2022

Full Marks - 60

Time - 3 hours

The figures in the right-hand margin indicate marks

Answer *all* questions

1. a) State and explain Maxwell's field equations. 10

   b) Write a note on Coulomb Gauge. 5

OR

   c) State and explain Physical concept of Electromagnetic field. 10

   d) Define energy density and give the formula of energy density. 5

2. a) Write short notes on the following : 5 + 5 + 5

   i) Dielectric constant

   ii) Wave impedence

   iii) Refractive Index.

OR

   b) Derive wave equation for electomagnetic wave propagation through a non-conductor. Show that it exhibits dispersive property. On what factor does the phase velocity of the wave in the non-conductor depend ? 7 + 5 + 3

3. Write short notes on the following : $3\frac{1}{2} + 3\frac{1}{2}$

a) i) Single Mode optical fibres

ii) Multi-mode optical fibres.

b) State and explain Brewster's law of Polarization. 8

OR

c) Write short notes on the following : $3 + 4$

i) Total Internal Reflection

ii) Evanscent waves.

d) Derive Freshnel's equations for reflection and refraction of electromagnetic waves at a plane boundary separating the two media. 8

4. a) Write short notes on the following : $7\frac{1}{2} + 7\frac{1}{2}$

i) Biot's laws for Rotatory Polarization

ii) Freshnel's theory of Optical Rotation.

OR

b) Write a note on Laurent's half-shade Polarimetor. 4

c) Explain the construction of Nicol prism. 11

5. a) What is a personal computer ? Draw the block diagram of computer and explain various blocks. 11

b) Convert the following hexadecimal numbers to octal number. 4

5B2, 700C, ABCD and 101

Convert the following hexadecimal number to decimal number :

49, FFF, AB1 and 11

OR

c) What is computer memory ? Describe different types of computer memories. What kinds of information are stored in a computer memory ? 11

d) Convert the following binary numbers to octal number : 4

11011110011 and 100001.001011

Perform the followings :

10110.1101 ÷ 11.1 and 1101.1 × 101

2019

Full Marks - 75

Time - 3 hours

The figures in the right-hand margin indicate mark

Answer ***all*** questions

1. a) Define Poynting vector. What is its dimension ? State and prove Poynting theorem. 10

b) Explain the concept of displacement current and derive the modified Ampere's law and show its importance by introducing the concept of displacement current. 5

OR

c) Establish the boundary conditions that must be satisfied by the field vectors when an electromagnetic wave is incident at the interface between two dielectric media. 10

d) Show that plane electromagnetic wave in free space travel with the speed of light. 5

2. a) Draw the circuit diagram and explain the operation of a full wave centre tap rectifier with a capacitor filter. Draw the nature of waveform of the output potential with increasing capacitance. 10

b) What do you mean by voltage and current regulation ? Obtain an expression for the percentage of regulation in a full wave rectifier circuit. 5

OR

c) Draw a neat circuit diagram of CE amplifier with necessary biasing arrangement. Show the simplified h-parameter equivalent circuit of this amplifier and obtain the expressions for voltage gain, current gain, input impedance and output impdance of the amplifier. 10

d) What is pinch-off voltage of JFET ? Draw and explain the drain characteristics of an n-channel JFET. 5

3. a) State the meaning of power amplifiers of Class A, B and C. Discuss the Class-B power amplifier and find out its overall efficiency. 10

b) Explain the operation of a simple FM demodulator. 5

OR

c) Under what condition an amplifier acts as oscillator ? Draw the circuit diagram of a Hartley oscillator and explain its action. Obtain the frequency of oscillation of this oscillator. 10

d) Define amplitude modulation (AM) ? Find out the bandwidth of an AM wave. 5

4. a) Name and explain different processes involved in the fabrication of circuit components like capacitor, resistor diode and transistors in IC. 10

b) Write down the advantages and disadvantages of an IC over discrete circuit components. 5

OR

c) What are the major blocks of a CRO ? Explain the function of each block of a CRO. Discuss how a CRO may by used to measure the frequency of an ac signal. 10

d) What are the advantages of digital multimeter of an analog multimeter ? 5

4. a) With necessary mathematics, discuss about Bose-Einstein Condensation. 9

b) Bose-Einstein Condensation occurs in liquid He^4 kept at ambient pressure at 2.17k. At what temperature it's codensation occur in gaseous state, whose density is 1000 times smaller than the density in liquid state. 3

c) With suitable examples, show a comparison between Fermions and Bosons. 3

OR

d) Discuss the theory of degenerate Fermi gas. Find the expressions for Density of States and Fermi energy. 9

e) Discuss the effect of temperature on Fermi-Dirac distribution function. 3

f) The number density of a free electron gas in 3-D is increased 8 times, then how does it's Fermi temeperature change ? 3

2019

Full Marks - 60

Time - 3 hours

The figures in the right-hand margin indicate marks

Answer ***all*** questions

1. a) What do you mean by ensemble ? Show a comparison among microcanonical, canonical and grand canonical ensemble. 9

b) A particle of unit mass is executing simple harmonic vibrations. Determine its trajectory in phase space. 3

c) What do you mean by 'microstate' and 'macrostate' ? Using this concept, explain the statement "Disorder is the most probable state". 3

OR

d) Calculate the entropy of a classical ideal gas and discuss Gibbs paradox. 9

e) Consider a system whose 3 energy levels are given by 0, E and 2E. The energy level E is two-fold degenerate and the other 2 are non-degenerate. Find the partition function of the system. 3

f) State and explain Maxwell-Boltzmann distribution law. 3

2. a) State Stefan's law of blackbody radiation and prove it by using thermodynamic principle. 9

b) Write the different properties of thermal radiation. 3

c) A blackbody at 500^0C has a surface area of $0.5m^2$ and radiation heat at the rate of 1.02×10^4 Js^{-1}. Calculate Stefan's constant. 3

OR

d) Derive Wien's law for the energy distribution in blackbody radiation. 9

e) If λ_m for solar radiation is $4900A^0$ and Wien's constant is b = 0.292 cm – k, calculate the temperature of the Sun. 3

f) Briefly discuss about Saha's ionization formula. 3

3. a) State and explain law of equipartition of energy. Using this law, prove that for a perfect gas whose molecules have *f* degrees of freedom

$$\frac{C_p}{C_v} = 1+\frac{2}{f}.$$ 9

b) What do you mean by negative temperature ? Discuss its physical importance. 3

c) At what temeperature will the average kinetic energy of atom be 1.0 eV ?
(Given $k = 1.38 \times 10^{-23}$ Joule/k). 3

OR

d) Derive Planck's formula for blackbody radiation and show that Wien's displacement law and Rayleigh-Jeans law are special cases of Planck's law. 9

e) Calculate the energy of an oscillator of frequency 6.63×10^{12} sec^{-1} at 300k treating it as Planck's oscillator. (Given $h = 6.63 \times 10^{-34}$ Joule-sec and $k = 1.38 \times 10^{-23}$ Joule/k). 3

f) Plot the curve showing the distribution of energy in blackbody radiation and explain it. 3

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.

□□

d) Answer briefly on the following : 3 × 2

i) What do you understand by primary, secondary and backscattered electrons in relation to SEM

ii) What is x-ray diffraction ? What information can be obtained by this method about a crystal ?

4. a) Discuss the use of nanowares for fabrication of light emitting diodes and solar cells. Also state their advantages and drawbacks. 9

b) Write short notes on the following : 3 × 2

i) Single electron device

ii) Magnetic quantum well.

OR

c) What are nanoelectromechanical systems (NEMS) ? Discuss the working of a NEMS accelerometer. Write down the various types of sensor made from NEMS ? 9

d) Write short notes on the following : 3 × 2

i) CNT based transistor

ii) Quantum dots heterostructure lasers.

2019

Full Marks - 60

Time - 3 hours

The figures in the right-hand margin indicate marks

Answer ***all*** questions

1. a) Define the density of states for electrons in materials ? Derive the expression for the density of states D(E) of 3D, 2D and 1D system. Plot the D(E) verses E curve for the above cases and compare. 9

b) Answer briefly on the following : 3 × 2

i) What is nanostructure ? Classify the nanostructures depending upon the spatial confinement. Give one example from each.

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

OR

c) Write down Schrodinger equation for infinite potential well and solve it to find out energy eigenvalues and eigen functions. Plot first three energy eiegnvalues and eigen functions. 9

d) Answer briefly on the following : 3 × 2

i) For n = 3, at which locations, a quantum particle in a 1D box of length L is most likely to be found ?

ii) Differentiate between nanowires and nanorods. Give important applications.

2. a) What do you mean by photolithography ? Describe the various steps involved in preparation of nanostructures in this technique. 9

b) Answer briefly on the following : 3 × 2

i) Differentiate between physical vapour deposition (PVD) and chemical vapour deposition (CVD).

ii) What is molecular beam epitaxy (MBE) ? Discuss the drawbacks of this technique.

OR

c) What do you understand by physical vapour deposition (PVD) ? What are various PVD techniques ? Briefly describe thermal evaporation methods of depositing thin films. 9

d) Answer briefly on the following : 3 × 2

i) What are sol, gel and precipitate in sol-gel method of nanostructures preparation ?

ii) Differentiate between bottom-up and top-down approach of preparation of nanostructure.

3. a) Describe the principle and working of a transmission electron microscopy (TEM) in detail. What type of information it can provide about the sample ? 9

b) Answer briefly on the following : 3 × 2

i) What are the advantages and disadvantages of scanning electron microscopy (SEM) over TEM ?

ii) Why optical microscopes are suitable for characterisation of nanostructures ?

OR

c) Describe the principle and the different modes operation of an atomic force microscope (AFM) with a neat sketch. 9

2022

Full Marks - 60

Time - 3 hours

The figures in the right-hand margin indicate marks

Answer *all* questions

1. a) Describe the density of states of materials at nanoscale. 9

   b) Describe Band structure and density of states of materials at nanoscale. 6

   OR

   c) Explain 3D, 2D, 1D nanostructures. 8

   d) Explain potential step and potential box. 7

2. a) Write note on MBE growth of quantum dots. 5

   b) Write note on the following : 5 + 5

      i) Spray pyrolysis

      ii) Hydrothermal synthesis.

   OR

   c) Write about Vaccum deposition. 5

   d) Explain the phenomenon of Physical Vapor Deposition(PVD). 5

   e) Explain E-bean evaporation. 5

3. a) Describe optical Microscopy techiques. 7½

b) Write a note on Atomic Force Microscopy. 7½

OR

c) Describe the principles of working of Transmission Electron Microscopy. 7½

d) Write a note on X-ray diffraction. 7½

4. a) Write short note on the following : 5 + 5 + 5

i) Quantum dots

ii) Nanowires and thin films for Photonic devices

iii) Nano Electromechanical systems (NEMS).

OR

b) Describe the following : 5 + 5 + 5

i) Micro Electromechanical systems (MEMS)

ii) Optical Switching and optical data storage

iii) CNT based transistors.

□□