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**FIRST SEMESTER 2022-2023**

# Course Handout Part II

Date: 06-08-2022

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

**Course No. : CHE G528**

## **Course Title : Introduction to Nanoscience and Technology**

## **Instructor-in-Charge : Dr. Satyapaul A. Singh**

**Course Description :** Introduction to nano-science, Basic idea of solid state physics and quantum mechanics, Quantum wells, Wires and dots, Properties of nanomaterials, Carbon nanotubes, Nanosynthesis, Characterisation methods, Application of nano-materials to various fields like electronics, medical, MEMS, photonics, molecular switches and others, Special reference to Chemical Engineering as in catalysis, heat transfer and special additive and performance materials (nanofluids, nanocomposites), Future of nano science and technology, Large scale manufacture and technological issues.

**Scope and Objective of the Course:**

As a part of this course students get exposure to nanoscience, nanotechnology, scientific understanding of nanomaterial properties, characterization and analysis. This course targets majorly to improve the student’s knowledge by synthesizing nanoparticles, further sharing the interesting topics in the form of presentations. The writing report and project presentations would give a chance to improve the communication and writing skills of a student that may be beneficial at later stages of his/her’s academic program.

At the end of the course, the student should be able to:

* Understand the importance of nanoscience and its applications
* Design a synthesis protocol for metal oxide systems
* Synthesize metal oxides and composites with different synthesis routes
* Understand the characterization methods and tuning the properties of nanomaterials for the desired application
* Improve the presentation and writing skills

**Textbooks:**

T1 – T. Pradeep, “Nano: The essentials; Understanding nanoscience and nanotechnology”, McGraw Hill Publishing Company Ltd, New York (2008).

T2 – Charles P. Poole, Jr., Frank J. Owens, “Introduction to nanotechnology”, John Wiley & Sons, New York (2003).

**Reference books:**

R1 – T. Pradeep, “A textbook of nanoscience and nanotechnology”, Tata McGraw Hill Educational Private Ltd, New Delhi (2003).

R2 – Donald A. Neamen, “Semiconductor physics and devices”, McGraw Hill Publishing Company Ltd, 3rd Edition (2007).

R3 – Zhong Lin Wang, “Nanowires and nanobelts: Materials, properties and devices”, Volume 1, Kluwar Academic Publishers, Dordecht (2003).

R4 – Peter Rodgers, “Nanoscience and technology: A collection of reviews from nature journals”, World Scientific, London (2010).

R5 – Ke Liu, Chunshan Song, Velu Subramani, “Hydrogen and syngas production and purification technologies”, John Wiley & Sons, New Jersey (2010).

**Course Plan:**

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| --- | --- | --- | --- |
| **Lecture No.** | **Learning objectives** | **Topics to be covered** | **Chapter in the Text Book** |
| 1 – 3 | Introduction to nanoscience | What is nanoscience and technology, Nanoscience in nature | Ch.1 of T1  Ch.1 of R1 |
| 4 – 5 | Solid state physics | Understanding crystal structures, energy bands, lattice vibrations, fermi levels, localized particles and its mobility; Applications in characterization techniques | Ch. 2 of T2 |
| 6 – 8 | Quantum mechanics | Energy quanta, wave-particle duality, wave equations, boundary conditions, statistical mechanics | Ch. 1 and 2 of R2 |
| 9 – 12 | Quantum wells, wires and dots | Synthesis of quantum dots, wires; Electronic structure of nanocrystals; Size and dimensionality effect | Ch. 7 of T1  Ch.1 of R3  Ch.9 of T2 |
| 13 – 16 | Properties of nanomaterials | Metal nanoclusters, semiconducting nanoparticles, physical properties | Ch. 4 of T2 |
| 17 – 20 | Carbon nanotubes | Synthesis, Mechanism of growth, Transport properties, mechanical and electrical properties | Ch.4 of T1 |
| 21 – 24 | Synthesis and characterization methods | Diffraction techniques, electroanalytical techniques, spectroscopic techniques and etc | Ch. 5 – 8 of R1 |
| 25 – 29 | Applications of nanomaterials in various fields | Molecular machines and devices, nanoelectronics, nanophotonics, nanobiotechnology and medicine, nanosensors, lab-on-chip technologies | R4 |
| 30 – 33 | Catalytic applications | Nanoparticles applications in gas-solid and liquid-solid reaction systems | R5 |
| 34 – 38 | Special performance materials | Composite materials, Metal organic frameworks, core-shell nanostructures | Review Articles |
| 39 – 42 | Future of nanoscience and technology | Nanotechnology: How far world can own nanotechnology? | Review Articles  and R4 |

**Laboratory component:**

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| --- | --- | --- |
| **Experiment No** | **Lab name** | **Experiment Name** |
| Expt-1 | Materials science lab | ZnO synthesis using solution combustion synthesis with glycine/urea and ODH as fuels (separate fuel for every batch) |
| Expt-2 | CAL | Sample preparation for SEM and analysis with XRF |
| Expt-3 | CAL & D228 | Analysis with XRD and pattern analysis |
| Expt-4 | D314 | ZnO material design using DFT tool |
| Expt-5 | D228 | Temperature Programming Reduction for ZnO material and effect of the fuel used |
| Expt-6 | D228 | Microscopic analysis of coated surfaces (dropcasted nanoparticles on silicon vafor, sputtered surface and Natural surfaces) |
| Expt-7 | Materials science lab | Role of Ligand to metal ration to obtain MOFs (Zn) and morphology analysis using reduction |
| Expt-8 | CAL & D228 | Sample preparation for SEM and analysis with XRF |
| Expt-9 | CAL | Analysis with XRD and pattern analysis |
| Expt-10 | D228 | CO2 capture studies using |
| Expt-11 | D228 | Photocatalytic degradation of dye solution |
| Expt-12 | MCSEE or CAL | FTIR analysis for pristine and spent ZnO catalysts |

**Evaluation Scheme:**

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage (%)** | **Date & Time** | **Nature of Component** |
| Mid exam | 90 min. | 20 | 01/11 3.30 - 5.00PM | Closed Book |
| Project work (Seminar and report) |  | 20 | TBA | Open Book |
| Laboratory sessions  (Report and/or Presentations) |  | 20 | TBA | Open Book |
| Comprehensive | 3 hrs. | 30 | 21/12 AN | Closed Book |
| Surprise tests/quizzes |  | 10 |  | Closed Book |

**Chamber Consultation Hour:** Will be announced in classroom (Chamber: **D 204**)

**Notices:** Will be updated in CMS

**Make-up Policy:** Make-up will be granted only for genuine cases with valid justification and only with prior permission of Instructor-in-charge.

**Academic Honesty and Integrity Policy**: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable

**Dr. Satyapaul A. Singh**

**INSTRUCTOR-IN-CHARGE**

**CHE G528**