-HB-2

Seat No.	

Set P

M.Sc. (Semester - I) (New) (CBCS) Examination: Oct/Nov - 2022
PHYSICS (ENERGY STUDIES)
Solid State Physics

Day & Date: Tuesday, 14-02-2023 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) Q.Nos.1 and 2 are compulsory
2) Attempt any three questions from Q.No.3 to Q.No.7
3) Figure to right indicate full marks.

Q.1 A) Choose the correct alternative. **10**

1) Plane cut to negative x-axis have the miller indices _____.
   a) (011) b) (001)
   c) (110) d) (100)

2) Effective mass depends on _____ ratio.
   a) dP/dt b) dE/dP
   c) dP/dK d) dE/dK

3) The intrinsic concentration of charge carriers in a semiconductor varies as ....
   a) T b) T^2
   c) T^3 d) T^{-1}

4) Relative permittivity εr of the air is _____
   a) 2 b) 0.5
   c) 1 d) 0

5) The electronic polarizability αe of a monoatomic gas is _____.
   a) $4\pi\varepsilon_0$ b) $4\pi\varepsilon_0 R$
   c) $4\pi\varepsilon_0 R^3$ d) $4\pi{\varepsilon_0}^2$

6) Packing fraction of BCC is _____.
   a) 74% b) 68%
   c) 52% d) 58%

7) FCC structure contains the contribution of _____ atoms.
   a) Two b) Four
   c) Nine d) Six

8) Conductivity in metal depends on _____ mobility.
   a) Proton b) Neutron
   c) Electron d) None of these

9) Miller indices of a plane parallel to X and Z axes are _____.
   a) (001) b) (100)
   c) (010) d) (101)

10) Number of tetrad axis in a simple cubic system are ____.
   a) 2 b) 3
   c) 4 d) 8

B) Write True or False. **06**

1. The addition of pentavalent impurity creates an n-type semiconductor
2. Fermi energy level in the case of a p-type semiconductor is close to the conduction band.
3. At Debye's temperature materials show the transition from normal to the superconducting state.
4. Rectifier rectifies internal resistance.
5. Conductance of the superconductor becomes zero at T_c.
6. Dielectric constant of metal is finite.

Q.2 Answer the following. **16**

a) Define packing fraction in detail.
b) Write about dielectric loss.
c) Derive an expression for the effective mass of the electron.
d) Write a short note on specific heat

Q.3 Answer the following. **16**

a) Show that the FCC is reciprocal of BCC**.**
b) Differentiate polycrystalline, nano-crystalline and amorphous materials

Q.4 Answer the following. **16**

a) Give the expression for inter-planar spacing (d).
b) What is Meissner's effect. Derive an expression for penetration depth.

Q.5 Answer the following. **16**

a) Classify the magnetic materials.
b) Write about the behavior of electrons in a periodic potential.

Q.6 Answer the following. **16**

a) Write about direct and indirect band gaps of semiconductors.
b) What is dielectric polarization? Give the expression for electronic polarization.

Q.7 Answer the following. **16**

a) What is meant by imperfections in crystals? Explain the various defects in the crystal.
b) What is a superconductor? Write about the London equation.

SLR-HB-3

Seat No.	

Set P

M.Sc. (Semester - I) (New) (CBCS) Examination: Oct/Nov-2022
PHYSICS (ENERGY STUDIES)
Analog and Digital Electronics

Day & Date: Wednesday, 15-02-2023 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) Question no. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7.
3) Figure to right indicate full marks.

Q.1 A) Multiple choice questions. **10**

1) A (A+B) = ?
   a) AB b) 1
   c) (1+AB) d) A

2) Master slave flip is also referred to as?
   a) Level triggered flip flop b) Pulse triggered flip flop
   c) Edge triggered flip flop d) Edge-Level triggered flip flop

3) Which interrupt is not level sensitive in 8085?
   a) RST 7.5 b) RST 6.5
   c) RST 4.5 d) RST 5.5

4) Which of the following flag condition is used for BCD arithmetic operations in microprocessor?
   a) Sign flag b) Auxiliary carry flag
   c) Parity flag d) Zero flag

5) The AND gate output will be high if the two inputs are _____.
   a) 00 b) 01
   c) 10 d) 11

6) A one-shot is a type of _____ multivibrator.
   a) Astable b) Monostable
   c) Timer d) b & c are correct

7) In 8085 microprocessor _____ register used as a working area in CPU.
   a) A b) B
   c) H d) None of these

8) An Integrator has _____ in the input terminal, for an Opamp based circuit.
   a) Resistance b) Inductor
   c) Capacitor d) None of these

9) Output impedance of IC 741 is typically _____ Ω.
   a) 100 b) 1000
   c) 10 d) 1

10) _____ Oscillator uses capacitive voltage divider feedback.
   a) Hartley b) Phase shift
   c) Colpit d) Wien bridge

B) Fill in the blanks / State True or False. **06**

1) Differential Amplifier consists of _____ transistors.
2) Data bus of 8085 microprocessor is _____ bit.
3) SR flip flop does not accept the input entry when _____.
4) Phase shift of the Phase shift circuit at the resonance frequency is 180^0 (True/False)
5) Switching regulator is used for high power applications. (True/False)
6) Ideal op-amp has infinite voltage gain because to obtain finite output voltage. (True/False)

Q.2 Answer the following **16**

a) Virtual ground concept
b) DeMorgans Theorem
c) PIPO shift register
d) Flags in 8085

Q.3 Answer the following.

a) What is feedback? Explain effect of negative feedback on input resistance of OpAmp. **10**
b) Draw and explain Integrator using 741 OpAmp. **06**

Q.4 Answer the following.

a) Describe 4 bit D flip-flop with timing diagram. **10**
b) Draw and explain 8:1 Multiplexers. **06**

Q.5 Answer the following.

a) Draw and explain Phase shift Oscillator using Opamp. Obtain an expression for frequency. **10**
b) Design a non-inverting amplifier with Av =11, Given Ib=100nA, Vi >1V. **06**

Q.6 Answer the following.

a) Explain inverting configuration of 3 inputs Op Amp as a summing, scaling and averaging amplifier. **10**
b) Reduce the following logical expressions using Boolean laws: **06**

$$\overline{A}BC + A\overline{B}\overline{C} + ABC + \overline{A}B$$

Draw logic diagram of reduced expression.

Q.7 Answer the following.

a) Draw and explain architecture of 8085 microprocessor. **10**
b) Draw and explain memory write cycle of 8085 microprocessor. **06**

SLR-HB-4

Seat No.	

Set P

M.Sc. (Semester-I) (New) (CBCS) Examination: Oct/Nov-2022
PHYSICS (ENERGY STUDIES)
Classical Mechanics

Day & Date: Thursday, 16-02-2023 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) Question no. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7.
3) Figure to right indicate full marks.

Q.1 A) Multiple choice questions. **10**

1) The Poisson bracket of $[u, p_j]$ = _____.
   a) $-\partial u/\partial p_j$ b) $\partial u/\partial q_j$
   c) $+\partial u/\partial p_j$ d) $-\partial u/\partial q_j$

2) The point transformation is the transformations of _____.
   a) Phase space b) configuration space
   c) both a & b d) point space

3) The reduced mass μ = _____.
   a) $(m_1 + m_2)/m_1 m_2$ b) $m_1 m_2/(m_1 - m_2)$
   c) $m_1 m_2/(m_1 + m_2)$ d) $(m_1 - m_2)/m_1 m_2$

4) In equations of motion $\dot{P}_J$ = _____.
   a) $-\partial H/\partial P_j$ b) $\partial H/\partial P_j$
   c) $\partial H/\partial q_j$ d) $-\partial H/\partial q_j$

5) If eccentricity ϵ = 0, then the shape of the orbit, which is formed due to motion under central force field will be _____.
   a) Ellipse b) Circle
   c) Hyperbola d) Parabola

6) The Hamiltonian is defined as _____.
   a) H=T-V b) H=T/V
   c) H=T*V d) H=T+V

7) The generating function $F_2(q, P, t)$ generates _____ transformations.
   a) exchange b) identity
   c) none d) infinite

8) The Phase space is _____dimensional space.
   a) 3N b) 2N
   c) 6N d) N

9) The Poisson bracket of [u,u] = _____.
   a) 1 b) u^2
   c) 0 d) 2u

10) If $m_1 \ll m_2$, then the centre of mass of system coincides with the centre of mass of _____.
   a) m_1 b) m_2
   c) in between m_1 and m_2 d) away from m_1

B) Fill in the blanks or write true or false. **06**

1) [X,Y]= [Y,X] is the property of the Poisson bracket.
2) The Hamiltonian formulation is more advantageous than the Newtonian.
3) In the Configuration space, the system is having a unique path.
4) There are three degrees of freedom for a flywheel.
5) The path of the particle is a straight line when it is moving under the constant conservative force field.
6) The Δ – variation involves time.

Q.2 Answer the following. **16**

a) State and prove the law of conservation of linear momentum of system particles.
b) Write a note on Kepler's laws of planetary motion.
c) Which conditions are used to verify that the transformation is canonical? Prove any one condition.
d) What is generating function? What are its different forms?

Q.3 Answer the following.

a) Discuss the Hamilton-Jacobi theory and derive the Hamilton-Jacobi partial differential equation and its solution. **10**
b) Deduce the relation between the Hamiltonian and Lagrangian. **06**

Q.4 Answer the following.

a) Define Hamiltonian. Why Hamiltonian formulation is preferred over Langrangian formulation. **10**
b) How the equations of motion are written in terms of Poisson brackets. **06**

Q.5 Answer the following.

a) What are the main features of the motion of a particle under the action of central force? Show that the area swept per unit time i.e. dA/dt remains constant in such a motion. **10**
b) What are constraints? Explain with its example. **06**

Q.6 Answer the following.

a) What is Poisson Bracket? List its properties. Explain Jacobi's identity with its proof. **10**
b) Distinguish between the configuration space and phase space. **06**

Q.7 Answer the following.

a) How a two-body problem does reduce to a single-body problem? Derive the equation of motion for it. **10**
b) Write a note on Rutherford's scattering. **06**

SLR-HB-6

Seat No.		Set	P

M.Sc. (Semester - II) (New) (CBCS) Examination: Oct/Nov-2022
PHYSICS (ENERGY STUDIES)
Quantum Mechanics

Day & Date: Monday, 20-02-2023 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. Nos. 1 and. 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figure to right indicate full marks.

Q.1 A) Choose correct alternative. (MCQ) **10**

1) Which of the following is the velocity at which a given crest moves?
   a) The phase velocity ω b) Group velocity
   c) Particle velocity d) Sound velocity

2) In which of the following effect, the electrons are emitted from a metal surface illuminated by the ultraviolet radiation.
   a) Photoelectric effect b) Diffraction
   c) Compton scattering d) Interference

3) The relationship between velocity v, momentum p and wavelength λ is given by
   a) $p = hv$ b) $p = \frac{h}{\lambda}$
   c) $p = \frac{mv}{c}$ d) $p = \frac{\lambda}{h}$

4) The Schrodinger's wave equation for a particle moving in one dimension is given by
   a) $\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$
   b) $\frac{d^2\psi}{dx^2} - \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$
   c) $\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m}{h^2}(E + V)\psi = 0$
   d) $\frac{d^2\psi}{dx^2} - \frac{8\pi^2 m}{h^2}(E + V)\psi = 0$

5) The Born interpretation of ψ is that
   a) $|\psi * \psi|\ \mathrm{dr}$ is proportional to the probability of finding the electrons in an infinitesimal region between r and $\mathrm{r} + \mathrm{dr}$
   b) $|\psi * \psi|\ \mathrm{dr}$ is inversely proportional to the probability of finding the electrons in an infinitesimal region between r and $\mathrm{r} + \mathrm{dr}$
   c) $|\psi * \psi|\ \mathrm{dr}$ is proportional to the negative probability of finding the electrons in an infinitesimal region between r and $\mathrm{r} + \mathrm{dr}$
   d) $|\psi * \psi|\ \mathrm{dr}$ is not related with the probability of finding the electrons in an infinitesimal region between r and $\mathrm{r} + \mathrm{dr}$

6) Acceptable / well behaved wave functions are those which satisfy the
   a) Ψ must be single valued
   b) Ψ and its first derivative with respect to its variables are continuous
   c) For bound states, Ψ must vanish at infinity
   d) All of the above

7) The zero-point energy of an electron in a one dimensional box is given by

a) $E_{zero\ point} = \frac{h^2}{4m_e a^2}$

b) $E_{zero\ point} = \frac{h^2}{8m_e a^2}$

c) $E_{zero\ point} = -\frac{h^2}{8a^2}$

d) $E_{zero\ point} = \frac{h^2}{8m_e}$

8) The potential energy of particle in harmonic oscillator is given by

a) $V = kx^2$ b) $V = \frac{1}{2}kx^2$

c) $V = \frac{1}{4}kx^2$ d) $V = \frac{1}{8}kx^2$

9) The first theory of chemical bonding is given by_____.

a) G. N. Lewis in 1916 b) G. N. Mendis in 1916

c) G. N. Lewis in 1961 d) G. N. Mendis in 1906

10) The Laplacian operator in quantum mechanics is defined

a) $\nabla^2 = \frac{\partial^2}{\partial x^2} - \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$

b) $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$

c) $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} - \frac{\partial^2}{\partial z^2}$

d) $\nabla^2 = \frac{\partial^2}{\partial x^2} - \frac{\partial^2}{\partial y^2} - \frac{\partial^2}{\partial z^2}$

B) Fill in the blanks or Write true /false **06**

1) The condition for an operator $\hat{A}$ to be hermitian is given by _____.
2) The minimum energy required to remove an electron from the hydrogen atom in its ground state is the _____.
3) The atomic unit of magnetic moment is known as _____.
4) Write whether following statement is true or false.
The electron inside the box is not at rest even at 0 K
5) Write whether following statement is true or false.
It is assumed that electrons in molecules occupy certain orbitals, which extend over all the nuclei in a molecule.
6) Write whether following statement is true or false.
The general concept of molecular orbitals and of the building up principle using molecular orbitals was developed in 1927 by Hund and Mulliken and in 1929 by Lennard Jones.

Q.2 Answer the following questions. **16**

a) Discuss the wave and particle nature of radiation
b) Write a note on break down of Born-Oppenheimer approximation.
c) State the postulates of quantum mechanics
d) Write a note on Normalization and Characteristics of Eigen functions of harmonic oscillator

Q.3 Answer the following

a) Obtain the Schrodinger's wave equation in three dimensions. **10**

b) Explain the Eigen functions of the position operator and Dirac delta function. **06**

Q.4 Answer the following

a) Obtain the expression for energy of particle in harmonic oscillator. **10**

b) With neat diagram explain the shape of atomic orbital. **06**

Q.5 Answer the following.

a) Obtain the expression for ground state energy of hydrogen atom. **10**

b) Explain the self-consistent field method in calculation of the ground state energy and wave functions of many electron atoms. **06**

Q.6 Answer the following.

a) Describe the molecular orbital treatment of hydrogen molecule. **10**

b) Apply the Born-Oppenheimer approximation and LCAO molecular orbital theory to Hydrogen molecule ion. **06**

Q.7 Answer the following.

a) With a diagram of P, Q, R Branches, explain the Vibration and vibrational spectra of diatomic molecules. **10**

b) Write a note on Eigen functions of position operator. **06**

SLR-HB-7

Seat No.		Set	P

M.Sc. (Semester - II) (New) (CBCS) Examination: Oct/Nov - 2022
PHYSICS (ENERGY STUDIES)
Electrodynamics

Day & Date: Tuesday, 21-02-2023 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. No 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to 7
3) Figures to the right indicate full marks.

Q.1 A) Choose the correct alternatives from the options. **10**

1) The scalar potential for quadrupole varies as _____.
   a) $V \propto \frac{1}{r^2}$ b) $V \propto \frac{1}{r^3}$
   c) $V \propto \frac{1}{r^4}$ d) $V \propto \frac{1}{r^5}$

2) In vacuum divegence of electric field over a surface is _____.
   a) zero b) charge enclosed by surface
   c) one d) none of above

3) A wire wound in the form of a solenoid has _____ self-inductance than when it is unwound.
   a) Smaller b) Equal
   c) Nearly equal d) Larger

4) The scalar potential is due to _____.
   a) Charge density b) Current density
   c) Surface current d) Line element

5) The normal component of magnetic field, above and below the surface _____.
   a) discontinuous b) continuous
   c) different d) independent of charges

6) The electric field inside a conductor is _____.
   a) Greater than zero b) Less than zero
   c) Zero d) none of these

7) Angular distribution of energy due to accelerated charged particle at low velocity is proportional to _____.
   a) $\mathrm{Sin}^2\theta$ b) $\mathrm{Sin}^3\theta$
   c) $\frac{1}{\mathrm{Sin}^3_\theta}$ d) $\frac{1}{\mathrm{Sin}^2_\theta}$

8) The radiation from an oscillating electric dipole is generally _____.
   a) Transverse electric b) Zero
   c) Positive d) Transverse magnetic

9) Unit of Poynting vector is _____.
   a) W/m b) W.m
   c) W/m^2 d) m/W

10) For radiation fields the ratio E/B is always equal to _____.
   a) One b) 1/velocity of light
   c) velocity of light d) less than velocity of light

Q.1 B) Fill in the blanks. **06**

1) When a high-speed electron hits a metal target, it rapidly decelerates, giving off what is called _____.
2) A charge Q is uniformly distributed on the surface of a cube and there is no other charge in consideration. Divergence of electric field is _____.
3) Amount of electrostatic energy stored in unit volume of electric field is _____.
4) Magnetic field does work _____.
5) Two particles with identical charges and mass collide, there is _____.
6) The Lorentz gauge condition is _____.

Q.2 Answer the following. **16**

a) What are boundary conditions?
b) State the Coulomb and Lorentz gauge conditions.
c) What are scalar and vector potentials?
d) Write the Maxwell's equations in differential form.

Q.3 Answer the following. **16**

a) Show that vector potential for dipole is $A_{dip} = \frac{\mu_0}{4\pi} \frac{m \times \hat{r}}{r^2}$.

b) Find the magnetic field at a distance 's' from a long straight wire, carrying a steady current 'I'.

Q.4 Answer the following. **16**

a) Derive an expression for the electric potential at a distance 'r' due to a point charge.
b) Explain the concept of Maxwell's displacement current.

Q.5 Answer the following. **16**

a) State and prove Poyntings theorem and explain the significance of Poyntings vector.
b) Obtain electromagnetic wave equations in conducting medium.

Q.6 Answer the following. **16**

a) Obtain the Fresnel's relation for the polarization parallel to the plane of incidence.
b) What is Hertz potential and explain its importance?

Q.7 Answer the following. **16**

a) Derive the relation for total power radiated by electric dipole.
b) Explain radiation from half wave antenna.

SLR-HB-8

Seat No.		Set	P

M.Sc. (Semester - II) (New) (CBCS) Examination: Oct/Nov - 2022
PHYSICS (ENERGY STUDIES)
Statistical Physics

Day & Date: Wednesday, 22-02-2023 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. Nos. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No.3 to Q. No.7.
3) Figure to the right indicates full marks.

Q.1 A) Choose Correct Alternative: **10**

1) Which one of the following definitions best describes the concept of work?
   a) The flow of energy from one object or substance to another due to a difference in temperature
   b) The flow of energy from one body to another through uniform molecular motion
   c) The force associated with molecular motion
   d) The random motion of molecules in a gas at low pressure

2) An isolated system is best described by which one of the following statements.
   a) Neither matter nor heat can pass into or out of the system
   b) The system has a boundary which allows heat to be transferred but does not allow material to pass into or out of the system
   c) The system has a diathermic boundary
   d) A system which has reached thermal equilibrium with its surroundings

3) Which one of the following statements describes a path function?
   a) A property of a system that depends only on the current state of the system, not on the path the system took to reach that state
   b) A property of a system that depends on the path taken between the initial and final states.
   c) The sum of kinetic and potential energy contained in a substance
   d) The heat energy absorbed by a system at constant pressure

4) Which one of the following equations defines the enthalpy of reaction, ΔH, for a reaction occurring at constant pressure that does expansion work? All terms have their usual meanings.
   a) $\Delta H = \Delta U$ b) $\Delta H = \Delta U + p\Delta V$
   c) $\Delta H = \Delta G - T\Delta S$ d) $\Delta H = q + w$

5) Gibbs paradox in statistical mechanics is related to.
   a) Additive property of the energy
   b) Additive property of the momentum
   c) Additive property of the entropy
   d) Additive property of the temperature

6) What is a process during which the pressure remains constant?
   a) Isometric process b) Isobaric process
   c) Isochoric process d) Isothermal process

7) What type of system energy is related to the molecular structure of a system?
   a) Macroscopic form of energy
   b) Microscopic form of energy
   c) Internal energy
   d) External energy

8) Consider the three collections of particles (ensembles) named micro canonical, canonical and grand canonical. Which one physical property is constant in all three ensembles?
   Total number of particles N incorrect
   a) Pressure, p
   b) Temperature, T
   c) Volume, V
   d) Total number of particles N

9) Consider the general labelling of systems as open, closed, or isolated. The first allows the exchange of matter and energy with its surroundings; the second allows only the exchange of energy, whereas the third allows no exchange at all. Which one of the following statements is correct?
   a) An isolated system obeys the rules of the canonical ensemble.
   b) An open system obeys the rules of the canonical ensemble.
   c) An open system obeys the rules of the microcanonical ensemble.
   d) A closed system obeys the rules of the microcanonical ensemble.

10) The ensemble which allows the subsystem to allow exchange of energy as well as
   a) Canonical ensembles
   b) Micro canonical ensembles
   c) Grand canonical ensembles
   d) Both a and c

B) State True or False: **06**

1) The Kinetic Energy of the particle is dependent on Temperature only. (True/False)
2) If a liquid crystallises in to a solid, entropy will be decrease. (True/False)
3) Gibbs paradox in statistical mechanics is related to additive properties of entropy. (True/False)

4) The Fermi energy (Ef) of the white dwarfs is 10 MeV. (True/False)
5) A system can exist in a state of negative temperature because the total energy E has an upper bound. (True/False)
6) If the system is known to be in a state of equilibrium, the corresponding ensembles must be Hamiltonian. (True/False)

Q.2 Answer the following. **16**

a) State and explain the Bose-Einstein condensation.
b) Explain the Pauli Paramagnetism.
c) Explain the concept of canonical, and microcanonical ensemble.
d) State the Density of state in phase space based on classical and quantum physics.

Q.3 Answer the following. **16**

a) Derive an expression for partition function of ideal gas in grand canonical ensemble.
b) State and explain the planks distribution law and derive the necessary expression for it.

Q.4 Answer the following. **16**

a) State and derive the equipartition theorem
b) What is Ensemble? What are different type of ensemble? Explain the concept of ensemble average and discuss the concept at stationary ensemble.

Q.5 Answer the following. **16**

a) State and explain nature of particle in Boson- Einstein statistics.
b) Show that the change in the entropy due to mixing of two ideal gases results in to the Gibb's paradox.

Q.6 Answer the following. **16**

a) Describe in detail the concept of Density Distribution in phase space.
b) Derive an expression for Entropy, Gibb's Free energy for canonical ensemble.

Q.7 Answer the following. **16**

a) State and describe the Liouville's equation.
b) Show that the change in the entropy due to mixing of two ideal gases results in to the Gibb's paradox

SLR-HB-10

Seat No.		Set	P

M.Sc. (Semester - III) (New) (CBCS) Examination: Oct/Nov-2022
PHYSICS (ENERGY STUDIES)
Semiconductor Physics

Day & Date: Monday, 13-02-2023 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. No. 1 & 2 are compulsory.
2) Attempt any three questions from Q. 3 to 7.
3) Figures to the right indicate full marks.

Q.1 A) Choose correct alternative **10**

1) Epitaxial techniques have been used for the growth of epilayers of III -V and, II -VI compound _____ and other materials.
   a) metals b) insulators
   c) semiconductors d) conductors

2) The maximum packing factor for a SC lattice of identical atoms with a lattice constant of 20 A^0 will be _____.
   a) 0.52 b) 0.68
   c) 0.34 d) 0.74

3) The initial process that occur in the formation of a crystal is_____.
   a) growth b) nucleation
   c) atomic bonding d) clusters

4) Czochralski method is crystal growth from_____.
   a) melt b) vapour
   c) solution d) solid

5) A semiconductor absorbs photons with energies_____.
   a) smaller than band gap energy only
   b) equal to the band gap energy only
   c) equal to the band gap or larger
   d) equal to the band gap or smaller

6) The driving force needed for the nucleation and growth of crystal is referred as ____.
   a) molecular force b) super saturation
   c) growth force d) atomic force

7) In indirect recombination the electron and hole pairs recombine at recombination level; *Er* in ____ steps.
   a) 2 b) 3
   c) 4 d) 5

8) The relation between frequency and wavelength is known as_____.
   a) the dispersion relationship
   b) de Broglie relation
   c) Cauchy's relation
   d) Planck relation

9) Which of the three semiconductors, Ge, Si and GaAs has a direct bandgap?
   a) Ge and GaAs b) Si and GaAs
   c) GaAs d) Ge and Si

10) Which of the following semiconductor has indirect band gap?
   a) Ge and GaAs b) Si and GaAs
   c) GaAs d) Ge and Si

Q.1 B) Fill in the blanks OR write True /False **06**

1) For lightly doped junction's electron tunneling is dominant phenomenon. (True/False)
2) In a semiconductor, the electrons occupy states near the top of the conduction band. (True/False)
3) A semiconductor with band gap of about 2 eV wide, allows only long wavelengths and the red part of the visible spectrum to transmit through it. (True/False)
4) First step in crystal growth is the transport of atoms through solution. (True/False)
5) Epitaxy means growth of many crystal films on top of a crystalline substrate. (True/False)
6) ____ epitaxy is a process of depositing epitaxial thin films from molecule of atomic beams on a heated substrate under UHV conditions.

Q.2 Answer the following. **16**

a) Write a note on direct recombination of electrons and holes.
b) Discuss bonding forces in semiconductors.
c) What are the advantages of Epitaxial technology?
d) Explain the term nucleation rate and induction time.

Q.3 Answer the following. **16**

a) Describe steady state carrier injection in case of semiconductor.
b) Explain with neat diagram Czocharalski method of crystal growth.

Q.4 Answer the following.

a) Discuss in detail "Effective mass" of an electron in a band. **10**
b) Explain with neat diagram Liquid Phase Epitaxy. **06**

Q.5 Answer the following. **16**

a) Obtain an expression for electrical conductivity (σ) and mobility (μ) in case of semiconductors.
b) Explain with neat diagram Molecular Beam Epitaxy.

Q.6 Answer the following. **16**

a) Explain Zone melting method of crystal growth.
b) Write a note on high field effects in semiconductors.

Q.7 Answer the followings. **16**

a) Explain indirect recombination and trapping of charge carriers of semiconductors.
b) Explain theory of nucleation and growth.

SLR-HB-11

Seat No.	

Set P

M.Sc. (Semester - III) (New) (CBCS) Examination: Oct/Nov - 2022
PHYSICS (ENERGY STUDIES)
Automatic and Molecular Physics

Day & Date: Tuesday, 14-02-2023 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. Nos. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figure to right indicate full marks.

Q.1 A) Choose correct alternative. (MCQ) **10**

1) In the case of 1st order, Stark effect for the hydrogen atom (Z =1) the ground state splits into ____.
   a) 2 levels b) 3 levels
   c) 4 levels d) does not split

2) The rotational constant for $H^{35}Cl$ is observed to be 10.5909 cm^{-1}. What is the value of B for $^2D^{35}Cl$?
   (Given: atomic masses (in kg): $^1H = 1.673 \times 10^{-27}$, $^2D = 58.06 \times 10^{-27}$, $^{35}Cl = 1.673 \times 10^{-27}$, $^{37}H = 61.38 \times 10^{-27}$)
   a) 5.44 cm^{-1} b) 4.44 cm^{-1}
   c) 6.44 cm^{-1} d) 54.4 cm^{-1}

3) The equilibrium vibration frequency for an oscillator is observed at 2990 cm^{-1}. The ratio of the frequencies corresponding to the first overtone band and the fundamental spectral lines is 1.96. Considering the oscillator to be anharmonic, the anharmonicity constant is
   a) 0.005 b) 0.02
   c) 0.05 d) 0.1

4) What is the moment of inertia I_B, of $^1H^{79}Br$ if the bond distance is 143 pm? Atomic masses are: ^1H=1.008 amu, ^{79}Br = 78.92 amu
   a) 3.33×10^{-47} $kg.m^2$ b) 3.00×10^{46} $kg.m^2$
   c) 2.34×10^{-37} $kg.m^2$ d) 1.22×10^{-7} $kg.m^2$

5) Put the energies of the $K\alpha, K\beta$, and $L\ \alpha$ X-rays from an element in order of increasing energy (from smallest to largest).
   a) $L\alpha, K\alpha, K\beta$ b) $K\alpha, K\beta, L\alpha$
   c) $K\alpha, L\alpha, K\beta$ d) $L\alpha, K\beta, K\alpha$

6) The bond order for the O_2 molecule is _____
   a) 1 b) 2
   c) 2.5 d) 0

7. The transition of longer wavelength observed in the case of Orthohelium is ____.
   a) $2^3P_{0,1,2} \longrightarrow 2^3S_1$ b) $2^3P_1 \longrightarrow 2^1S_0$
   c) $2^3P_{0,1,2} \longrightarrow 2^3S_1$ d) $3^1P_1 \longrightarrow 1^1S_0$

8) The total number of emission lines observed during the transition of electrons from $3^2P_{3/2}$ to $3^2S_{3/2}$ are _____.
   a) 2 b) 4
   c) 6 d) 8

9) The spectroscopic symbol for the ground state of Al (Z = 13) is $2P_{1/2}$. Under the action of a strong magnetic field (when L-S coupling can be neglected) the ground state energy level will split into _____
   a) 3 levels b) 4 levels
   c) 5 levels d) 6 levels

10) The fine structure of atomic spectral lines arises from
   a) Electron spin-orbit coupling
   b) Interaction between electron and nucleus
   c) Nuclear spin
   d) Stark effect

B) Fill in the blanks OR Write true /false **06**

1. According to Moseley's law, the frequency of a spectral line in an X-ray spectrum varies as a square of the atomic number of the element. (True/False)
2. The shortest wavelength observed in the Paschen series of hydrogen spectra is _____.
3. The spectral term separation ΔT is expressed in terms of cm^{-1} which is caused due to spin-orbit interaction and is related to the atomic number Z by Z^{-4}. (True/False)
4. The energy of the Kα X-ray of sodium (Z = 11) is 1.02 keV.
5. The Lande's g-factor for $8G_{1/2}$ is - 4/3
6. Oxygen has the electronic configuration 1s22s22p4. In the ground state, the total ms of all 8 of the electrons has the largest possible value consistent with the Pauli principle is 1.

Q.2 Answer the following questions. **16**

A) Write an electronic configuration of Na_2 (Na, Z = 11) and S_2 (S, Z = 16) diatomic molecules in accordance with molecular orbital approach and state the bond order in each case.

B) Find the possible multiplicities × of the terms of the types (a) $\times D_2$; (b) $\times P_{3/2}$

C) What is Stark effect? discuss the weak-field Stark effect in hydrogen for Hα line.

D) From the following data, find the energy required to dissociate a KCl molecule into a K atom and a Cl atom. The first ionization potential of K is 4.34 eV; the electron affinity of Cl is 3.82 eV; the equilibrium separation of KCl is 2.79 Å. (Hint: Show that the mutual potential energy of K^+ and Cl^- is — (14.40/R) eV if R is given in Angstroms).

$$\left(\frac{e^2}{4\pi\varepsilon_0} = 1.44 \times 10^{-9}\ eV.m\right)$$

Q.3 Answer the following questions. **16**

A) i) Discuss the rotational spectrum of a diatomic molecule treated as a non-rigid rotator.

ii) The rotational spectrum of $^{79}Br^{19}F$ shows a series of equidistance lines 0.71433 cm^{-1} apart. Calculate the rotational constant, B, and hence the moment of inertia and bond length of the molecule. Determine the wave number of the J = 9 to J = 10 transition, and find which transition gives rise to the most intense spectral line at room temperature, (say 300 K). Calculate the number of revolutions per second which the BrF molecule undergoes when (a) the J = 0 state (b) J = 1 state, and (c) the J = 10 state. (Atomic masses in kg: ^{79}Br = 131.03 x 10^{-27}, ^{19}F = 31.55 x 10^{-27}; h = 6.626 x10^{-34} Js, c = 2.998 x 10^{8} m/s, k = 1.381 x 10^{-23} J/K) Hint: Use E= ½ $I\omega^2$

B) i) Discuss the basic foundation behind the magnetic spin resonance spectroscopy techniques?

ii) Differentiate between nuclear magnetic resonance and electron paramagnetic resonance spectroscopic techniques,

iii) Show how many signals you will see in the electron spin resonance spectrum of H-atom considering nuclear hyperfine interaction. Sketch the predicted spectrum in first derivative form and label it properly.

iv) If the observed chemical shift of a proton is 200 Hz from tetramethylsilane $(CH_3)_4Si$ and instrument frequency is 60 MHz, what is the chemical shift in terms of δ? Express it in τ value.

Q.4 Answer the following questions. **16**

A) i) Draw a neat labelled schematic diagram showing electronic, vibrational and rotational energy levels of a molecule and comment on their individual separations with typical energy/wavenumber values.

ii) Give a brief account of Franck-Condon principle and discuss how it is useful in explaining the intensity distribution in absorption bands of molecules based on internuclear separations of upper and lower electronic states.

iii) Obtain the number of vibrational modes for the following molecules and sketch them

a) H_2O b) CO_2

B) i) In a multielectron atom, consider two identical particles (electrons, noninteracting). Let ψ_α and ψ_β be the eigenfunctions corresponding to the states α and β, in which the two particles can be found. Considering total eigenfunctions, show that the two particles can not be in a state with the same set of quantum numbers.

ii) Evaluate the Lange' g factor for the $^3P_1$ state in 2p3s configuration of ^6C. On the application of a magnetic field B = 0.1 tesla, calculate the Zeeman splitting of the state ΔE in joules. (μ_b = 9.2740 x 10^{-24} J/T)

iii) Nitrogen (Z = 7) has three electrons in the 2p level (in addition to two electrons each in the 1s and 2s levels), (a) Consistent with the Pauli principle, what is the maximum possible value of the total M_s of all seven electrons? (b) List the quantum numbers of the three 2p electrons that result in the largest total M_s. (c) If the electrons in the 2p level occupy states that maximize M_s, what would be the maximum possible value for the total M_L? (d) What would be the maximum possible total M_L if the three 2p electrons were in states that did not maximize M_s?

Q.5 Answer the following questions. **16**

A) What do you mean by spin-orbit interaction? Calculate the change in total energy of the atom due to spin-orbit coupling. Find the magnitude of spin-orbit energy for $2_{P_{\frac{3}{2}}}$ state of the hydrogen (Z=1) atom. The radius of the orbit is $3a_0 = 1.5\text{Å}$

$e = 1.6 \times 10^{-19}C, \hbar = 6.58 \times 10^{-16}\, eV.s, m = 9.1 \times 10^{-31}kg$

$c = 3 \times 10^{8}ms^{-1};\ \varepsilon_0 = 8.8542 \times 10^{-12}F.m^{-1}$ spin g -factor $g_s = 2$

(Bohr radius $a_0 = 0.529\text{Å}, \vec{S}.\vec{L} = \frac{\{j(j+1)-l(l+1)-s(s+1)\hbar^2}{2}; \langle\frac{1}{r^3}\rangle = \frac{z^3}{a_0^3 n^3 l(l+\frac{1}{2})(l+1)}$

B) i) Discuss the vibrational-rotational spectra of a diatomic molecule by showing P, Q and R branches with proper selection rules,

ii) Designate proper branches (P, Q and R) for the following type of vibrations of a heteronuclear diatomic molecule

a) Symmetric stretching mode in which dipole vibrate parallelly along the bond length.

b) Bending mode in which dipole vibrate perpendicularly along the bond length,

iii) Explain why vibrational-rotational spectra cannot be obtained for homonuclear diatomic molecules having identical nuclei?

Q.6 Answer the following questions. **16**

A) Discuss the Paschen Back effect for one vale nce electron system by considering the principal doublet (i.e. D1 and D2 lines) $^2S_{1/2} \longleftarrow {}^2P_{1/2,3/2}$ transitions of sodium. Justify the phenomenon of Paschen Back effect by considering magnetic interaction energy i. e. ΔE

B) Find the most probable radius for the electron of a hydrogen (Z =1) atom in the 1s states. Given, $P_{1,0}(r) = \frac{4r^2}{a_0^3} e^{\frac{-2r}{a_0}}$. Calculate the average orbital radius of a 1s electron in the hydrogen atom. What is the probability of the electron in the 1s state of the hydrogen atom being at a radius greater than the Bohr radius a_0? (Given, e = 2.71818)

Given: $\int_0^\infty x^m.e^{-ax^n}dx = \frac{1}{n}\frac{\Gamma(\frac{m+1}{n})}{a^{(m+1)/n}};\ \Gamma(n) = (n-1)!$

Q.7 Answer the following questions. **16**

A) Explain the valence band theory of Heitler- London i.e. Quantum mechanical treatment of Hydrogen (H_2) Molecule.

B) i) What are non-equivalent and equivalent electrons? Is it possible to have two equivalent electrons in the same atom? Calculate the spectral terms for non-equivalent (s,s) (s,p) and (p,p) electrons and for two equivalent (s^2) and (p^2) electrons.

ii) What do you mean fine structure? With neat labelled diagram discuss the fine structure of doublets for a) $^2P_{1/2}$ and $^2P_{3/2}$ and b) $^2D_{3/2}$ and $^2D_{5/2}$ states with justification based on magnitude of ΔT_{ls}

iii) Calculate the ESR frequency of an unpaired electron in a magnetic field of 3000 G
(0.30 T). (g = 2.00, μ_B = 9.273 x 10^{-24} J/T, h = 6.626 x 10^{-34} Js)

SLR-HB-13

Seat No.	

Set P

M.Sc. (Semester - III) (New) (CBCS) Examination: Oct/Nov-2022
PHYSICS (ENERGY STUDIES)
Materials Characterization

Day & Date: Wednesday, 15-02-2023 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Question no. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7.
3) Figure to right indicate full marks.

Q.1 A) Multiple choice questions. **10**

1) ASTM stands for _____.
   a) American Society for Tensile Measurement
   b) American Society for Testing and Materials
   c) American Society for Tool Measurement
   d) American Society for Tensile Material

2) The driving force for sintering is reduction in _____.
   a) Internal energy b) Surface tension
   c) Surface energy d) Entropy

3) The temperature of gas is held constant, while its volume is decreased. The pressure exerted by the gas on the wall of the container increases, because its molecules _____.
   a) Strike the walls with higher velocities
   b) Strike the walls with large force
   c) Strike the walls more frequently
   d) Are in contact with the walls for a shorter time

4) A bulb contains one mole of hydrogen mixed with one mole of oxygen at temperature T. The ratio of rms values of velocity of hydrogen molecules to that of oxygen molecules is _____.
   a) 1 : 16 b) 1 : 4
   c) 4 : 1 d) 16 : 1

5) Which mathematical method is used in X-ray crystallography?
   a) Fourier Transform b) Laplace Transform
   c) Partial differentiation d) Geiger method

6) In single X-ray diffraction measurement, the crystal is mounted on _____.
   a) X-ray source b) Goniometer
   c) Diffraction plate d) Fluorescent plate

7) Hall voltage is zero when the semiconductor is _____.
   a) Extrinsic b) Intrinsic
   c) P type d) None of the above

8) In Hall Effect, the output voltage produced across the crystal is due to ____.
   a) Drop across the crystal due to the current passed through it
   b) Induced voltage by the applied magnetic field
   c) Movement of charge carriers towards one end
   d) All of the above

9) The representation of Beer Lambert's law is given as A = abc. If 'A' represents absorption, 'b' represents distance and 'c' represents concentration, what does 'a' represent?
   a) Intensity b) Transmittance
   c) Absorptivity d) Admittance

10) Which of the following is not a limitation of Beer Lambert's law, which gives the relation between absorption, thickness and concentration?
   a) Concentration must be lower
   b) Radiation must have higher bandwidth
   c) Radiation source must be monochromatic
   d) Does not consider factors other than thickness and concentration that affect absorbance

B) Write True or False. **06**

1) Ceramics have high modulus of elasticity.
2) Ceramics are employed to protect the infrastructure from heat.
3) An ideal gas is that which can be liquefied.
4) Bragg's law is not a sufficient condition for diffraction by crystalline solids.
5) The Hall Effect coefficient is 6.25 when the number of electrons in a semiconductor is 10^{20}.
6) According to Beer Lambert's law, absorbance depends on colour of the solution.

Q.2 Answer the following. **16**

a) Explain the applications of International Standards.
b) What are the different X-ray cameras and where are they used?
c) Describe the mechanism of electrical transport in metals.
d) How is the refractive index of thin films determined?

Q.3 Answer the following. **16**

a) What are the various spectroscopic tools? Why are they necessary?
b) Using the kinetic theory of gases, obtain an expression for the relation between total kinetic energy, pressure and volume of the gas.

Q.4 Answer the following. **16**

a) How are cubic structures analysed? Explain.
b) Describe the technique of measurement of band gap in solids using Photoluminescence spectroscopy.

Q.5 Answer the following. **16**

a) What are Standard Distribution functions? Where are they used?
b) Explain the factors affecting the intensity in powder XRD.

Q.6 Answer the following. **16**

a) Explain the working of a rotary oil pump.
b) How is the Hall voltage measured? Obtain an expression for it.

Q.7 Answer the following. **16**

a) Explain the Four probe method for conductivity.
b) How is Vibrational spectroscopy helpful in determining molecular bonds and structure?