

Dept. of Nanoscience & Technology

Syllabus for Pre-Ph.D examination-2023

Unit-I: Basics and Synthesis of Nanomaterials

Limitation of Mechanics at the Nanoscale - Success of Quantum Mechanics – Wave particle Duality –Quantum mechanics of a free particle confined to 1 to 3-dimensional box. Size dependent properties – Crystal structure - Energy band – magnetic property – Electron related chemical property – Formation of energy gap– Confinement effects – Discreteness of energy levels – concepts of nanomaterials- Top-down and bottom-up approaches in Nanotechnology - Microfabrication and Moore's law. Synthesis of Nanomaterials by Soft Chemical Methods: Chemical precipitation and coprecipitation: Metal nanocrystals synthesis by polyol, and borohydrate reduction methods, Sol-Gel synthesis; Microemulsions synthesis, normal and reverse micelles formation, Hydrothermal. Chemical processes Synthesis methods of dimensionally modulated Inorganic nanostructured materials. Hydrothermal and sonochemical method-combustion technique –Phytochemical synthesis- colloidal precipitation – template process – growth of nanorods – solid-state sintering. Thermolysis routes, Photochemical synthesis, Synthesis in supercritical fluids and electrochemical synthesis. Fabrication of Nanomaterials by Physical Methods: Inert gas condensation, Arc discharge, RF- plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy (MBE), Chemical vapour deposition (CVD) method.–

Nano-imprint lithography- chemical and electrochemical Plating of metals & Bi-metals- Nanocomposites of conducting polymers – metal oxides nanocomposites for Gas Sensors and Biosensors-Photocatalysis- Hydrogen energy-Nanomagnetism.

Unit- II: Characterization of Nanomaterials & Instrumentation Techniques

Surface energy of nanomaterials-size effect-Principle, Instrumentation and applications of UV-VIS spectroscopy, FT-IR Spectroscopy-Mass Spectroscopy- Raman Spectroscopy, NMR and ESR- Surface characterization techniques-ESCA (XPS &AES). Particle size analyzer in nano range- Structural elucidation an Particle size analysis using Scherer formula by XRD- Principles, instrumentation techniques and applications of following sophisticated instrumental techniques: TGA/DTA & DSC, SEM, TEM and AFM, CLSM and VSM.

Unit II: Basics of Materials Science and Nano Engineering

Space lattice-Crystal Symmetry-Planes and Miller indices- imperfection in crystals- -Primary and Secondary bonding in solids-Fermi-Dirac- Electronic distribution- Optical- mechanical properties of solids- Metal and Semiconductors- -Mechanisms of phase transformation-homogeneous and heterogeneous nucleation- Grain growth- Precipitation in solid solution-order and disorder transformations--Polymer nanocomposites-Ex situ and in-situ approaches-Physical and chemical properties of nano-composites-Effect of processing conditions on morphology and properties of polymer nanocomposites-Carbon/Polymer nanocomposites- Properties and Applications- Kinetics in Nano-structured Materials- Zero, one and two dimensional nanostructures- clusters of metals and semiconductors, Nano-structured materials-Graphene, Graphene oxide and reduced Graphene oxide -phonons in nanostructures- Carbon Nanotubes – Photonics- Nanostructures as single electron transistor –Principle and design.

Unit IV: Crystalline Properties & Dielectrics and Ferroelectrics and Solar cells

Semiconductor – P-N Junction - FET – LED – MOSFET – Logic gates –Nanoelectronics – Moors Law – Quantum phenomena for Nanoelectronics – Quantum dots – Volatile memories and non volatile memory – Read only memory (ROM)– Dynamic Random Access Memory – Nano ferroelectrics – Magnetoresistive random access memory (MRAM) – Principles gas sensors – Biosensors – Chemical sensors – Basic principle of capacitor and supercapacitor – Types of Supercapacitor – Supercapacitor energy storage mechanism – Photons – Photo voltaic effect- PEC Solar cells – types of solar cells - dye sensitized and organic solar cells.

Unit-V Nanobiotechnology:

Overview of Nanobiotechnology- Historical perspective of integration of biology, chemistry and material science, Basic capabilities of nanobiotechnology and nanomedicine.

Principles of Nanobiotechnology: Biomolecular structure and stability-Protein folding-Self-assembly-Self-organization-Molecular recognition-Flexibility-Information-Driven nanoassembly, Protein based nanostructures and DNA based nanostructures.

Nanomaterials as drug delivery system: Fundamentals and types of nanocarriers-quantum dots polymer based, lipid, viral, carbon nanotubes, protein and metal/metal oxide, graphene based materials; Drug encapsulation strategies; Targeted and non-targeted drug delivery; Surface functionalisation; routes of drug delivery.

Nanomaterials in tissue engineering: Extracellular matrix as biological scaffold, Natural polymers in tissue engineering applications, Degradable polymers for tissue engineering, Degradation of bioceramics. Cell source, Cell culture: harvest, selection, expansion, and differentiation, Cell nutrition, Cryobiology, Scaffold design and fabrication, Controlled **Unit** release strategies in tissue engineering

Nanomaterials as Biosensor- Structure and functional properties of Biomaterials, Biomolecular sensing, Molecular recognition and Flexibility of biomaterials, protein based and DNA based nanosensors. **Bionanomaterial as building blocks** - Protein based Nanostructures building blocks and templates. DNA based nanostructures- DNA origami method.

Nanotechnology in Agriculture and Food technology - Insecticides development using nanotechnology and Nanofertilizers. Nanotechnology in food processing, food safety and biosecurity, toxin and contaminant detection, Smart packaging.

Nanomarine biology and Nanomedicine- Nano Marine biotechnology -Nanomedicine - Nanodevices- NEMS, BioMEMs

Nanotoxicology – exposures, routes of entry, cellular and organ based toxicity, model system to assess toxicity

Reference Books:

1. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Wiley, New York, (2001), ISBN 0-471 48943 3.
2. Quantum Mechanics, Vol I and Vol II, Claude Cohen-Tannaoudji, Bernard Diu, Franck Laloe, John Wiley & Sons (2005).
3. Molecular Quantum Mechanics (3rd Edition), P.W. Atkins and R. S. Friedman, Oxford University Press, (2004), ISBN: 0-19-566751-4.
4. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry,

- Cambridge UK 2005.
5. Chemistry of Nanomaterials : Synthesis, properties and applications by CNR Rao et.al. 3. Active Metals: Preparation, characterization, applications – A. Furstner, Ed., VCH, New York 1996.
 6. Introduction to Nanotechnology – Charles P.Poole Jr and Frank J.Owens .,Wiley India Pvt.Ltd.,2007
 7. Nanotechnology and Nanoelectronics – W.R.Fahrner .,Springer., 2006
 8. Nanostructures and Nanomaterials – Guozhong Cao, Imperial College Press., 2004.
 9. Molecular Nanoelectronics – Mark A.Reed and Takhee Lee, Asps, 2003
 10. Materials Science and Engineering: An Introduction, William D. Callister, 2006, John Wiley & Son
 - 11.Introduction to Materials Science and Engineering, Yip-wah Chung, 2006, CRC
 12. Materials science and engineering - V.Raghavan, Prentice Hall of India PVT, New Delhi - 200
 13. Materials Sci. and Engg.: An Introduction, William D.Callister,2006,John Wiley & Sons
 - 14.Physical Chemistry – Atkins Peter, Paula Julio
 - 15.J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005
 16. The Handbook of Nanotechnology (2005) Wiley B. Roszek
 - 17.Biomedical applications of nanotechnology (2007) Wiley
 18. Introduction to Nanotechnology –(2005) L. Bruus
 - 19.Springer - Handbook of Nanotechnology (2004)
 - 20.** M.Y. Berezin, Nanotechnology for Biomedical Imaging and Diagnostics: From Nanoparticle design to application, John Wiley and Sons, Canada, 2015.
 21. M. Rai, K. Kon, Nanotechnology in Diagnosis, Treatment and Prophylaxis of Infectious Diseases, Academic Press, Elseiver, Amsterdam, 2015
 - 22.R. Bawa, G.F. Audette, I. Rubinstein, Handbook of Clinical Nanomedicine: Nanoparticles, Imaging, Therapy, and clinical application, CRC Press, 2016.
 - 23.Kenneth A. Howard, Thomas Vorup-Jensen, Dan Peer, Nanomedicine, Springer Nature, New York, 2016
 24. S. Thomas, Y. Grohens, N. Ninan, Nanotechnology Applications for Tissue Engineering, William Andrew, Elsevier, USA, 2015
 - 25.Y. Pathak, D. Thassu, Drug Delivery Nanoparticles Formulation and Characterization, Informa Healthcare, USA, 2016.