Applied Chemistry for Emerging Electronics and Futuristic Devices		Semester	I/II
Course Code	**1BCHEE102/202**	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy (Theory and Lab hours)	64	Total Marks	100
Credits	04	Exam Hours	03
Examination type (SEE)	Descriptive		

Course outcome (Course Skill Set)

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

CO1: Understand and analyze the properties, classification and applications of semiconductor materials, energy storage and conversion devices.

CO2: Demonstrate knowledge of nanomaterials and quantum dots including their synthesis, properties, and device applications.

CO3: Explain the role of functional polymers and composites in flexible electronic applications.

CO4: Apply experimental skills and electrochemical concepts to sensor systems and evaluate corrosion control and e-waste management techniques.

Module-1 Materials for Energy Devices

Semiconductors: Introduction, n-type and p-type semiconductor materials (organic and inorganic), difference between organic and inorganic semiconductors. Organic photovoltaics - working principle and applications of Poly (3-hexylthiophene) (P3HT) as a donor and Phenyl-C61-butyric acid methyl ester (PCBM) as an acceptor.

Energy Storage Devices: Introduction, classification of batteries-primary, secondary and reserve battery, characteristics - capacity, power density, shelf life & cycle life. Construction and working of lithium-ion battery and its advantages in EV applications. Construction and working of ultra-small asymmetric super capacitor and its applications in IoT/wearable devices.

Energy Conversion Devices: Introduction, construction, working principal, advantages and limitations of solar photovoltaic cell (PV cell). Working principle and applications of Micro-electromechanical systems (MEMS)-based energy harvesters.

Number of Hours**: 08**

Module-2 Nano and Quantum Dot Materials

Nano materials: Introduction, size dependent properties of nanomaterials - surface area, catalytic, optical properties and electrical conductivity. Synthesis of TiO_2 nanoparticles by sol-gel method and its uses in sensor applications.

Quantum Dot Materials: Introduction, types, optical and electronic properties of quantum dots (QDs).

Inorganic Quantum Dot Materials (IQDMs): Introduction, synthesis and properties of silicon based QDs by sol gel method and Cd-Se Quantum Dots by hot injection method and applications in optoelectronic devices.

Organic Quantum Dot Materials (OQDMs): Introduction, synthesis and properties of chitosan-carbon quantum dots hydrogel and its applications in next-generation flexible and wearable electronics. Synthesis and properties of Graphene Quantum Dots using citric acid method and its applications in emerging electronics.

Number of Hours**: 08**

Module-3 Functional Polymers and Hybrid Composites in Flexible Electronics
Stretchable and Wearable Microelectronics: Introduction, basic principle and working of lithography for micro-patterned copper deposition**.** Synthesis, properties and applications of PDMS (Polydimethylsiloxane) and its uses in e-skin (electronic skin) and RFID applications. **Polymers:** Introduction, synthesis, conduction mechanism of polyaniline and its electronic devices applications. Molecular weight of polymers: Number average and weight average molecular weight of polymers-numerical problems. Synthesis and properties of Polyvinylidene Fluoride (PVDF) and its applications in E-nose devices. **Polymer Composites:** Introduction, synthesis and properties of epoxy resin-magnetite (Fe_3O_4) composite (ultrasonication method) for sensors applications. Synthesis and properties of Kevlar Fiber Reinforced Polymer (KFRP) for smart electronic devices applications. Number of Hours: **08**
Module-4 Electrode System and Electrochemical Sensors
Electrode System: Introduction, types of electrodes, overview of Nernst equation, reference electrode-construction, working and applications of calomel electrode. Ion selective electrode- definition, construction, working of glass electrode, determination of pH using glass electrode. Construction and working of concentration cell and numerical. **Sensing Methods:** Introduction, principle and instrumentation of colorimetric sensors; its application in the estimation of copper in PCBs. Principle and instrumentation of potentiometric sensors and its application in the estimation of iron in steel, conductometric sensors; its application in the estimation of acid mixture in the sample. Number of Hours: **08**
Module-5 Corrosion Science and E-waste Management
Corrosion Chemistry: Introduction, electrochemical theory of corrosion, types of corrosion, differential metal corrosion in electronic circuits and differential aeration corrosion-waterline and pitting corrosion. Corrosion control- galvanization, anodization, cathodic protection and impressed current method. Corrosion penetration rate (CPR) - definition, importance and weight loss method-numerical problems. **Metal Finishing:** Introduction, technological importance of metal finishing, difference between electroplating & electroless plating, electroplating of chromium for hard and decorative coatings, electroless plating of copper on PCBs. **E-waste:** Introduction, sources of e-waste, need of e-waste management & effects of e-waste on environment and human health. Extraction of gold from e-waste from bioleaching method. Number of Hours: **08**
PRACTICAL COMPONENTS OF IPCC
LIST OF EXPERIMENTS
1. Estimation of total hardness of water by EDTA method. 2. Determination of chemical oxygen demand (COD) of industrial effluent sample. 3. Estimation of iron in TMT bar by diphenyl amine indicator method. 4. Determination of total alkalinity of given water sample. 5. Determination of Hydrogen Peroxide in PCB Cleaner (Permanganate method) 6. Estimation of acid mixture by conductometric sensor (Conductometry) 7. Estimation of iron in rust sample by Potentiometric sensor (Potentiometry) 8. Determination of pKa of vinegar using pH sensor (Glass electrode) 9. Estimation of copper present in e-waste by optical sensor (Colorimetry).

10. Determination of Viscosity coefficient of conductive Inks 11. Smartphone-Based colorimetric estimation of total phenolic content in coffee products. 12. Green synthesis of copper nanoparticles for conductive ink applications.
Suggested Learning Resources: (Text Book/ Reference Book/ Manuals): **Text books:** 1. Engineering Chemistry, Suba Ramesh, Vairam, Ananda Murthy, 2011, Wiley India, ISBN: 9788126519880. 2. A Textbook of Engineering Chemistry, R.V. Gadag and Nityananda Shetty, I. K. International Publishing house. 2nd Edition, 2016. 3. Engineering Chemistry: Jain & Jain, Publisher: Dhanpat Rai Publishing Company, ISBN: 978-935316118.
Reference Books / Manuals:
1. Electrochemical Energy System: Dr. K. K. Rajeshwar (IIT Madras), Publisher: IIT Madras Open Courseware (Free PDF & videos), ISBN: N/A (Open Educational Resource). **2. Advances in Corrosion Science and Technology**, M.G. Fontana, R.W. Staettle, Springer publications, 2012, ISBN: 9781461590620. **3. Engineering Chemistry:** Jain & Jain, **Publisher:** Dhanpat Rai Publishing Company, **ISBN:** 978-9353161181. **4. Smart Materials**: Harvey, James A. Handbook of materials selection, 2002, John Wiley & Sons Canada, Limited, ISBN: 9780471359241. **5. Energy Storage and Conversion Devices;** Supercapacitors, batteries and hydroelectric Cells Editor: Anurag Gaur, 2021, CRC Press, ISBN: 9781000470512.
Web links and Video Lectures (e-Resources): 1. **https://youtu.be/HT21wrGl6oM** 2. **https://youtu.be/aG2F-fd2drM** 3. **https://youtu.be/ivWXuOd5SrI** 4. **https://www.youtube.com/watch?v=BGdCj3-PEoE** 5. **https://www.youtube.com/watch?v=xvtOPHsukzE** 6. **https://www.youtube.com/watch?v=VxMM4g2Sk8U** 7. **https://www.youtube.com/watch?v=0bjRNq1PKak** 8. **https://youtu.be/XIjDw5Sw9c4** 9. **https://youtu.be/lB2zbQvnwXw** 10. **https://youtu.be/FNohb7ZKxMI** 11. **https://www.youtube.com/watch?v=Y-nZbZzBOPg** 12. **https://en.wikipedia.org/wiki/Graphene_quantum_dot** 13. **https://youtu.be/NCOwWEMEQN8** 14. **https://youtu.be/u_2YRTmOTWQ** 15. **https://youtu.be/ygtbo5KDXeI** 16. **https://youtu.be/whyIdJab1kM** 17. **https://youtu.be/3TYH-8pPDV4** 18. **https://youtu.be/xS60SGWSw4s** 19. **https://youtu.be/zJTQLce-WC8** 20. **https://www.youtube.com/watch?v=dmZtRntO1QI** 21. **https://www.youtube.com/watch?v=Kbta_BXZ4Vs&t=73s**
Teaching-Learning Process (Innovative Delivery Methods): The following are sample strategies that educators may adopt to enhance the effectiveness of

the teaching-learning process and facilitate the achievement of course outcomes. 1. Self-Learning using AI Tools 2. Activity Based Learning 3. Models and Working Models 4. Simulations and Interactive Simulations 5. Experiential Learning 6. Flipped Class Learning 7. Hybrid Learning 8. ICT Based Learning
Assessment Structure (IPCC): (Circular-Ref.: VTU/BGM/IPCC 2025/3748, DATED: 24TH Oct 2025) The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each). The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks.** The CIE Theory component consists of IA tests for **25 marks**. The CIE Practical component for continuous assessments will be for **15 marks** through rubrics and for lab Internal Assessment will be conducted for **10 marks** through rubrics. • To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**. • To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25marks**, i.e., **10marks**. • To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**. A student is deemed to have **completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO3, PO4, PO6, PO11)	Demonstrates an in-depth understanding of corrosion mechanisms and expertly applies appropriate surface coating techniques for effective material	Shows clear understanding of corrosion processes and applies relevant surface coating methods with reasonable effectiveness for material	Provides a general understanding of corrosion mechanisms and applies basic surface coating techniques with limited	Displays minimal understanding of corrosion and surface coatings; application is unclear or inappropriate for material protection.	Fails to demonstrate understanding of corrosion or surface coating techniques; no evidence of application in engineering systems.

	protection.	protection.	accuracy.		
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO6, PO11)	Demonstrates a thorough analysis of sustainable chemistry principles and critically evaluates various green energy fuels with strong justification.	Clearly analyses key sustainable chemistry concepts and evaluates green energy fuels with appropriate relevance	Shows a basic understanding of sustainable chemistry and provides a general evaluation of green fuels, but lacks depth.	Demonstrates minimal understanding of sustainable chemistry; evaluation of green fuels is weak.	Fails to analyse sustainable chemistry principles or evaluate green energy fuels.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO11)	Thoroughly examines the synthesis methods and critically evaluates the applications of nanomaterials in advanced energy storage technologies.	Clearly examines common synthesis techniques and explains relevant applications of nanomaterials in energy storage technologies.	Demonstrates a basic understanding of nanomaterial synthesis and mentions general applications in energy storage.	Provides minimal explanation of synthesis, applications and shows limited understanding of nanomaterials in energy storage.	Fails to examine synthesis and application of nanomaterials.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO11)	Effectively applies appropriate functional materials in diverse engineering applications with clear justification.	Correctly applies functional materials in relevant engineering contexts and shows reasonable understanding of their impact.	Shows basic application of functional materials with limited understanding.	Applies functional materials inaccurately and limited connection to performance.	Fails to apply functional materials appropriately and no understanding of their use in engineering.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO3, PO4, PO6, PO11)	Demonstrates an in-depth understanding of corrosion mechanisms and expertly applies appropriate surface coating techniques for effective material protection.	Shows clear understanding of corrosion processes and applies relevant surface coating methods with reasonable effectiveness for material protection.	Provides a general understanding of corrosion mechanisms and applies basic surface coating techniques with limited accuracy.	Displays minimal understanding of corrosion and surface coatings; application is unclear or inappropriate for material protection.	Fails to demonstrate understanding of corrosion or surface coating techniques; no evidence of application in engineering systems.
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO6, PO11)	Demonstrates a thorough analysis of sustainable chemistry	Clearly analyses key sustainable chemistry concepts and evaluates green	Shows a basic understanding of sustainable chemistry and provides a	Demonstrates minimal understanding of sustainable chemistry;	Fails to analyse sustainable chemistry principles or evaluate green

	principles and critically evaluates various green energy fuels with strong justification.	energy fuels with appropriate relevance	general evaluation of green fuels, but lacks depth.	evaluation of green fuels is weak.	energy fuels.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO11)	Thoroughly examines the synthesis methods and critically evaluates the applications of nanomaterials in advanced energy storage technologies.	Clearly examines common synthesis techniques and explains relevant applications of nanomaterials in energy storage technologies.	Demonstrates a basic understanding of nanomaterial synthesis and mentions general applications in energy storage.	Provides minimal explanation of synthesis, applications and shows limited understanding of nanomaterials in energy storage.	Fails to examine synthesis and application of nanomaterials.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO11)	Effectively applies appropriate functional materials in diverse engineering applications with clear justification.	Correctly applies functional materials in relevant engineering contexts and shows reasonable understanding of their impact.	Shows basic application of functional materials with limited understanding.	Applies functional materials inaccurately and limited connection to performance.	Fails to apply functional materials appropriately and no understanding of their use in engineering.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO3, PO4, PO6, PO11)	Demonstrates an in-depth understanding of corrosion mechanisms and expertly applies appropriate surface coating techniques for effective material protection.	Shows clear understanding of corrosion processes and applies relevant surface coating methods with reasonable effectiveness for material protection.	Provides a general understanding of corrosion mechanisms and applies basic surface coating techniques with limited accuracy.	Displays minimal understanding of corrosion and surface coatings; application is unclear or inappropriate for material protection.	Fails to demonstrate understanding of corrosion or surface coating techniques; no evidence of application in engineering systems.
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO6, PO11)	Demonstrates a thorough analysis of sustainable chemistry principles and critically evaluates various green energy fuels with strong	Clearly analyses key sustainable chemistry concepts and evaluates green energy fuels with appropriate relevance	Shows a basic understanding of sustainable chemistry and provides a general evaluation of green fuels, but lacks depth.	Demonstrates minimal understanding of sustainable chemistry; evaluation of green fuels is weak.	Fails to analyse sustainable chemistry principles or evaluate green energy fuels.

	justification.				
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO11)	Thoroughly examines the synthesis methods and critically evaluates the applications of nanomaterials in advanced energy storage technologies.	Clearly examines common synthesis techniques and explains relevant applications of nanomaterials in energy storage technologies.	Demonstrates a basic understanding of nanomaterial synthesis and mentions general applications in energy storage.	Provides minimal explanation of synthesis, applications and shows limited understanding of nanomaterials in energy storage.	Fails to examine synthesis and application of nanomaterials.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO11)	Effectively applies appropriate functional materials in diverse engineering applications with clear justification.	Correctly applies functional materials in relevant engineering contexts and shows reasonable understanding of their impact.	Shows basic application of functional materials with limited understanding.	Applies functional materials inaccurately and limited connection to performance.	Fails to apply functional materials appropriately and no understanding of their use in engineering.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge(2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 and PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best(4)	Student is capable of discussing single design with its merits and de-merits(3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 andPO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation.(3-4)	Student is capable of implementing the design. (1-2)
Result andAnalysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases.(4)	Student will be able to run the code for few cases and analyze the output(3)	Student will be able to run the program but not able to analyze the output(1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion).	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

	Transitions between sections are smooth. (7-8)			

Note: Can add Engineering and IT tool usage based on the nature of the course

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms