2022

Full Marks - 60

Time - 3 hours

The figures in the right-hand margin indicate marks

Answer ***all*** questions

Part-I

1. Answer the following by fill in the blanks or one word sentence answer : 1×8

   a) The electric field inside a perfectly conducting media is ___.

   b) The concept of displacement current was introduced by ___.

   c) Electromagnetic waves are ___waves.

   d) Polarised light can be produced by ___prism.

   e) What is the medium of wave propagation ?

   f) How many types of polarization wave there ?

   g) What is the unit of polarization ?

   h) Which phenomena establishes the transverse nature of light waves ?

Part-II

2. Answer any ***eight*** of the following : $1\frac{1}{2} \times 8$

   a) Define Poynting vector.

   b) What are the four Maxwell's equation ?

   c) What is electromagnetic energy density ?

   d) Electromagnetic waves are transverse in nature; comment ?

   e) Write an expression for skin depth in case of good conductor.

   f) State the properties of elctromagnetic waves.

   g) Does all electromagnetic waves obey the laws of reflection ? Justify your answers.

   h) What is Polarization in electromagnetic waves ?

   i) What are phase retardation plates ?

   j) Why half shade polarimeter is used ?

Part-III

3. Answer any ***eight*** of the following : 2×8

   a) Write the expressions for Lorentz and Coulomb gauge. Hence explain the two conditions.

   b) Whether the following potential is in the Coulomb gauge or Lorentz gauge ?

$$V(\vec{r}, t) = 0, \quad \vec{A}(\vec{r}, t) = \frac{1}{4\pi \epsilon_0} \frac{qt}{r^2} \hat{r}$$

c) Write the physical context of the statement $\vec{\nabla} \cdot \vec{B} = 0$

d) What do you mean by Polarization of a wave ? How the polarization vector is related to the plane to vibration ?

e) Calculate the velocity of propagation 'C' in free space, if $\mu_0 = 4\pi \times 10^{-7}$ Wb/Am and $\epsilon_0 = 8.85 \times 10^{-12} C^2/Nm^2$.

f) Differentiate between conduction current and displacement current.

g) For plane electromagnetic waves propagating in $\vec{K}$ direction we have that $\vec{B} = \frac{\vec{K} \times \vec{E}}{w}$ show that $\vec{E} = \frac{-w}{K^2}(\vec{K} \times \vec{B})$

h) What happens to an electromagnetic wave when it hits an insulating material ?

i) What are the types of Polarization ?

j) What is Fresnel's theory of optical rotation ?

Part-IV

4. a) State and prove Poynting's theorem. 6

OR

b) Define scalar and vector potentials. Derive Maxwell's equations in differential form.

5. a) State and prove the boundary conditions at the interface of dielectric. 6

OR

b) Starting from Maxwell's equations, derive the equation of EM wave in conducting media.

6. a) Derive the transmission and reflection co-efficients for a plane wave of frequency w, travelling in the Z-direction and polarized in the X-direction, falling at the interface of two linear media at normal incidence. 6

OR

b) Obtain an expression for Fresnel's equation if the electric field vectors are perpendicular to the plane of incidence.

7. a) What is meant by circular polarization ? Derive the expression for elliptically polarized and circularly polarized wave. 6

OR

b) What is the use of retardation plate ? Explain in details about phase retardation plates.

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Part-II

2. Answer any ***eight*** of the following : $1\frac{1}{2} \times 8$

a) Explain the term 'most probable macrostate'.

b) What do you mean by ensemble ?

c) What is the significance of partition function in statistical mechanics ?

d) What do you mean by degenerate Fermi gas ?

e) Plot the figure for showing the variation of Fermi-Dirac distribution function with temprature.

f) Discuss the importance of Kirchhoff'slaw.

g) Describe the significance of negative temperature.

h) Two balck bodies are at temperature 27°C and 127°C, find the ratio of heat energies radiated by them.

i) The maximum wavelength of radiation emitted by a body at 2000K is 5μm. What will be maximum wavelength of radiation emitted by the body at 2500k ?

j) Which parameters are used for defining a macrostate of the given system ?

Part-III

3. Answer any ***eight*** of the following : 2×8

a) Write the canonical partition function for an ideal gas.

b) In microcanonical ensemble for a system of N non-interacting particles find the fundamental volume in phase space.

c) Describe the situation, where grand canonical ensemble is more preferable than other types of ensembles.

d) A two-levels system has energies O and E. If both the levels are doubly, degenerated, then find the mean energy of a classical particle in the system at temperature T.

e) In how many ways 3 fermions can be distributed in four energy states.

f) What is Gibbs Paradox ? How can be it resolved.

g) Explain Bose-Einstein condensation.

h) State salient features of Blackbody Radiation.

i) If P is the total pressure radiation and ζ is the total density of radiation due to all the beams, then what is the relation between them.

j) Write the conditions, at which Planck's law reduces to Wien's law and Rayleigh Jeans law.

Part-IV

4. a) Show a comparison between microcanonical ensemble, canonical ensemble and grand canonical ensemble.

OR

b) Define entropy and find the relationship between entropy and thermodynamic probability.

5. a) Find an expression for the entropy of a classical ideal gas. 6

OR

b) State and prove law of equipartition of energy. Discuss its application to specific heat.

6. a) Discuss the salient features of Fermi-Dirac and Bose-Einstein statistics. Give the comparative picture of the two statistics. 6

OR

b) Using Bose-Einstein statistics, derive Planck's law.

7. a) Derive Stefan Boltzmann law from thermodynamic principle. 6

OR

b) Deduce Wien's displacement law and stefan Boltzmann law from Planck's radiation formula.

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2022

Full Marks - 60

Time - 3 hours

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Answer ***all*** questions

Part-I

1. Answer the following : 1×8

   a) The dimension of phase space for a system having N particle is ___.

   b) At equlibrium, the entropy of a system is ___.

   c) Which type of ensembles include only isolated systems ?

   d) The ratio of C_p/C_v for a diatomic gas is ___.

   e) Give one example of Boson.

   f) Eloctrons should obey ___ distribution law.

   g) Good absorbers of radiation are ___ emitters of radiation.

   h) Distribution of energy in the spectrum of a black body can be represented ___ law.

[Turn over

2022

Full Marks - 80

Time - 3 hours

The figures in the right-hand margin indicate marks

Answer ***all*** questions

Part-I

1. Answer the following : 1×12

   a) One angstrom is equal to ___ nanometer.

   b) If E is the energy for the 1D system, the 1D density of states (DOS) varies with E as ___.

   c) The expectation value of $\hat{p}$ for a particle in a 1D square well of length L is ___.

   d) Out of ball milling and physical vapour deposition synthesis techniques which one represents bottom-up approach.

   e) Sol is a ___.

f) In top-down approach, the minimum size of the prepared nanoparticle is about ___ nm.

g) Nanostructures confined in two dimensions are termed as ___.

h) The empirical formula for obtaining crystallite size is given by ___.

i) Give an example for each 1D and 2D nanostructures.

j) Which of the following microscopes uses electron beam as a probe : STM, TEM and AFM.

k) Write one application of quantum dots.

l) Each carbon in a CNT bonded with how many carbons by covalent bond.

Part-II

2. Answer any ***eight*** of the following : $1\frac{1}{2} \times 8$

a) What do you mean by nanomaterials ?

b) Write the expression for energy for an electron in a 1D potential well of length L.

c) Draw the DOS for 0D and 2D nanoparticles.

d) What do you mean be optical data storage ?

e) What is microelecotromechanical system (MEMS) ?

f) Write an advantage of hydrothermal synthesis process.

g) What do you mean by aspect ratio of nanostructure material ?

h) Estimate the de-Broglie wavelength of a 10 keV electron.

i) What do you understand by backscattered eletrons in relation to SEM ?

j) What do you mean by heterostructure ?

Part-III

3. Answer any ***eight*** of the following : 3×8

a) Explain the term : "Bulk properties get modified upon size reduction to nanoscale."

b) Explain quantum confinement in two dimensions using suitable examples.

c) What is lithography ? Write down different types of lithography ?

d) Derive the expression for density of states (DOS) for a three dimensional (3D) bulk system.

e) Why optical microscopes are not suitable for characterization of nanostructures ?

f) What are sol, gel and preceipitate in sol-gel methods on nanostructures preparation ?

g) For $n = 2$, at which locations, a quantum particle in a 1D box of length L is most likely to be found ?

h) What are the advantages and diadvantages of scanning electron microscopy (SEM) over TEM ?

i) What do you understand by chirality in CNTs ?

j) What do you mean by quantum dots ?

Part-IV

4. a) Write down Schrodinger equation for infinite potential well and solve it to find out energy eigenvalues and eigen functions. Plot first three energy eigenvalues and eigen functions. 7

OR

b) Describe the physical phenomena of different length scales. How the size effects in nano systems ? Differentiate between nanowires and nanorods with suitable examples.

5. a) What do you understand by physical vapour deposition (PVD) ? Briefly describe the thermal evaporation methods of depositing thin films. 7

OR

b) Describe the principle and working of pulsed laser deposition (PLD) method for deposition of thin films. State its advantages, drawbacks and applications.

6. a) Describe the principle and the different modes operation of an atomic force microscope (AFM) with a neat sketch. 7

OR

b) Describe the X-ray difraction method suitable for nanostructure samples. Discuss about the Debye-Scherrer formula of X-ray diffraction.

7. a) What are nanoelectromechanical systems (NEMS) ? Discuss the working of a NEMS accelerometer. 7

OR

b) Discuss the principle and working of a quantum dot hetero-structure lasers. Mention its advantages over conventional laser.

2019

Full Marks - 40

Time - 2 hours

The figures in the right-hand margin indicate marks

Answer *all* questions

1. a) Explain the terms 'instrument accuracy' and precision' in a measurement and discuss the need for having them properly matched to each other. 6

b) Distinguish between systematic and random errors in a measurement and how they are usually minimized. 4

OR

c) Explain briefly the design and specification of electronics voltmeters and write down the principle of voltage measurement of both dc and ac voltages. 6

d) Define probable error and show how it is extrapolated from the experimental values. 4

2. a) What are the major components of a cathode ray tube (CRT) ? Explain the function of each part of a CRT. 6

b) Describe briefly the time base generator used in a CRO. 4

OR

c) Explain the function of electrostatic focussing system and deflection system of a CRT. 6

d) Discuss how a CRO may be used to measure frequency and amplitude of an alternating voltage signal. 4

3. a) What is a signal generator ? How it differs from a conventional oscillator ? With a neat block diagram, discuss the principle of operation of low frequency signal generator. 6

b) What are the advantages of a digital voltmeter over a conventional electromechanical voltmeter. 4

OR

c) Discuss the basic differences in the working principles and performances of analog and digital voltmeters. 6

d) What do you mean by loading effect of a Voltmeter ? Write down the specification of a digital multimeter. 4

4. a) With block diagram, describe the working principle of a digital multimeter. 6

b) What is a pulse ? Explain why pulse generators find increasing application in instrumentation. 4

OR

c) Describe the principle of measurment of frequency and time period using universal counter. 6

d) Define 'distortion' of a periodic signal and how it is estimated. 4

2019

Full Marks - 60

Time - 3 hours

The figures in the right-hand margin indicate marks

Answer ***all*** questions

1. a) What is Compton effect ? Obtain an expression for the shift in wavelength of X-ray beam. 9

   b) i) Explain photoelectric effect and stopping potential. 3

   ii) Describe the distribution of energy in black body radiation. 3

OR

   c) Discuss Bohr's postulates and on its basis explain the spectral series of hydrogen atom with energy level diagram . 9

   d) i) Calculate the radius of 2nd Bohr orbit of hydrogen and the velocity of electron in this orbit. 3

   ii) Explain fine structure of spectral lines. 3

2. a) State and explain Heisenberg's uncertainty principle. Explain how its validity is supported by the gamma-ray microscope experiment. 9

b) i) Calculate the de-Broglie wavelength of an electron with 15eV energy. 3

ii) An electron has a speed 4×10^5m/s within accuracy of 0.01%. Calculate the uncertainty in the position of electron. 3

OR

c) Derive the expression for the probability current density from Schrodinger equation. 9

d) The state of a free particle is represented by a wave function

$$\psi(x, 0) = Ne^{-x^2/2a^2 + ik_0x}$$

i) Find out the factor N. 3

ii) In what region of space the particle is most likely to be found ? 3

3. a) Derive energy eigen values and normalized wave functions for a particle in a one dimensional infinite regid box. 9

b) i) Show that the probability of finding a particle in ID box is maximum at the centre if the particle is in ground state. 3

ii) Consider a particle of mass 9.1×10^{-31} kg and energy E = 342 eV confined in a ID box of length 10^{-31}m. Calculate the quantum number n of this state of the system. 3

OR

c) A free particle of mass 'm' and energy 'E' encounters an one dimensional potential step defined by

$v(x) = 0$ for $x < 0$

$= v_0$ for $x \geq 0$

obtain the reflection and transmission co-efficients for the case $E > V_0$. 9

d) i) Establish the conservation statement for the potential step problem 3

ii) If a beam of electrons impinges on any energy barrier of height 0.04eV and of infinite width, find the fraction of electrons reflected and transmitted at the barrier if the energy of the striking electron is 0.03eV. 3

4. a) Discuss the semi-empirical mass formula by giving the meaning of each term in it. Plot the binding energy curve and discuss the application of this curve. 9

b) i) The radius of nuclei having mass number 27 is 3.6 fermi. Claculate the radius of nuclei having mass number 125. 3

ii) Explain the principle and working of nuclear reactor. 3

OR

c) State the laws of radioactive decay. Derive expressions for half life and mean life time of a radioactive substance. 9

d) i) Calculate the half life time and mean life time of a radioactive substance of which the decay constant is 4.28×10^{-4} per year. 3

ii) What is the difference between nuclear fusion and nuclear fission. 3