MAHATMA GANDHI UNIVERSITY

Kottayam, Kerala

Undergraduate Programmes (HONOURS)
2024 Admission Onwards

SYLLABUS						
SIGNATURE COURSE						
Name of the College	B.C.M. College, Kottayam					
Faculty/ Discipline	Chemistry					
Programme	BSc (Hons) Chemistry					
Course Coordinator	Dr. Mamatha Susan Punnoose					
Contributors	Dr. Mamatha Susan Punnoose					
Course Name	Introduction to Nanomaterials					
Type of Course	DSE					
Specialization title	Principles and Applications of Nanoscience					
Course Code	To be prepared by the University					
Course Level	200					
Course Summary	This course provides a foundational understanding of nanomaterials, including their historical background, classification, unique properties, and synthetic methodologies. Emphasis is placed on both chemical and physical methods of synthesis, as well as the principles of green chemistry applied to nanomaterials.					
Semester	3	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		4				60
Pre-requisites, if any						

Course Outcomes (CO)

Number of COs		**6**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Understand the historical development and significance of nanomaterials	U	PO1, PO2, PO3
2	Explain the classification of nanomaterials based on their dimensional structures	E	PO1, PO2, PO3
3	Evaluate the unique properties of nanomaterials compared to bulk materials	E	PO1, PO2
4	Describe and analyse various chemical and physical methods for synthesizing nanomaterials	AN	PO1, PO2, PO3, PO10
5	Discuss and apply the principles of green chemistry to the synthesis of nanomaterials	A	PO1, PO6, PO7, PO10
6	To understand the applications of nanomaterials in daily life	U	PO6, PO7

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2	2	3	-	-	-	-	-	-	-
CO 2	2	2	2	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-
CO 4	3	3	3	-	-	-	-	-	-	1
CO 5	3	-	-	-	-	3	3	-	-	1
CO 6	-	-	-	-	-	2	2	-	-	-

'0' is No Correlation, '1' is Slight Correlation (Low level), '2' is Moderate Correlation (Medium level) and '3' is Substantial Correlation (High level).

Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Introduction and properties of nanomaterials			
	1.1	Historical background and significance of nanomaterials	2	["1"]
	1.2	Overview and definition of nanomaterials, Richard Feynman's hypothesis	3	["1"]
	1.3	Classifications and Types of Nanomaterials- 1D,2D,3D	4	["2"]
	1.4	Unique Properties of Nanomaterials- metal and metal oxide nanomaterials, concept of bulk versus nanomaterials, size and shape dependent properties, quantum effect, surface area to volume ratio and reactivity.	10	["3"]
2	Synthetic Methodologies of Nanomaterials			
	2.1	Top-Down Approaches: Definition, advantages, and limitations	4	["4"]
	2.2	Bottom-Up Approaches: Definition, advantages, and limitations	4	["4"]
	2.3	Chemical Synthesis Methods- Sol-Gel Method, Hydrothermal Synthesis, micro emulsion technique, chemical reduction, chemical vapor deposition, physical vapor deposition.	10	["4"]
3	Nanomaterial synthesis-Physical & Green strategies			
	3.1	Physical Methods of Nanomaterial Synthesis- mechanical milling, laser ablation, sputtering, arc-discharge method, photolysis, radiolysis, microwave and ultrasound assisted synthesis	8	["4"]
	3.2	Green Chemistry and Nanomaterials- Definition and overview of green chemistry, atom economy, twelve principles of green chemistry, concept of green solvents	6	["5"]

Module	Units	Course Description	Hrs	CO No.
4	Applications of nanomaterials			
	4.1	Nanomaterials in electronics and energy : sensors, solar cells, batteries, supercapacitors	3	["6"]
	4.2	Nanomaterials in medicine and health care : drug delivery systems, cancer therapy and antibacterial coatings	3	["6"]
	4.3	Synthesis of metal oxide nanoparticles (ZnO, CuO) by chemical route (any one method)	3	["6"]

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture involving chalk & board method, multimedia presentation, group discussion, peer teaching, hands on experiment

Assessment Types	**MODE OF ASSESSMENT** Mode of Assessment: Theory **A. Continuous Comprehensive Assessment (CCA)** **• Theory – 30 Marks** Assignments , MCQ, Viva, Involvement in classroom activities, Experiential learning **B. End Semester Evaluation (ESE)** **• Theory – 70 Marks** Assessment Methods – Written examination Duration of Examination – 2.00 Hrs Pattern of examination for Theory – Non-MCQ Different parts of written examination – Part - A , B , C Answer Type: ∘ PART - A ∘ MCQ - (10 out of 10) – 10 × 1 = 10 ∘ PART - B ∘ Short answer - (6 out of 9) – 6 × 5 = 30 ∘ PART - C ∘ Short Essays - (2 out of 4) – 2 × 15 = 30

References

- 1. Pradeep, T. A Textbook of Nanoscience and Nanotechnology. Tata McGraw-Hill Education, 2012. 2. Ahluwalia, V. K. Green Chemistry. Narosa Publishing House, 2011. 3. Shah, M. A., and Tokeer Ahmad. Principles of Nanoscience and Nanotechnology. Narosa Publishing House, 2010. 4. Cao, Guozhong, and Ying Wang. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications. World Scientific Publishing, 2011. 5. Vollath, Dieter. Nanomaterials: An Introduction to Synthesis, Properties and Applications. John Wiley & Sons, 2013. 6. Kulkarni, Sulabha K., and Jayant K. Kulkarni. Nanotechnology: Principles and Practices. Springer, 2014. 7.Rao, C. N. R., Achim Müller, and Anthony K. Cheetham. The Chemistry of Nanomaterials: Synthesis, Properties and Applications. Wiley-VCH, 2004.

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successful implementation of the specialization, for as long as the college offers this programme.

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SYLLABUS						
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Faculty/ Discipline	Chemistry					
Programme	BSc (Hons) Chemistry					
Course Coordinator	Dr. Mamatha Susan Punnoose					
Contributors	Dr. Sr. Remya Simon, Ms. Ann Maria Binoy					
Course Name	Characterization techniques for Nanomaterials					
Type of Course	DSE					
Specialization title	Principles and Applications of Nanoscience					
Course Code	To be prepared by the University					
Course Level	200					
Course Summary	This course explores the principles and methodologies involved in the characterization and assessment of nanomaterials, with a specific focus on their biosafety implications. Students will gain an understanding of advanced characterization techniques and the regulatory frameworks governing nanomaterial applications in biological and environmental contexts.					
Semester	4	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		4				60
Pre-requisites, if any						

Course Outcomes (CO)

Number of COs		**5**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Understand the principles underlying UV-Visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR)	U	PO1, PO2
2	Apply spectroscopic techniques to analyze nanoparticles using Raman spectroscopy and X-ray Diffraction spectroscopy	AN	PO1, PO2, PO3
3	Understand and analyse the principles of Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM)	AN	PO1, PO2, PO3
4	Characterization of zinc oxide, copper oxide, silver, and gold nanoparticles using electron microscopic techniques	S	PO1, PO2, PO3
5	To understand the principles of Nanotoxicology	AN	PO1, PO6, PO7

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	2	-	-	-	-	-	-	-	-
CO 2	3	2	2	-	-	-	-	-	-	-
CO 3	3	2	2	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	-	-	-	-	-
CO 5	1	-	-	-	-	2	3	-	-	-

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Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Spectral Characterization Techniques			
	1.1	Principles of UV-Visible spectroscopy	4	["1"]
	1.2	Principles of Fourier Transform Infrared Spectroscopy (FTIR)	5	["1"]
	1.3	Principles of Raman spectroscopy	4	["2"]
	1.4	Principles of X-ray Diffraction spectroscopy	4	["2"]
2	Electron Microscopic Techniques-I			
	2.1	Introduction and Principles of Electron Microscopic techniques	4	["3"]
	2.2	Principles of Scanning Electron Microscopy (SEM)	5	["3"]
	2.3	Instrumentation of SEM	5	["3"]
3	Electron Microscopic Techniques -II			
	3.1	Using electron microscopic techniques–Scanning Electron Microscopy (SEM)	6	["3"]
	3.2	Principles of Tunneling Electron Microscopy (TEM)	5	["3"]
	3.3	Characterization of zinc oxide, copper oxide, silver and gold nanoparticles.	6	["4"]
4	Nanotoxicology and Biosafety of Nanomaterials			
	4.1	Mechanisms of nanomaterial toxicity- In vitro toxicity assays, Cell viability assays, Genotoxicity assays.	4	["5"]
	4.2	Inflammatory Response- Understanding and measuring the inflammatory effects of nanomaterials in living organisms.	4	["5"]
	4.3	Analyze UV spectrum of nanomaterials.	4	["5"]

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture involving chalk & board method, multimedia presentation, group discussion, peer teaching, hands on training

Assessment Types	**MODE OF ASSESSMENT** Mode of Assessment: Theory **A. Continuous Comprehensive Assessment (CCA)** **• Theory – 30 Marks** Assignments, MCQ, Viva, Involvement in classroom activities, Experiential learning **B. End Semester Evaluation (ESE)** **• Theory – 70 Marks** Assessment Methods – Written examination Duration of Examination – 2.00 Hrs Pattern of examination for Theory – Non-MCQ Different parts of written examination – Part - A , B , C Answer Type: ◦ PART - A ◦ MCQ - (10 out of 10) – 10 × 1 = 10 ◦ PART - B ◦ Short answer - (6 out of 9) – 6 × 5 = 30 ◦ PART - C ◦ Short Essays - (2 out of 4) – 2 × 15 = 30

References

- 1. Zhao, Yuliang, Guibin Jiang, and Jun-Jie Zhu. Characterization of Nanomaterials: Advances and Key Technologies. Springer, 2016. 2. Edelstein, A. S., and R. C. Cammarata. Nanomaterials: Synthesis, Properties, and Applications. CRC Press, 2001. 3. Kumar, Narendra, and Yashwant Pathak. Nanotoxicology: Materials, Methodologies, and Assessments. CRC Press, 2017. 4. Sahu, Saura C., and Daniel A. Casciano. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. John Wiley & Sons, 2014. 5. Wiesner, Mark R., and Jean-Yves Bottero. Environmental Nanotechnology: Applications and Impacts of Nanomaterials. McGraw-Hill Education, 2007.

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SYLLABUS						
SIGNATURE COURSE						
Name of the College	B.C.M. College, Kottayam					
Faculty/ Discipline	Chemistry					
Programme	BSc (Hons) Chemistry					
Course Coordinator	Dr. Mamatha Susan Punnoose					
Contributors	Dr. Sr. Remya Simon, Ms. Ann Maria Binoy					
Course Name	Applications of Nanostructures in Nanomedicine and Agriculture					
Type of Course	DSE					
Specialization title	Principles and Applications of Nanoscience					
Course Code	To be prepared by the University					
Course Level	300					
Course Summary	This course explores the cutting-edge applications of nanostructures in the fields of nanomedicine and agriculture. Students will gain insights into how nanotechnology is revolutionizing medical treatments and agricultural practices, focusing on both theoretical concepts and practical applications.					
Semester	5	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		4				60
Pre-requisites, if any						

Course Outcomes (CO)

Number of COs		**5**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Understand the principles underlying in the drug delivery systems and drug targeting strategies	U	PO1, PO2, PO3
2	Understand and analyse the role of quantum dots and nanoparticles in diagnostics and imaging	AN	PO1, PO2, PO3
3	Understand and analyse the role of nanoparticles in cancer therapy and regenerative medicine	AN	PO1, PO2
4	To understand and analyse the role of nano-pesticides and nanofertilizers in enhancing the crop productivity	AN	PO1, PO2, PO3, PO7
5	To understand and evaluate the soil properties and parameters for ensuring soil quality	E	PO1, PO7, PO10

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2	1	2	-	-	-	-	-	-	-
CO 2	3	2	1	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-
CO 4	2	3	2	-	-	-	2	-	-	-
CO 5	3	-	-	-	-	-	2	-	-	2

'0' is No Correlation, '1' is Slight Correlation (Low level), '2' is Moderate Correlation (Medium level) and '3' is Substantial Correlation (High level).

Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Drug delivery systems			
	1.1	Basics of drug delivery, Introduction about drug delivery systems	3	["1"]
	1.2	Polymer and metal based drug delivery systems	4	["1"]
	1.3	Drug targeting strategies for site specific drug delivery-passive and active targeting Time and rate controlled drug delivery	3	["2"]
2	Diagnostics and imaging			
	2.1	Quantum dots and magnetic nanoparticles for imaging, Biosensors and lab-on-a-chip technologies	5	["3"]
	2.2	Biosensors and lab-on-a-chip technologies, Early disease detection and personalized medicine	5	["3"]
	2.3	Nanoparticles in cancer therapy (photothermal therapy, chemotherapy	4	["4"]
3	Applications of Nanostructures in Agriculture			
	3.1	Definition and scope of nanotechnology in agriculture,properties of nanomaterials relevant to agriculture (size, surface area, reactivity)	6	["4"]
	3.2	Concept and advantages over conventional fertilizers, Types: macro- and micronutrient nano-fertilizers, Mechanisms of nutrient release and plant uptake, Case studies and field trials using nano-fertilizers	7	["4"]
	3.3	Controlled delivery and targeted action, Reduced environmental impact and improved efficacy, Formulation techniques and application methods Safety, regulation, and toxicity concerns	8	["4"]
4	Nanostructures in Plant Disease Management			
	4.1	Nano-based diagnostics: biosensors for early disease detection, Antimicrobial nanomaterials (e.g., silver, zinc oxide)	5	["5"]
	4.2	Nano-encapsulation for controlled release of agrochemicals, Nano-enabled vaccines and immunity boosters for plants	5	["5"]
	4.3	Current research trends in nano-agriculture, Preparation of nano-formulations for pesticides and fertilizers	5	["5"]

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture involving chalk & board method, multimedia presentation, group discussion, peer teaching, experimental demonstrations and practical training in laboratory

Assessment Types	**MODE OF ASSESSMENT** Mode of Assessment: Theory **A. Continuous Comprehensive Assessment (CCA)** **• Theory – 30 Marks** Assignments, MCQ, Viva, Involvement in classroom activities, Experiential learning **B. End Semester Evaluation (ESE)** **• Theory – 70 Marks** Assessment Methods – Written examination Duration of Examination – 2.00 Hrs Pattern of examination for Theory – Non-MCQ Different parts of written examination – Part - A , B , C Answer Type: ◦ PART - A ◦ MCQ - (10 out of 10) – 10 × 1 = 10 ◦ PART - B ◦ Short answer - (6 out of 9) – 6 × 5 = 30 ◦ PART - C ◦ Short Essays - (2 out of 4) – 2 × 15 = 30

References

- 1.Sankar, V., and S. Ramesh. Textbook of Novel Drug Delivery Systems. BSP Books, 2022. 2.Chanda, Ranabir, Jyotirmoy, and Alugubelli Gopi Reddy. Textbook of Novel Drug Delivery System. AITBS Publishers, 2022. 3.Rockall, Andrea G., Andrew Hatrick, Peter Armstrong, and Martin Wastie. Diagnostic Imaging. John Wiley & Sons, 2013. 4.Putman, Chas, and Carl Ravin. Textbook of Diagnostic Imaging. 2nd ed., W.B. Saunders, 1994. 5.Cox, Joseph Frank. Crop Production and Soil Management. J. Wiley & Sons, Incorporated, 1925. 6.Bimbraw, Avtar Singh. Established and Emerging Practices for Soil and Crop Productivity. 1st ed., Kindle Edition, 2021. 7.Jayanthi, C. Text Book on Agronomic Management of Soil Productivity. Narendra Publishing House, 2019.

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Name of the College	B.C.M. College, Kottayam					
Faculty/ Discipline	Chemistry					
Programme	BSc (Hons) Chemistry					
Course Coordinator	Dr. Mamatha Susan Punnoose					
Contributors	Dr. Mamatha Susan Punnoose					
Course Name	Nanomaterials for Sustainable Energy					
Type of Course	DSE					
Specialization title	Principles and Applications of Nanoscience					
Course Code	To be prepared by the University					
Course Level	300					
Course Summary	This course explores the role of nanomaterials in advancing sustainable energy technologies. It covers the synthesis, properties, and applications of nanostructured materials in key areas such as solar energy conversion, energy storage, fuel cells, and hydrogen production. Emphasis is placed on the design principles and mechanisms by which nanomaterials enhance efficiency, reduce costs, and improve environmental compatibility in energy systems.					
Semester	6	**Credits**			4	**Total Hours**
Course Details	**Learning Approach**	Lecture	Tutorial	Practical	Others	
		4				60
Pre-requisites, if any						

Course Outcomes (CO)

Number of COs		**6**	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Demonstrate an understanding of the principles and significance of energy conversion processes, including indirect and direct energy conversion, and the application of nanoscale catalysts to improve energy efficiency and industrial productivity	U	PO1, PO2, PO3
2	Analyze the photovoltaic principles underlying solar energy generation and evaluate the role of nanomaterials in enhancing the efficiency and performance of solar power systems, including dye-sensitized solar cells, perovskite solar cells, quantum dot solar cells, and light-emitting diodes	AN	PO1, PO2
3	Understand the various methods of hydrogen production, including those from fossil fuels, photochemical, thermal decomposition, and electrolysis methods, and evaluate the use of nanomaterials in optimizing hydrogen storage capacity and methods.	U	PO1, PO2, PO3, PO7

Number of COs		6	
CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
4	Explain the principles, construction, and applications of different types of electrochemical energy storage devices, such as primary and secondary batteries, lithium batteries, lead-acid batteries, and nickel-cadmium batteries, with a focus on the integration of nanomaterials to enhance their performance.	E	PO1, PO7, PO10
5	Evaluate the role and impact of advanced nanomaterials, including nano-electrochemical systems, in the development and enhancement of rechargeable batteries and fuel cells, as well as the use of carbon materials like graphene, graphene oxide, reduced graphene oxide, fullerene, and carbon nanotubes for efficient energy storage.	E	PO1, PO2
6	Apply the knowledge of nanomaterials and their applications in sustainable energy solutions, emphasizing the improvement of energy storage and conversion efficiency, as well as the reduction of environmental impact through innovative use of advanced nanomaterials in various energy systems.	A	PO1, PO6, PO7

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

CO-PO Articulation Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	2	3	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-
CO 3	2	2	2	-	-	-	1	-	-	-
CO 4	2	-	-	-	-	-	1	-	-	1
CO 5	2	2	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	2	1	-	-	-

'0' is No Correlation, '1' is Slight Correlation (Low level), '2' is Moderate Correlation (Medium level) and '3' is Substantial Correlation (High level).

Course Content

Content for Classroom transaction (Units)

Module	Units	Course Description	Hrs	CO No.
1	Nanomaterials for sustainable energy			
	1.1	Energy conversion process, indirect and direct energy conversion	4	["1"]
	1.2	Application of nanoscale catalysts to improve energy efficiency and industrial productivity	4	["1"]
	1.3	Nanomaterials for energy generation-Photovoltaic principles	4	["2"]
	1.4	Nanomaterials for solar power- solar energy materials and devices	4	["2"]
2	Nanomaterials for energy storage			
	2.1	Hydrogen energy, hydrogen energy production by fossil fuels, photochemical, thermal decomposition and electrolysis methods	5	["3"]
	2.2	Hydrogen storage- Hydrogen storage capacity and factors affecting hydrogen storage	4	["3"]
	2.3	Storage Methods and Materials- metal hydrides, metallic alloy hydrides and carbon nanotubes, capacitors, fuel cells	5	["3"]

Module	Units	Course Description	Hrs	CO No.
3	Electrochemical energy storage devices			
	3.1	Batteries - Primary and secondary, lithium batteries, lead acid batteries, nickel cadmium batteries	5	["4"]
	3.2	Nano-electrochemical systems, integration of Nanotechnology in Electrochemical Devices	5	["4"]
	3.3	Nanomaterials for rechargeable batteries and fuel cells	3	["4"]
4	Advanced Carbon Nanomaterials for Energy Storage			
	4.1	Structural, electrical, and electrochemical properties of graphene, graphene oxide (GO) and reduced graphene oxide (rGO)	6	["5"]
	4.2	Fullerene, Carbon Nanotubes- single walled and multi- walled, and other carbon Allotropes for Advanced Energy Storage Applications	6	["5"]
	4.3	Fabrication of a Low-Cost Supercapacitor Using Activated carbon Electrodes	5	["6"]

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture involving chalk & board method, multimedia presentation, group discussion, peer teaching, experimental demonstrations

Assessment Types	**MODE OF ASSESSMENT** Mode of Assessment: Theory **A. Continuous Comprehensive Assessment (CCA)** **• Theory – 30 Marks** Assignments, MCQ, Viva, Involvement in classroom activities, Experiential learning **B. End Semester Evaluation (ESE)** **• Theory – 70 Marks** Assessment Methods – Written examinations Duration of Examination – 2.00 Hrs Pattern of examination for Theory – Non-MCQ Different parts of written examination – Part - A , B , C Answer Type: ◦ PART - A ◦ MCQ - (10 out of 10) – 10 × 1 = 10 ◦ PART - B ◦ Short answer - (6 out of 9) – 6 × 5 = 30 ◦ PART - C ◦ Short Essays - (2 out of 4) – 2 × 15 = 30

References

- 1.Mahmoud, Sawsan A., and Basma S. Mohamed. "Solar Energy Conversion and Storage: Rose Bengal-Triton X-100 by Photogalvanic Cell." Journal of Energy Technologies and Policy, vol. 5, no. 12, 2015 2.Kadambi, V., and Manohar Prasad. An Introduction to Energy Conversion. Volume 2. New Age International, 2004. 3.Viswanathan, Balasubramanian. Energy Sources: Fundamentals of Chemical Conversion Processes and Applications. Elsevier, 2016. 4.Capareda, Sergio. Introduction to Biomass Energy Conversions. CRC Press, 2023. 5.Gould, I. "Energy and the Environment." Electron Transfer in Chemistry, vol. 5, Wiley-VCH, 2001, pp. 589–644. 6.Jain, Abhilasha, and Dipti Vaya. "Photocatalytic Activity of TiO_2 Nanomaterial." Journal of the Chilean Chemical Society, vol. 62, no. 4.. 2017.

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