VI Semester

Open Elective 21CHE654 -NANOCHEMISTRY AND NANOTECHNOLOGY FOR ENGINEERS			
Course Code	**21CHE652**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

CLO 1	Impart the basic knowledge of Nano chemistry and synthetic methods involved in nanotechnology.
CLO 2	Understand the basic principles and instrumentation of characterization techniques used in nanotechnology and its technological importance.
CLO 3	Master the knowledge about green systems.
CLO 4	Enlighten the needs and utilization of nanomaterials in the various fields such as energy, water treatment process, Agriculture, medicine, engineering and textile industries.
CLO 5	Apply the knowledge of Nanocomposites, Biodegradable polymer-based nanocomposites, Clay polymer nanocomposites.

Pedagogy (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

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1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Show Video/animation films to convince abstract concepts.
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

Module-1 - Basic concepts of Nanomaterials - 08 hours

Introduction to Nanoscience; History and Scope, Interdisciplinary nature, Structure of nanomaterials, general properties of bulk materials and nanomaterials, Methods of synthesis-Top down and Bottom up approaches, Chemical methods of synthesis & advantages-Sol-gel, Co-precipitation Solution combustion methods, Chemical vapor deposition method and Spray pyrolysis. Introduction, Synthesis, Properties and applications of: Carbon nanowires, CNTs-Single walled & Multiwalled CNTs, Fullerenes, Carbon nanorods, Graphene, Graphite, Carbon black.

Pedagogy	**Chalk and talk/power point presentation:** History and Scope, Interdisciplinary nature, Structure of nanomaterials, general properties of bulk materials and nanomaterials, Methods of synthesis-Top down and Bottom up approaches, Chemical methods of synthesis & advantages-Sol-gel, Co-precipitation Solution combustion methods, **Videos/Learning material:** Synthesis, Properties and applications of: Carbon nanowires, CNTs-Single walled & Multiwalled CNTs, Fullerenes, Carbon nanorods, Graphene, Graphite, Carbon black **Self-study:** Surface properties of nanomaterials

Module-2 -Characterization of Nanomaterials - 08 hours

Principle, instrumentation and applications of Powder X-ray diffraction, Fourier transform infrared spectroscopy, UV-Vis spectroscopy , Scanning electron microscopy, transmission electron microscopy, Thermal gravimetric analysis, Energy dispersive spectroscopy and BET-analysis.

Pedagogy	**Chalk and talk/power point presentation**: Principles of instruments like Powder XRD, FTIR, UV-spectroscopy, SEM, TEM, TGA and EDS. **Videos/Learning material**: Instrumentation and applications of instruments like Powder XRD, FTIR, UV-spectroscopy, SEM, TEM, TGA and EDS.

	Self-study: Differential scanning calorimeter

Module-3 Nanomaterials for Green systems - 08 hours

Green materials, including biomaterials, biopolymers, bioplastics, and composites Nanotech Materials for Truly Sustainable Construction: Windows, Skylights, and Lighting. Paints, Roofs, Walls, and Cooling. Multifunctional Gas Sensors, Biomimetic Sensors, Optical Interference Sensors Thermo-, light-, and stimulus-responsive smart materials.

Pedagogy	**Chalk and talk/power point presentation**: Green materials, including biomaterials, biopolymers, bioplastics, and composites Nanotech Materials **Videos/Learning material**: Multifunctional Gas Sensors, Biomimetic Sensors, Optical Interference Sensors Thermo-, light-, and stimulus-responsive smart materials **Self-study:** Smart polymers.

Module-4 -Nanotechnology & its applications - 08 hours

Introduction, materials used and applications in renewable energy generation, drug delivery, cosmetics, tissue engineering, bioinformatics, information technology, agriculture & food technology, high integrated circuits, nanomedicine, molecular motors, bioelectronics & spintronics, Fuel cells, Photocatalytic hydrogen generation. Water remediation-Photocatalytic degradation of toxic dyes, Photocatalytic reduction of Cr^{6+} to Cr^{3+}, Defluorination of water. Electrochemical sensor, Biosensors, Textiles & Cosmetics, Defense & Aerospace.

Pedagogy	**Chalk and talk/power point presentation**: Introduction, materials used and applications in renewable energy generation, drug delivery, cosmetics, tissue engineering, bioinformatics, information technology, agriculture & food technology, **Videos/Learning material**: Fuel cells, Photocatalytic hydrogen generation. **Self-study:** Electro photocatalytic water splitting to generate hydrogen.

Module-5- Nanocomposites. - 08 hours

Introduction, Doping technique, binary and ternary nanocomposites, synthesis, properties and applications of metal-metal oxide and metal oxide-metal oxide nanocomposites, Biodegradable polymer based nanocomposites, Ternary epoxy nanocomposite systems, glass-metal nanocomposites, nanocomposites from biomaterials, Thermo plastic based nanocomposites, Nylon-6 nanocomposites, Clay polymer nanocomposites.

Pedagogy	**Chalk and talk/power point presentation**: Introduction, Doping technique, binary and ternary nanocomposites, synthesis, properties and applications of metal-metal oxide and metal oxide-metal oxide nanocomposites. **Videos/Learning material**: Thermoplastic based nanocomposites, Nylon-6 nanocomposites, Clay polymer nanocomposites. **Self-study:** Polymer-polymer interaction parameters.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

CO 1	Discuss the fundamental principles, synthetic method and advantages of nanomaterials.
CO 2	Explain the concepts of characterization techniques used in Nanoscience and Nanotechnology.
CO 3	Enumerate the principles of Green systems.
CO 4	Describe the applications of nanomaterials in energy, water purification, agriculture, textile and engineering fields.
CO 5	lustrate the functioning and properties nanocomposites namely nanometal oxides, nanopolymers and nanoclays.

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:
Three Unit Tests each of **20 Marks (duration 01 hour**)
1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**
4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)
6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**
(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:
Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**
1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
The students have to answer 5 full questions, selecting one full question from each module. Marks scored out of 100 shall be reduced proportionally to 50 marks

Suggested Learning Resources:

Books

1. AK Bandyopadhyay, Nanomaterials , New Age International (P) Ltd., 2nd Edition, 2010.
2. Rao. C. N, Muller. A, Cheetham . A. K, Nanomaterials chemistry, Wiley-VCH, 2007.
3. N. Kumar, Concise concepts of nanoscience and nanomaterials, Scientific publishers, 2018

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/results?search_query=Characterization+of+Nanomaterials
2. https://www.youtube.com/watch?v=qUEbxTkPIWI&list=PLbMVogVj5nJSl_2XmFjuRmvuAgCOZXUjv
3. https://www.youtube.com/watch?v=qUEbxTkPIWI
4. https://www.youtube.com/watch?v=4j5cMHVPStc

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- https://www.vlab.co.in/broad-area-chemical-sciences
- https://demonstrations.wolfram.com/topics.php
- https://interestingengineering.com/science