

- Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
- Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
- Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.
- F.A. Cotton & G. Wilkinson (1999), **Advanced Inorganic Chemistry**, 6th Edition, John Wiley & Sons.

References (Practical):

- Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.
- Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanoscale Materials and their applications	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an introduction to nanoscale materials and their applications.
- To provides an insight into bottom-up and top-down-approach, the methods of synthesis of nanoparticles, simple characterization techniques and applications of nanomaterials.

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand the concept of nano dimensions.
- Know the various methods of preparation of nanomaterials.
- Understand the principles of optical and electron microscopy techniques of characterizing nanomaterials.
- Understand the Appreciate the real life applications of nanomaterials.

Unit 1: Introduction to Nanodimensions

Hours: 12

0D, 1D, 2D nanomaterials, Quantum Dots, Nanoparticles, Nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects in nano systems, Quantum confinement and its consequences, Semiconductors. Band structure and band gap. Optical Properties Surface plasmon resonance

Unit 2: Preparation of Nanomaterials

Hours: 10

Top down and Bottom up approach, Photolithography. Ball milling. Vacuum deposition. Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, Sol-Gel synthesis, Hydrothermal synthesis, Spray pyrolysis, Electrochemical deposition, Pulsed Laser deposition. Characterization of nanomaterials: Basic principle of optical methods and electron microscopy.

Unit 3: Applications of Nanomaterials

Hours: 8

Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts, Nanocomposites as catalysts. Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbon nanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

Practical

(Credits: 02, Laboratory periods: 60)

1. Synthesis of silver nanoparticles by chemical methods and characterization using UV-visible spectrophotometer.
 - a. Turkevich Method
 - b. Burst Method
2. Synthesis of silver nanoparticles by green approach methods (using soluble starch, glucose or cinnamon bark) and characterization using UV-visible spectrophotometer.
3. Synthesis of metal sulphide nanoparticles and characterization using UV-visible spectrophotometer and determination of Band gap.
 - a. MnS
 - b. ZnS
 - c. CuS
4. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.
5. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.
6. Phytochemicals mediated synthesis of gold nanoparticles (AuNPs) using tea leaves and to study the effect of size on color of gold/silver nanoparticles.
7. Preparation of magnetic nanoparticles (MNPs) of Fe₃O₄ using green tea leaf extract.

8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References (Theory):

1. West, A. R. (2014), **Solid State Chemistry and Its Application**, Wiley.
2. Smart, L. E.; Moore, E. A., (2012), **Solid State Chemistry: An Introduction**, CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997), **New Direction in Solid State Chemistry**, Cambridge University Press.
4. Poole Jr.; Charles P.; Owens, Frank J. (2003), **Introduction to Nanotechnology**, John Wiley and Sons. Harris, D. C. (2007), **Quantitative Chemical Analysis**, 6th Edition, Freeman.
5. Chattopadhyay, K.K.; Banerjee, A. N. (2009), **Introduction to Nanoscience and Technology**, PHI.

References (Practicals):

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; **Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory**, J. Chem. Educ. 2015, 92, 339–344.
2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), **Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis**, L. Alcaer (ed.), *Conducting Polymers*, 105-120, D. Reidel Publishing.
3. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981), **Hexagonal Tungsten Trioxide and Its Intercalation Chemistry**, *Solid State Ionics*, 5, 1981, 355-358.
4. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; **Synthesis of ZnO Nanoparticles by Precipitation Method**, *Orient J Chem* 2015, 31(2).