University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSECHE206**				
Course Title	**CHEMISTRY OF NANOMATERIALS -I**				
Type of Course	**DSE**				
Semester	3				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours			4
Pre-requisites	Higher secondary Chemistry				
Course Summary	This course covers the fundamental principles of materials science and engineering, including atomic structure, crystallography, mechanical properties, electrical properties, thermal properties, and magnetic properties. It also explores the synthesis, processing techniques of materials and it's vide applications in various fields**.**				

Detailed Syllabus:

Module	Unit	Course Description CHEMISTRY OF NANOMATERIALS -I	Hrs 60
I	**INTRODUCTION TO MATERIALS SCIENCE**		**9**
	1	Definition and scope of materials science, Classification of Materials- Metals and alloys, Polymers, Ceramics, and Composites	3
	2	Metals and Alloys- basic features and examples Polymer- basic features and examples Ceramics- basic features and examples Composites- types (elementary idea only), main features, and examples	4
	3	Basic application of materials in technology and industry- electronics, automobiles, medicine, and engineering	2
II	**MOLECULAR STRUCTURE OF MATERIALS**		**9**
	4	Bonding forces and energies- Primary interatomic bonds- ionic, covalent, metallic bonding; secondary bonding, Van der Waals forces- Debye, Keesom and London-dispersion forces, hydrogen bonding- inter and intra molecular hydrogen bonding	4
	5	Structure of crystalline solids- Unit cell, Bravais lattices, crystal systems, crystallographic point groups, Weiss and Miller indices. Closed packed crystal structures- BCC, FCC, HCP	3
	6	Defects in crystals: Stoichiometric and non-stoichiometric point defects.	2
III	**PHYSICAL PROPERTIES OF MATERIALS**		**9**

	7	Mechanical properties of metals and polymers: Stress-strain behaviour, tension and compression properties.	2
	8	Thermal properties of polymers and ceramics: Glass transition temperature, thermal stability, and thermal conductivity	2
	9	Electrical properties of metals and alloys: Conductivity and resistivity	2
	10	Magnetic properties of metals and alloys: Saturation magnetisation, coercivity, retentivity, hysteresis loop. Types of magnetic behaviour: Diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, and ferrimagnetism	3
IV	**SYNTHESIS, PROCESSING, AND APPLICATIONS OF MATERIALS**		**18**
	11	Solid-state methods: Powder preparation methods (milling, comminution)	2
	12	Gas-Phase methods: Chemical vapor deposition (CVD) and Physical vapour deposition (PVD)	3
	13	Liquid phase methods: Sol-gel methods, solvothermal, and hydrothermal	2
	14	Emerging Techniques: Additive manufacturing (3D-printing) electrospinning, microwave processing, spark plasma sintering, and nanotechnology (basic idea only)	2
	15	Materials for Energy storage applications Batteries- lithium-ion, sodium-ion Supercapacitors- Activated carbon, MnO_2, Co_3O_4 Conductive polymers: Polyaniline, Polypyrrole	3
	16	Materials for medical applications Metals and alloys: Titanium (Ti) -hip, knee, and dental implants; Titanium and stainless steel -bone screws, plates, stents, braces Cobalt-chrome alloys - Artificial heart valves, joint prostheses Nickel-titanium alloy- stents (elementary idea) Polymers: Polylactic acid (PLA), polyglycolic acid (PGA), polyethylene glycol (PEG) -biodegradable sutures, drug delivery systems Polyethylene terephthalate (PET), polytetrafluoroethylene (PTFE)- Vascular grafts Polyurethane- catheters, pacemaker leads, wound dressings Ceramics: Hydroxyapatite (HA) - bone grafts, coating for metal implants	3
	17	Materials for Environmental remediation applications Materials for Pollution Control- Photocatalytic materials-TiO_2, ZnO Adsorbent materials- Activated carbon, clay, zeolites, fly ash Metal-organic frameworks (MOFs) for gas capture Materials for water treatment- Activated carbon and zeolites: Removal of dyes, pesticides, heavy metals Bio-based adsorbents: chitosan, sawdust, cellulose, alginate	3
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc.**		**15**
		1. Identify and present a real-world application in electronics, medicine, or automotive industry for any one category of metals, polymers and ceramics	

		2. Analyse the stress-strain curve of two materials (e.g., a metal vs. a polymer). 3. Compare and classify physical properties of materials 4. Emerging techniques in materials synthesis (Microwave-Assisted Synthesis, Spark Plasma Sintering (SPS) etc. 5. Investigate the advancements and current challenges in biomedical materials 6. Analyse any nanomaterial-based wastewater treatment technique (e.g., Arsenic removal using iron oxide nanomaterial; dye removal from textile effluents in water treatment using zinc oxide (ZnO) and titanium dioxide (TiO_2) etc. 7. Explore sustainable and eco-friendly materials used in water filtration	

References

1. W.D Callister. Jr, *Materials Science and Engineering*, Wiley India Pvt. Ltd, 2007
2. Raghavan V, *Materials Science and Engineering*, 4th Edition, Prentice Hall of India, 1998
3. Joel I. Gersten and Frederick W. Smit, "*The Physics and Chemistry of Materials*", Wiley, 2007
4. Fahlman, B.D., *Materials Chemistry*, Springer, 2007
5. James F. Shackelford, *Introduction to Materials Science for Engineers*, 8th Edition, 2020
6. William F. Smith and Javad Hashemi, *Foundations of Materials Science and Engineering*; 6th Edition, McGraw-Hill, 2022
7. Huan Pang, Xiaoyu Cao, Limin Zhu, Mingbo Zheng, *Synthesis of Functional Nanomaterials for Electrochemical Energy Storage*, Springer, 2020.
8. Seeram Ramakrishna, Murugan Ramalingam, T. S. Sampath Kumar, Winston O. Soboyejo, *Biomaterials: A Nano Approach*, CRC Press, 2010
9. Ajay Kumar Mishra, *Nanomaterials for Water Remediation: Inorganic Oxide Materials, Vol 2*, Smithers-Rapra Publisher, UK, 2016
10. Shivani Bhardwaj Mishra and Ajay Kumar Mishra, *Bio- and Nanosorbents from Natural Resources*, Springer, 2018

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Define the fundamental concepts and scope of materials science, classify materials, and explain their distinct characteristics	An	1,3
CO-2	Understand and explain the nature of interatomic bonding, including primary and secondary bonding forces, crystal structures, and defects in materials	An	1,2
CO-3	Analyse and interpret the mechanical, thermal, electrical, and	E	1,2,3

	magnetic properties of materials		
CO-4	Understand and compare various material synthesis including solid-state, gas-phase, and liquid-phase methods as well as emerging techniques, and apply this knowledge to solve real-world problems related to energy storage, environmental remediation, and biomedical applications.	C	1,3,5
CO-5	Evaluate and apply material properties, synthesis techniques, and innovations for advanced applications in electronics, medicine, automotive, water treatment, and biomedical engineering.	C	1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY OF NANOMATERIALS -I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,3 PO-1,2	An	F, C	L	
2	CO-2	PSO-1,2 PO-1,2	An	C	L	
3	CO-3	PSO-1,2,3 PO-1,2	E	C	L	
4	CO-4	PSO-1,2,5 PO-1,2	C	F, C	L	
5	CO-5	PSO-1,2,3 PO-1,2	C	M	T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	3	-	-	2	1	-	-	-	-	-	-

CO 2	3	3	-	-	-	3	2	-	-	-	-	-	-
CO 3	2	1	3	-	-	3	2	-	-	-	-	-	-
CO 4	3	2	-	-	3	2	2	-	-	-	-	-	-
CO 5	3	3	2	-	-	3	3	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓	✓	✓
CO 5		✓	✓	