

Dept. of Nanoscience & Technology

Syllabus for Pre-Ph.D examination-2019-24

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. Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis- Preliminary aspects of lithography – Nano-imprint lithography.

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 :Nanobiotechnologies

Unit- V : Nanobiotechnology – Basic concepts of nanobiotechnology; Biological Nanomolecules-DNA computers and DNA microprocessors, lipids as nanobricks and mortar, protein 3D structure as protein pores for biosensor; Fundamentals and types of nanocarriers – Drug encapsulation strategies; Drug targeting – targeted and non-targeted drug delivery, surface functionalization, routes of drug delivery- Neuronal, ocular, cardiovascular, pulmonary and lymphatic system; Nanomedicine – Cancer therapy- Inflammation- Tissue Bioengineering - Regeneration, Growth and Repair, nanostructure as antibiotics; Imaging and detection - Fluorophores and Quantum dots – Labeling, functionalization and Image analysis; Biosensor-DNA and Protein based biosensor, Nanodevices- NEMS, BioMEMs, nanoparticle role in MRI, X ray, Ultrasonography, Nanotoxicology – exposure, routes of entry, cellular and organ based toxicity, model system to assess toxicity- Nano Marine biotechnology.

Reference Books:

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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
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- 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, Elsevier, 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.