P.A.H. Solapur University, Solapur

School of Physical Sciences

M. Sc.-I, SEM. II, Physics (Energy Studies)

HCT - 2.1: Quantum Mechanics

Question Bank

Unit I: Operator Formalism

Four marks questions

1. Write a note on linear vector spaces.
2. Prove Schwartz inequality.
3. Discuss scalar product of state vectors.
4. Write a note on state vectors.
5. Write the definitions of norm, basis, orthogonal and orthonormal vectors.

Eight marks questions

1. Explain the operators.
2. Explain the commutator and its properties.
3. Prove the uncertainty relations between the operators.
4. Explain the unitary transformations and its properties.
5. What is the matrix representation of kets, bras, and operators? Explain in detail the matrix representation of operators.
6. Discuss Dirac notations? Explain its properties.
7. Explain vectors.
8. What is the Hermitian adjoint? Explain the properties of the Hermitian conjugate rule.
9. Discuss the eigenvalues and eigenvectors of an operator and prove, for a Hermitian operator, all of its eigenvalues are real and the eigenvectors corresponding to different eigenvalues are orthogonal.

Unit II: Introductory Quantum Mechanics

Four marks questions

1. Discuss the probability interpretation.
2. Prove the time-independent Schrodinger equation.
3. Write an expression for the Schrodinger equation for a particle subject to forces.
4. Write the postulates of quantum mechanics.
5. Discuss the conservation of probability.

Eight marks questions

1. Derive expression for time dependent Schrodinger equation for one dimension.
2. Write the proof for Ehrenfest's theorem.
3. Explain the postulates of quantum mechanics.
4. Discuss in detail box normalization.
5. Explain the Schrodinger and Heisenberg pictures.
6. Explain the interaction picture.
7. Discuss in detail position and momentum representations.
8. Develop the connection between position and momentum representations.
9. Express the position operator in momentum representation and momentum operator in position representation.
10. Explain the admissibility condition of the wave function.

Unit III: Solution of Schrodinger equation for some solvable systems and Angular Momentum Algebra

Four marks questions

1. Explain the properties of the wave functions in infinite square well.
2. Prove $[L¿¿x, L_y]=i\hbar L_z¿$.
3. Show that $[L^2, L¿¿x]=0¿$
4. If f is an eigenfunction of the $L^2$and L_z, show that $L_{\pm}f$ is also an eigen function.
5. Write a note on angular momentum.

Eight marks questions

1. Explain the infinite square potential well.
2. Explain the finite square potential well.
3. Find the solution of harmonic oscillator using operator method.
4. Derive the expressions for the simultaneous eigenfunctions of the L^2 and L_z operators.
5. Derive the expressions for the eigenvalues of the L^2 and L_z operators.
6. Prove the relations $[L¿¿x, L_y]=i\hbar L_z¿$ and $[L¿¿y, L_z]=i\hbar L_x¿$.
6. Show that $[L^2, L¿¿x]=0¿$ and $[L^2, L¿¿\pm]=0¿$.
7. Explain with diagram ladder of the angular momentum states.
8. Explain with diagram ladder of the stationary states for the simple harmonic oscillator.
9. What is the angular momentum? Explain the commutation relations for the angular momentum.
10. Explain the algebraic method for the harmonic oscillator.

Unit IV: Addition of Angular Momenta and approximation methods

Four marks questions

1. Write a note on the total angular momentum eigenstates
2. Show that $[J^2, J¿¿x]=0¿$
3. Discuss algebraic theory of spin.
4. Write a note on Pauli's matrices.
5. Discuss the validity of WKB approximation.

Eight marks questions

1. Express the J^2 and J_z in terms of matrices.
2. Express the Pauli's spin operators in matrix representation.
3. Prove the theorem $E_g \leq \langle H \rangle$ and find the ground state energy for the one-dimensional harmonic oscillator.
4. Find the general solution of Schrodinger equation in classical region using WKB approximation.
5. Find the allowed energy levels in potential well with two vertical walls using WKB approximation.
6. Prove that: a) $[S¿¿x, S_y]=i\hbar S_z¿$ and $\sigma_j \sigma_k = \delta_{jk} + i \sum_l \epsilon_{jkl} \sigma_l$.
7. An electron is in spin state $\chi = A \begin{pmatrix} 3i \\ 4 \end{pmatrix}$:
   a) Determine the normalization constant A. b) Find the expectation values of S_x, S_y and S_z.

P.A.H. Solapur University, Solapur

School of Physical Sciences

M. Sc.-I, SEM. II, Physics (Energy Studies)

HCT - 2.2: Electrodynamics

Question Bank

Unit-I: Electrostatics and Magnetostatics:
4 Marks Questions.

1. A long cylinder carries a surface charge density that is proportional to the distance from the axis: $\rho = \sigma k$ for some constant k. Find the electric field inside the cylinder.
2. Find the vector potential of an infinite solenoid with n turns per unit length, radius R and current I.
3. State and explain the Biot-Savart law.
4. Write a short note on Dirac delta function.
5. Deduce an expression for differential form of Ampere's law.

8 Marks Questions.

1. State and explain Gauss's law in differential form and deduce an expression for the Poisson and Laplace's equations.
2. Find the electric field inside a sphere which carries a charge density proportional to the distance from the origin, for some $\rho = \sigma k$constant k.
3. Write a note on method of images and multipole expansion in electrostatic field.
4. A electric dipole consists of two equal and opposite charges ($+q$) separated by distance d. Find the approximate potential at points far from the dipole.
5. Derive an expression for Ampere's law and Differential form of Ampere's law.
6. Explain in brief the boundary condition in electrostatics and magnetostatics.
7. Discuss in detail uniqueness theorems and method of images.
8. Deduce vector potential and explain in brief magnetic field of a localized current distribution.
9. Find the magnetic field at the center of a square loop, which carries a steady current I. Let R be the distance from center to side.
10. Use of Gauss's law to find the electric field inside and outside a spherical shell of radius R, which carries a uniform surface charge density σ.

Unit-II: Time varying fields and Energy, force, momentum relations:

4 Marks Questions.

1. Write a short note on Maxwell's equations.
2. An infinitely long straight wire carries a slowly varying current *I(t).* Determine the induced electric field, as a function of the distance s from the wire.
3. Derive an expression Poynting's theorem.
4. Elaborate on the concept of Displacement current.
5. Derive an expression for energy stored magnetic field.

8 Marks Questions.

1. Derive an expression for energy stored in electric and magnetic field.
2. How the Maxwell corrected Ampere's law? What is the physical significance of displacement current?
3. Derive an expression Poynting's theorem.
4. Give full account of Maxwell's equations in matter.
5. Give brief account of magnetic interaction of two current loops.
6. Define and explain electromotive force. What is the Faraday"s law of electromagnetic induction and Lenz"s law?
7. Give an energy relation in quasi-stationary current systems,
8. Derive the general expression for electromagnetic energy.
9. A long coaxial cable carries current *I* (the current flows through down the surface of inner cylinder, radius *a*, and back along the outer cylinder, radius *b*). find the magnetic energy stored in a section of length *l.*
10. Discuss in detail scalar and vector potentials.

Unit-III: Electromagnetic wave equations:
4 Marks Questions.

1. Discuss in detail Lorentz's gauges.
2. Discuss in detail Coulomb's gauges.
3. Discuss in detail Skin effect and skin depth.
4. Express the electromagnetic wave equations in D' Almbertian Operator.
5. Discuss the case of oblique incidence of electromagnetic wave at boundaries.

8 Marks Questions.

1. What are the Gauge transformations? Explain the (a) Coulomb Gauge and (b) Lorentz Gauge.
2. Explain in brief the reflection and refraction of electromagnetic waves at plane boundaries.

3. Explain electromagnetic wave equations. Deduce an expression for electromagnetic plane waves in conducting medium.
4. Derive an expression for coefficient of Reflection (R) and Transmission (T).
5. Calculate the coefficient of reflection (R) at the interface for pair of media having refractive indices n_1 = 1.50 and n_2 = 1.33.
6. Explain electromagnetic wave equations. Deduce an expression for electromagnetic plane waves in stationary medium.
7. Write a note on wave equations in terms of electromagnetic potentials? What is D'Alembertian operator?
8. Discuss the case of Normal and oblique incidence of electromagnetic wave at boundaries.

Unit IV: Radiation emission:
4 Marks Questions.

1. Explain Larmor's formula.
2. Write a short note on electric dipole radiation.
3. Explain in detail the radiation from a half wave antenna.
4. Write a short note on angular distribution of radiation.
5. Write a short note on magnetic dipole radiation.

8 Marks Questions.

1. Explain in detail the concept of radiation damping.
2. Write a note on electric dipole, electric quadrupole and magnetic dipole radiation.
3. Deduce an expression for Lienard-Wiechert potentials of a point charge.
4. Explain in the radiation by a moving charge and derive Larmor's formula.
5. Deduce an expression for Larmor's formula and write a note on angular distribution of radiation.
6. Explain in brief the radiation by a moving charge.
7. Explain angular distribution of radiation. and gives a short note on fields and radiation of a localized oscillating source.

P.A.H. Solapur University, Solapur

School of Physical Sciences

M. Sc.-I, SEM. II, Physics (Energy Studies)

OET 2.1 Fundamental of Electronics

Question Bank

Each question having four marks.

1) A certain soldering iron has a resistance of 600 ohms when operated from a 230 volts power line. How much current does it take from the power line?
2) Calculate the energy used (in kWh) to run twelve 150 W light bulb for ten hours?
3) State and Explain Thevenin's theorem?
4) State and explain Kirchhoff 'current law?
5) Discuss briefly the Kirchhoff's voltage law?
6) Define the term i) Cycle ii) time period
7) Explain the difference phase and phase term?
8) What is meant by intrinsic semiconductor?
9) Explain what is Hole in Brief?
10) What is PN junction Diode? Explain it?
11) What are the important application of diode?
12) What id ideal diode and real diode?
13) What is Zener diode? Draw circuit diagram?
14) Define the term Common mode rejection ratio?
15) What is differential amplifier? Can be used in single ended input configuration?
16) Describe the block diagram of op-amp?
17) What is voltage Follower?
18) Explain switching action of a transistor?
19) Draw the switching waveform for the astable multivibrator?
20) Explain operation of an astable multivibrator?

Each question having eight marks

1) What is nonsinusoidal oscillator? Explain it briefly?
2) Draw a circuit of astable multivibrator and explain its working?
3) Sketch a transistor Schmitt trigger circuit and briefly explain its operation giving input output waveform?
4) Draw an internal operational circuit of timer IC 555?
5) Explain the operation of a bisatble multivibrator?
6) Distinguish between a bistable and monostable multivibrator?
7) Discuss the principle of transistors bistable multivibrator?
8) What is multivibrator? Explain the difference between the three types of multivibrators?
9) Explain in details of switching action of a transistor?
10) What is essential difference between direct current and altering current?
11) State and explain the three version of ohms's law relating voltage, current and resistance?
12) Briefly define each of the following, giving its unit and symbol: Charge, Potential, Potential difference, Current resistance and Conductance?

13) What is maximum power transfer theorem? Show that power lost in the internal resistance of a source is equal to the power delivered to the load the power efficiency is only 50%?
14) Explain briefly the following;
    i) Linear resistor ii) Non-linear resistor
15) What is capacitor? Give its three application?
16) Write a short note on a variable capacitor?
17) What is difference between an ideal current source and a practical current source?
18) Draw V-I characteristics of a junction diode when it's a) forward biased b) reverse biased
19) Briefly explain (without derivation) the behaviour of junction in forward bias and reverse bias mode and draw its volt-ampere characteristics?
20) What is PN junction diode? How its terminal are identified?
21) In What respect is an LED different from an ordinary PN junction diode? State application of LEDs.
22) Explain with the help of neat diagrams, the structure of a N-channel FET, and its volt-ampere characteristic. In what way it is different from a bipolar junction transistors?
23) Distinguish between FET and BJT?
24) Describe some of the characteristics of a practical op-amp?
25) What is voltage followers? Describe its main characteristics?
26) Explain in details of instrumentation amplifier?
27) Distinguish between operation amplifier and Instrumentation Amplifier?
28) Explain in details ideal characteristics of op-amp?
29) Explain comparator Schmitt trigger wave generator (Square wave and Triangular wave)?
30) Discuss the term in details of DC and AC characteristics of op-amp?
31) Define the term a) LED b) Solar Cell c) Photodiode
32) Explain in details first order low pass and high pass filter?
33) Discuss V to I and I to V converter precision rectifier?
34) Explain the effect of temperature on the volt-ampere characteristic of diode?
35) Draw a block diagram of IC 555 and explain in details?
36) Explain the application of network laws to simple dc network?
37) Distinguish between monostable and astable multivibrators?
38) **Why the Reset pin of IC 555 is normally connected to Vcc, and why the control voltage (pin 5) of 555 timers is connected to ground through a 0.01 µf capacitor?**
39) **Explain in details p-n junction with terms of unbiased and biased junctions?**
40) **How PN junction diode is working? Draw and explain V-I characteristic of PN diode with neat diagram?**

P.A.H. Solapur University, Solapur

School of Physical Sciences

M. Sc.-I, SEM. II, Physics (Energy Studies)

OET - 2.2: Conventional & Nonconventional Energy

Question Bank

Unit I: Energy Science and Energy Technology

4 Marks Questions.

1. Write a short note on non-conventional energy sources.
2. Discuss in detail various sciences and energy science.
3. Deduce an energy and power equations.
4. Write merits and demerits of hydro energy.
5. Write a short note on conventional energy sources.

8 Marks Questions.

1. Explain in brief the types of coal, coal production and processing.
2. Discuss primary hydro energy resources and types of hydroelectric plants.
3. Explain thermodynamics and energy analysis.
4. Elaborate on the concept of hydraulic turbines.
5. Explain in brief conventional and non-conventional energy sources.
6. How did the steam engine change the world?
7. What is fossil fuel? Is any major source of energy rather than fossil fuels?
8. How does energy affect on human and environment?
9. What were the main energy sources historically?
10. What is energy? Write a note on brief history of energy technology.

Unit II: solar energy

Each question having four marks.

1) What is PN junction Diode? Explain it?
2) What is meant by intrinsic semiconductor?
3) Define solar spectrum in details?
4) Explain efficiency of solar cell in details?
5) Define i) solar thermal Collector ii) Flat plate collector

Each question having eight marks

1) How PN junction diode is working? Draw and explain V-I characteristic of PN diode with neat diagram?
2) Write a note on Economic of photovoltaic (PV)?
3) Explain in details p-n junction with terms of unbiased and biased junctions?
4) Explain environmental impact of photovoltaic?
5) Write a note on i) Parabolic collectors ii) paraboloidal dish collector

Unit III: Wind and Biomass Energy

Four Marks Questions

1. Discuss the sources of wind energy and global wind patterns.
2. Write a note on modern wind turbines and write an expression for kinetic energy of wind.
3. Discuss the design of a modern horizontal-axis wind turbine.
4. Give the idea of biomass potential and use.
5. Write a note on biomass energy production.

Eight Marks Questions

1. Explain wind characteristics.
2. Discuss wind farms and explain environmental impact and public acceptance of wind energy.
3. Give detailed information about the photosynthesis and crop yields.
4. Explain in detail environmental impact, economics and potential of biomass.
5. Describe the economics of wind power.
6. Derive the expression for dependence of the power coefficient C_p on the tip-speed ratio.
7. What is turbine? Discuss its control and operation.
8. Explain the principles of a horizontal-axis wind turbine.

Unit IV: Nuclear energy

Four Marks Questions

1) Explain binding energy?
2) Explain stability of nuclei?
3) Write a note on fission reaction?
4) Explain fusion reaction?
5) What is plasma? What is the constituent of it?

Eight Marks Questions

1) Discuss in great detail environmental impact of nuclear power?
2) Discuss in thermal reactor with diagram?
3) Discuss controlled fusion reaction?
4) Explain charged particle in E and B field?
5) Why nuclear power is important?

P.A.H. Solapur University, Solapur

School of Physical Sciences

M. Sc.-I, SEM. II, Physics (Energy Studies)

SCT 2.1 Statistical Physics

Question Bank

04 marks

1) Distinguish between different ensembles.
2) Distinguish between 1^{st} and 2^{nd} order phase transitions.
3) Explain the concept of microstates and macro states.
4) Explain the concept of statistical equilibrium.
5) What is an ensemble? Explain the concept of Canonical Ensemble.
6) Write Liouville's theorem in classical mechanics
7) Write a note on a PV diagram.
8) Write a note on grand canonical ensembles.
9) Explain the P.T. curve.
10) what is phase equilibrium.
11) Write a note on the canonical ensemble and state its partition function.
12) Write a note on the laws of thermodynamics.
13) What are the thermodynamic systems and equilibria?
14) Explain the Nearst's heat theorem.
15) Explain the concept of equipriori probability.
16) Explain the concept of microstates.
17) Explain the law of corresponding states.
18) Explain Gibbs's free energy.
19) Explain phase space and quantum state.
20) State and explain the third law of thermodynamics.

08 marks

1) How the paradoxical situation arises when we mix the samples of the same gas.
2) Explain the second-order phase transition.
3) Derive Ehrenfest equation for second-order phase transition.
4) Show that during the first-order phase transition, Gibb's function is continuous, but the first derivative of Gibb's function changes discontinuously.
5) Explain the canonical ensemble. Obtain an expression for canonical distribution.
6) Write a note on microcanonical, canonical and grand canonical ensembles
7) Write laws of thermodynamics and their consequences.
8) Explain the Second latent heat equation.
9) Show that during the second-order phase transition.
$$(\partial^2 G_1/ \partial T^2) \neq (\partial^2 G_2/ \partial T^2)$$
10) Explain the first-order phase transition.

11) Derive Clausius Clapeyron equation.
12) Give the condition for B E condensation.
13) Derive Ehrenfest equations.
14) What is the Gibbs paradox and how it is resolved?
15) Give the condition for ideal Bose gas.
16) By using the Vander Waals equation at reduced states calculate the values of critical constants.
17) Show that the average energy of a single particle of ideal fermi is 3/5 times the Fermi energy of the system.
18) Explain strongly degenerate fermi gas.
19) Explain weakly degenerate fermi gas.
20) Express elliptical motion of 1D harmonic oscillator in phase space.
21) Write about MB statistics.
22) Write about BE statistics.
23) Write about FD statistics.
24) Write about classical ideal gas.
25) Obtain Plank's law for black body radiation.
26) Connection between free energy and themodynamical quantities.
27) Write a note on black body radiations.
28) Write about thermodynamical potentials.
29) Write about Maxwell's relations.
30) Write about the paradoxical situation given by Gibbs.