B.M.S. COLLEGE OF ENGINEERING, BENGALURU

Autonomous Institute, Affiliated to VTU

Department of chemistry

COURSE TITLE: Green Chemistry and Green Engineering	**Course Code: 23CY7OEGCE**	**Credits**: 03
L:T:P:S 3:0:0:0	**Contact Hours**: 40	**Hours/Week**: 03
Semester : 7th sem (Open elective)	**Course instructor**	**Dr.Kalyan Raj**

Course Objectives:

- Impart the knowledge of principle and applications of green chemistry
- Assess various aspects of green synthesis practiced and hurdles in its implementation
- Analyze various green materials and processes as an alternative to conventional systems

Course Content

Unit-1

Introduction to Green chemistry **08 hours**

Introduction - Emergence of green chemistry, Important environmental laws, pollution prevention Act of 2000, Need, Objectives and Limitations in Green Chemistry, ethical awareness of green chemistry.

Principles of green chemistry- Twelve principles of Green Chemistry with explanation, Importance of Green chemistry in sustainable development.

Green metrics – Atom economy, Numerical on atom economy. reaction mass efficiency, environmental (E) factor.

Greener alternative – safer routes to synthesize carbaryl (to avoid the incidents such as Bhopal Gas incident), safer route to synthesize cyclohexanol (to avoid the incidents such as Flixiborough accident), Green hydrogen as a fuel (National Green hydrogen mission).

Unit-2

Green synthesis **08 hours**

Green solvents: Supercritical carbon dioxide, water, ionic liquids, fluorous biphasic solvent, PEG as a solvent for organic reactions.

Microwave assisted reactions – Introduction, methodology, advantages, disadvantages.

Ex - synthesis of Asprin

Ultrasound assisted reactions – Introduction, methodology, advantages, disadvantages.

Ex – Synthesis of paracetamol

Photocatalytic reactions – Introduction, methodology, advantages, disadvantages.

Unit-3

Energy saving materials **08 hours**

Light Emitting Diodes - Principle, working and Fabrication of Light emitting diodes,

Fiber Optics - Types of Fibers, composition and fabrication technology, Materials development for fiber optic, Transmission losses, Use of fiber in lighting

Solar Heating & Cooling System - Solar water heating systems, Liquid based systems for buildings, Solar air heating systems, Methods of modeling and design of Solar heating system, cool roof paints, Vapour absorption refrigeration cycle; Water, ammonia & lithium bromide-water absorption refrigeration systems; Solar desiccant cooling, Applications of solar flat plate water heater

Unit-4

Waste Management **08 hours**

E-Waste management – Introduction, importance, sources of e-waste, Composition, Characteristics, Toxic materials used in manufacturing electronic and electrical products, effect of waste on human health.

Different waste management approaches (Reduce, Reuse, Recycle), Recovery of metals from electronic industry.

Waste-to-wealth- Municipal Solid Waste to electricity, Advantages and limitations. Carbon sequestration.

Bio-medical waste management: Introduction, hazard of biomedical waste, Classification, waste minimization, waste segregation and labeling, waste handling, collection, storage and transportation Disposal.

Unit-5

Green industrial materials **08 hours**

Wood-based materials - Degradation and durability of wood-based materials, Development of binder less board, wood polymer composite (WPC) advantages and processings of WPC.

Biodegradable Polymers – Introduction, criteria for biodegradability (with examples), assessing biodegradability (petri-dish screen, environmental chamber method, composting methods, soil burial tests)

Green Building materials: Plant based materials, recycled stone, hempcrete, recycled metal and nontoxic reusable materials. Green materials in civil constructions.

Text Books

1. Green chemistry: A text book, Ahluwalia.V.K, Narosa publishing house, 2021
2. Chemistry for green environment, Srivastava.M.M, Narosa publishing house, 2008

Reference Books

1. Environmental chemistry: Green chemistry and pollution, Lichtfouse, Eric et al, New Delhi, Springer, 2009.
2. Green Technologies and Environmental Sustainability, Ritu Singh, Sanjeev Kumar, 2018

e-books

1**.** Green chemistry principles and industrial applications, Radhakrishna Arakali, Kindle edition

2. Green Chemistry and Green Engineering Processing, Technologies, Properties, and Applications, Shrikaant Kulkarni, Neha Kanwar Rawat, A. K. Haghi, Apple Academic Press. https://doi.org/10.1201/9781003057895

NPTEL/SWAYAM/MOOCs

1. http://nptel.ac.in/
2. https://swayam.gov.in/

Course outcomes: On completion of the course, the student will have the ability to:		**PO**	**Strength**
CO1	Analyze the principles of green chemistry and its application in the form of alternative materials and processes.	PO2	3
CO2	Implement green chemistry solutions to environmental problems through eco-friendly waste management systems.	PO6	3
CO3	Apply the knowledge of green chemistry to investigate feasibility of implementing recycled materials for industrial use.	PO7	3

Scheme

Component	**Type of assessment**	**Max. Marks**		**Weightage**	**Total**	**Total Marks**
Theory	AAT# (Alternative Assessment Tool AAT1 and AAT2)	10+10		10	50	50
	Test 1	40	Best of Two tests	40		
	Test 2	40				
	Test 3	40				
	CIE	50		50		
SEE	Sem End Exam	100		50		50 (SEE)
Grand Total Marks						**100**
***minimum CIE marks ≥ 20 to gain eligibility to write the SEE**						

BMS COLLEGE OF ENGINEERING, BENGALURU-19

Autonomous Institute, Affiliated to VTU

DEPARTMENT OF CHEMISTRY

Course Name	Green Energy Technology	Course Code	23CY7OEGET
Credits	03	L-T-P-S	3- 0 -0-0
Contact hours	40	Faculty Handling	Dr.Srinidhi Raghavan.M
Semester	7th (open elective)		

Course Objectives:

The fundamental of the course is to:

- Enhance engineering students' knowledge of green energy management.
- Validate the importance of green energy technologies for India's future.
- Illustrate the necessary factors and significance of energy resources.
- Instruct on the importance of addressing environmental impacts and risks, pollution control, and remediation through green energy technologies.

A	Course Outcomes: At the end of the course the student will have	POs Mapped	Strength of mapping
CO1	Develop a profound understanding of the significance of green energy management for a sustainable future.	PO1	1
CO2	Apply acquired knowledge in energy management to address and resolve societal challenges.	PO2	2
CO3	Refining the skills necessary to solve energy-related problems and mitigate environmental impacts.	PO3,PO7	3,7

Module– I

Green Energy Technology: General introduction of green energy. Green energy conservation and its importance, green energy sources and types, role of energy in economic development and social transformation. **Green Energy Emergency**- Importance and significance of green energy needs. Three factors - Social equity, Economic viability, and environmental protection. **(8 hours)**

Module -II

Green energy Management: Factors for green energy management – – Goals of green energy management – **Golden rule of green energy technology** – (Environmental – Social – Governance)- Clean Energy vs Renewable Energy**. Major sources of renewable energy-c**lassification and application. Energy Storage Breakthroughs (**8 hours)**

Module -III

Sustainable Energies: – Solar Power- Types of solar cells- PV cell construction-working- challenges- Solar Power Advancements- Smart Grid Integration: Wind energy – Wind Power Revolution- Construction and monitoring and challenges.

safety in wind farms, wind energy conservation, wind mill components. Wave energy **(**using ocean waves to generate electricity**).** Geothermal Energy: Geothermal Power Plants and Geothermal Heat Pumps: Use the stable temperatures underground to heat and cool buildings. Biomass- biomass feedstocks. **(8 hours)**

Module - IV

Biodiversity and Green technology: Sustainable utilization, Endangered and threatened species. Sustainable utilization of wastes, Biofertilizers, Ecofriendly biopesticides, Bioremediation, Bioaccumulation, bio indicators. Biofuels- Types of biofuels- biodiesel - cellulosic ethanol – methane. Hydrogen as a green energy component**:** Hydrogen production (alkaline and PEM electrolyser, Hydrogen Fuel Cells.)– Storage and Distribution – Challenges and technological importance of Hydrogen. Batteries **(**energy storage is crucial in the transition to renewables**)**-The green batteries for future in India.

(8 hours)

Module -V

Future green technology- Carbon capture and storage (capturing and removing carbon from the atmosphere), LED lighting (ultra-energy-efficient light bulbs) vertical farming (uses less land, less water, and can be set up in cities). **Pollution prevention and remediation:** Types of pollution- Pollution prevention – Pollution risk management- Types of remediation- Carbon Footprints and Carbon Accounting- Sustainable Product Development- Monitoring and Evaluation. Green energy initiatives in India. (**8 hours)**

Text Books:

1. **Textbook of Green Energy Technologies by Kalbande 2018**
2. **Renewable Energy& Green Technology: by Anjan K. Sahoo & Dr. S. P. Nanda-2021**
3. **Green Energy Technologies- Dr. Utkarsh Sharma-2018**

Reference Books:

- **Nanotechnology Applications in Green Energy Systems- Rajan Kumar,**

Scheme

Component	Type of assessment	Max. Marks		Weightage	Total	Total Marks
CIE - Theory	AAT-1	5		10	50*	50 (CIE)
	AAT-2	5				
	Test 1	40	Best of Two test	40		
	Test 2	40				
	Test 3	40				
SEE	End Exam	100		50		50 (SEE)
Grand Total Marks						**100**
*** minimum CIE marks (Theory) ≥ 20.0 to gain eligibility to write the SEE**						

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BMS COLLEGE OF ENGINEERING, BENGALURU-19
Autonomous Institute, Affiliated to VTU

DEPARTMENT OF CHEMISTRY

Course Name	Energy Crisis Management	Course Code	23CY7OEECM
Credits	03	L-T-P-S	3- 0 -0-0
Contact hours	38	Faculty Handling	Dr.Malini.S
Semester	7th Sem (open elective)		

Course Objectives:

- Assess the energy crisis, storage methods and valuability of energy resources across different user segments
- Analyze the strategies of energy saving equipment in energy management
- Apply the knowledge of energy management to effectively drive the engineering processes.

CO	On completion of the course the student will have ability to	PO	Mapping
CO_1	Apply the principles of sustainable reactivity in energy crisis management involving energy storage, audit, modelling and conservation under multidisciplinary situations	PO6	3
CO_2	Analyse the properties, processes and devices used in energy generation, usage and wastage.	PO2	3
CO_3	Analyse the strategies associated with energy conversion, quantification and sustainable usage of energy in engineering processes.	PO7	3

Unit-1

Introduction to energy crisis management **(06 hrs)**

Introduction to energy – Laws of energy, Forms, sources and conservation of energy, energy efficiency, relationship between energy conservation and energy efficiency, energy consumption in various sectors, role of energy in economic development and social transformation.

Energy management – Principles, objectives, benefits, phases and components of energy crisis management programme in an organization.

Energy crisis scenario – Global and Indian energy scenario, Commercial and non-commercial energy, energy consumption.

Energy policies and treaties – Indian energy conservation act, Indian electricity act. International Energy Treaties - Montreal energy treaty on Ozone depletion, Kyoto energy treaty on greenhouse gases, Rio energy treaty on climatic change.

Unit-2

Energy saving equipment **(08 hrs)**

Solar Energy equipment – Design of photovoltaic cell (Off & On Grid), Measurement of solar radiations - Global Horizontal Irradiance, Construction and working of pyranometer, Solar collectors (flat plate, cylindrical parabolic, solar ponds), Solar energy storage system characteristics and capacity. Stand alone, hybrid and grid connected system, Advantages and disadvantages.

Wind Energy equipment – Components of wind mill, working principle, classification (based on propeller blade, capacity, location & usage, turbine speed), wind power, factors affecting wind power, wind-power curve, wind power conversion efficiency, site selection, Advantages and disadvantages of wind turbines.

Tidal energy equipment – Construction and working of tidal power plant (single and double basin), Advantages and disadvantages of tidal power plant.

Geothermal energy equipment – Structure of Geothermal power plants (Hydrothermal, Geopressured, Petrothermal), Factors affecting geothermal power plants, Advantages and disadvantages.

Unit-3

Energy efficient storage technology **(08 hrs)**

Thermal energy storage **–** Definition, Classification (sensible, latent, thermochemical), Construction and working of Aquifer and Rock-bed storage, advantages and limitations.

Electrical Energy storage **-** Super-capacitors, construction, working, classification, similarities and differences between supercapacitors and batteries, advantages and limitations.

Magnetic Energy Storage - Theory of Superconductivity, superconducting systems, classification, charging methodologies, Meissner effect, Cycling and performance, advantages and limitations.

Unit-4

Energy Generation from Waste **(08 hrs)**

Bio-chemical conversion **-** Municipal Solid waste to electricity, Agro residue to Biogas, Classification, construction, working of biogas plant, Advantages and limitations.

Thermo-chemical conversion **-** Gasification of Biomass, factors affecting gasification, Fluidized bed Gasifiers, Biomass briquetting, advantages and limitations.

Bio-electro-chemical conversion **–** Microbial fuel cells, Principle, Classification, construction, working and applications, advantages and limitations.

Unit-5

Energy audit and Modeling **(08 hrs)**

Energy Audit – Importance, objectives and outcomes, types of energy audit, energy audit procedures, Energy optimization methodologies (short, medium, long term), Energy index and Cost index, Numerical, energy audit instruments (classification, functioning and examples), energy managers (role and responsibilities).

Energy modelling – Interdependence of energy-economy-environment, energy demand analysis, energy forecasting, Sectoral energy demand forecasting, Interfuel substitution model and I-O model for energy analysis.

Text Books

1. Energy engineering and management, Amlan Chakrabarthi, 2nd edition, 2019, PHI learning private limited, New Delhi-110092
2. Energy and environment engineering, S. N. Sapali, Dr. M. R. Gidde, 2nd edition, 2021, Nirali Prakashan Publishers, Pune 411005

Reference Book

1. Handbook of energy engineering, Albert Thumann, D. Paul Mehta, 8th edition, 2021, River publishers, Denmark
2. Handbook of Energy Audits, Albert Thumann, Terry Niehus, William J. Younger, 9th edition, 2012, River publishers, Denmark
3. Energy Management and Conservation, K.V. Sharma, P. Venkataseshaiah, IK. International, Publishing House, 2011

e-books

1. Energy Engineering, B. L. Singhal, Tecknowledge Publication, 2022. https://campusfunda.com/Book/book-view/NDA5MA
2. Advanced Energy Engineering, S.Ramachandra and R.Devaraj, Airwalk Publications,
3. 1st edition – 2019, Kindle Edition 2020, https://www.amazon.in/Advanced-Energy-Engineering

Scheme

Component	Type of assessment	Max. Marks		Weightage	Total	Total Marks
CIE - Theory	Quiz 1	10		10	50*	50 (CIE)
	Quiz 2	10				
	Test 1	40	Best of Two test	40		
	Test 2	40				
	Test 3	40				
SEE	End Exam	100		50		50 (SEE)
Grand Total Marks						**100**
*** minimum CIE marks (Theory) ≥ 20.0 to gain eligibility to write the SEE**						

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B.M.S. COLLEGE OF ENGINEERING, BANGALORE
Autonomous Institute, Affiliated to VTU

DEPARTMENT OF CHEMISTRY

Course Name	**Nano and Smart Materials for Engineering Applications**	**Course Code**	**25CY7OENSE**
Credits	**03**	**L-T-P-S**	**3- 0 -0-0**
Contact hours	**38**	**Faculty Handling**	**Dr. K. L. Nagashree** **Dr. S. Manjunatha** **(2 sections)**
Semester	**7th sem (open elective)**		

Course Outcomes:

CO NO.	*AT THE END OF THE COURSE THE STUDENT WILL HAVE ABILITY TO*	PO	STRENGTH
CO1	Apply various techniques to synthesize and characterize nano and smart materials.	1	3
CO2	Apply the knowledge of nano and smart materials in engineering applications.	1	3
CO3	Implement sustainable solutions through nano and smart materials in the field of energy and environment.	6,11	2

Unit-I

INTRODUCTION **8 Hrs**

Nanomaterials: Definition, historical perspective, scope and interdisciplinary nature of nanoscience and nanotechnology. Quantum effects in nanomaterials. Size dependent properties and classification.
Smart materials: Definition, need and classification, features of smart systems, traditional vs. smart systems. Applications of nano and smart materials, smart materials in nanoscience and technology.

Unit-II

SYNTHESIS OF NANO AND SMART MATERIALS **8 Hrs**

Nano materials: Top down and bottom-up approaches, sol gel, co-precipitation, vapour deposition, combustion and hydrothermal methods. Advantages and disadvantages.

Smart materials: Hydrothermal, emulsion polymerization, atom transfer radical polymerization and chemical oxidative polymerization. Advantages and disadvantages.

Unit-III

CHARACTERIZATION **8 Hrs**

XRD-X-ray powder diffraction, **SEM**-Scanning electron microscopy, EDAX, **TEM**-Transmission electron microscopy, **BET**-Surface area analysis, UV-Visible spectroscopy, **AFM**-Atomic force microscopy, rheological characterization.

Unit-IV

APPLICATIONS OF NANOMATERIALS **7 Hrs**

Energy conversion and storage, automobile industry, Biomedical Science, Biotechnology, Electronics and communication, Pharmacy, Environmental sciences, Sport sector, Agriculture, Food, Cosmetics, Military.

Unit-V

APPLICATIONS OF SMART MATERIALS **7 Hrs**

Sensors and actuators, bio-medical applications, aerospace applications, construction and architecture, energy and robotics, textile industry, automobile industry, catalysis (chemical industry), optical devices, packaging industry.

Text book:

C. N. R. Rao, A. Muller, A. K. Cheetham, "*The Chemistry of Nanomaterials Synthesis, Properties and Applications*" John Willey & Sons 2004.

References:

1. Charles P.Poole Jr., "*Introduction to Nanotechnology*", John Willey & Sons , 2003.
2. T. Pradeep "*NANO-The Essential, understanding Nanoscience and Nanotechnology".* Tata McGraw-Hill, 2007.
3. Robert W Kelsall, Ian W Hamley, Mark Geoghegan, "*Nano scale Science and Technology*" John-Wiley, 2005.
4. Dr. Sandeep Singh Kharb and Dr. Manish Jindal, "*Introduction To Smart Materials*", Abhishek publications, 2024.
5. https://nptel.ac.in/courses/112104173.
6. https://nptel.ac.in/courses/118104008.

Scheme

<table>
<tr><th>Component</th><th>Type of assessment</th><th colspan="2">Max. Marks</th><th>Weightage</th><th>Total</th><th>Total Marks</th></tr>
<tr><td rowspan="5">CIE - Theory</td><td>Quiz 1</td><td colspan="2">10</td><td rowspan="2">10</td><td rowspan="5">50*</td><td rowspan="5">50 (CIE)</td></tr>
<tr><td>Quiz 2</td><td colspan="2">10</td></tr>
<tr><td>Test 1</td><td>40</td><td rowspan="3">Best of Two test</td><td rowspan="3">40</td></tr>
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<tr><td>SEE</td><td>End Exam</td><td colspan="2">100</td><td>50</td><td></td><td>50 (SEE)</td></tr>
<tr><td colspan="6">Grand Total Marks</td><td>100</td></tr>
<tr><td colspan="7">* minimum CIE marks (Theory) ≥ 20.0 to gain eligibility to write the SEE</td></tr>
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