SEMESTER-2nd
MAJOR COURSE
NYT222J: NANOTECHNOLOGY (INTRODUCTORY NANOSCIENCE _ PHYSICAL, CHEMICAL & BIOLOGICAL CONCEPTS- II)

CREDITS: THEORY: 04; PRACTICALS: 02

COURSE OBJECTIVES:

This course aims to focus on the combined knowledge of thermodynamics, system & surroundings, equilibrium & phase rule, energy band gap, semiconductor properties & wave function properties to enable a student to define and understand materials and nanomaterials in different states with physical, chemical and cell biological perspectives.

THEORY (4 CREDITS)

UNIT-I

Overview of laws of Thermodynamics, Intensive and Extensive Properties, Thermodynamic Processes. PV diagrams, System and its types, Surrounding, Component, Co-ordinates, Phase Equilibrium, Phase Diagram, Lever Rule, Gibb's Phase Rule Phase Diagram of Simple Binary systems

UNIT-II

Band Theory of Solids (metals, insulators and semi-conductors), Energy Band Gap, Intrinsic and Extrinsic Semiconductors, Fermi-Dirac distribution, Fermi level, Doping. Direct and Indirect Band Gap Semiconductors (GaAs, CdS, Si, Ge). Wave Function and its Properties, Schrodinger's Wave Equations (Time-dependent and Time-independent).

UNIT-III

Definition of Nanomaterials based on Bohr Radius and de-Broglie Wavelength, Exciton and its Types, Confinement Regimes, Free Particle, Quantum Confinement, Particle in a 2D box, Particle in a ID box, Particle in a OD box, Concepts of density of states in 3D, 2D, ID and OD materials.

UNIT-IV

Cell as a functional unit: Structure, scale and function of cell organelles. Overview of extracellular and intracellular communications. Introduction to biomolecules as nanomaterials, Overview of surface & bulk properties of biomaterials, concept of biocompatibility. Biomolecular machines: Overview of biomolecular nanomotors - microfilaments, microtubules and intermediary filaments, ATPase, kinesin, dynein, microbial nanomotors (bacterial flagella, cilia- structure and function).

LEARNING OUTCOMES:

Unit -1: At the end of unit I, the student will be able to:

Know about the basic concepts and laws of thermodynamics, concept of entropy and develop critical understanding of thermodynamic potentials and their physical interpretations. Also, an understanding of the practical applications of substances at low temperatures is expected, followed by conceptualization of the phase equilibrium and analysis for different systems.

Unit - II: At the end of unit II, the student will be able to:

Develop an understanding about the Band theory of solids, carrier concentrations in semiconductors, Fermi level concepts, conductivity and mobility concepts of semiconductors. Wave function, Schrodinger's Wave equation and different types of Band gap semiconductors.

Unit - III: At the end of unit III, the student will be able to:

Demonstrate an understanding of nanomaterials with respect to exciton Bohr radius and deBroglie wavelength and discrete optical and electronic spectral changes, followed by an understanding of evolution of quantum size effects and their influence on the electronic structure of the semiconducting nanostructures, simple quantum mechanical analogy of a particle in 1 dimensional, 2 dimensional and 3 dimensional boxes with concepts of density of similar states.

Unit - IV: After completion of Unit IV, Student will be able to:

Know about cell and organelle structure, membrane structure and transport, and develop a concept of biologicals as nanoparticles, further leading towards the concept of nano-bio-compatibility with an overview of nanoscale machines/motors in biological systems.

LABORATORY COURSE-II (2 CREDITS)

1. To find a low resistance using Carey Foster's bridge without calibrating the bridge wire.
2. To determine the energy gap of a semiconductor using Four probe method.
3. To determine the Hall coefficient for a semiconductor sample.
4. To find the coefficient of thermal conductivity of copper using Searle's conductivity apparatus.
5. To plot a graph between temperature and pressure at constant volume using Joly's apparatus.
6. To determine the wavelength of sodium light using a plane diffraction grating.
7. Estimation of protein concentration by Lowry's method or Biuret method.
8. Determination of absorption spectra of DNA and protein using UV-Visible spectrophotometer.
9. Estimation of DNA by Diphenylamine reaction.
10. Estimation of RNA by Orcinol method

Note: Practical exercises will be conducted subject to the availability of necessary equipment and reagents.

REFERENCES:

1. Introductory Nanoscience: Physical & Chemical Concepts, Masaru Kuno, Garland Science.
2. Elementary Solid-State Physics-Principles and Applications, M. Ali Omar, Pearson.
3. Nanotechnology Principles & Practices, S. K. Kulkarn, Capital Publishing Company.
4. Solid State Physics, A. J. Dekker, Macmillan India Ltd, 2004.
5. Concepts of Modem Physics, Arthur Beiser, McGraw Hill.
6. Lehninger's Principles of Biochemistry by D. L. Nelson and M. M. Cox, CBS Publications, 8^{th} Edition, 2021
7. Molecular Cell biology by Harvey Lodish, W.H Freeman 2016.
9. Practical Physics, C. L. Arora, S. Chand Publishing,
10. Experiments in Physical Chemistry; Das, R. C, and Behra, B.; Tata McGraw Hill, 1983.
11. Practical Biochemistry: An Introductory Course by Fiona Frais. University Park Press, 2016.
12. A Textbook of Practical Biochemistry by David Plummer McGraw Hill Education; 3rd edition 2017.