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)	**60**	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 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, difference between organic and inorganic semiconductors, organic photovoltaics - Poly (3-hexylthiophene) (P3HT) as a donor and Phenyl-C61-butyric acid methyl ester (PCBM) as a acceptor, construction, working and applications.

Energy Storage Devices: Introduction, classification of batteries-primary, secondary and reserve battery, characteristics (capacity, power density, cell balancing & cycle life), construction and working of lithium-ion battery 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 applications of photovoltaic cell of (PV cell), Introduction to MEMS-Based Energy Harvesters, working principle and applications.

Number of Hours: **08**

Module-2 Nano and Quantum Dot Materials

Nanomaterials: Introduction, size dependent properties of nanomaterials -Surface area, Catalytic and electrical, synthesis of TiO_2 nanoparticles by sol-gel method for 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 CdSe Quantum Dots by hot injection method and applications in optoelectronic devices, Quantum Dot-based copper conductive ink by wet chemical reduction method, properties and applications.

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

Polymers: Introduction, Synthesis, conduction mechanism polyaniline and electronic devices applications, Number average molecular weight and weight average and numerical, synthesis and properties of Polydimethylsiloxane (PDMS) in RFID (Radio Frequency Identification) applications, synthesis and properties of Polyvinylidene Fluoride (PVDF) applications in E-nose devices.

Polymer Composites: Introduction, synthesis and properties of epoxy resin- Fe_3O_4 composite for sensors applications, synthesis of Kevlar Fiber Reinforced Polymer (KFRP)-properties and smart electronic devices applications.

Number of Hours: **08**

Module-4 Electrode System and Electrochemical Sensors

Electrode System: Introduction, types of electrodes, Nernst equation (Preview), 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 numericals.

Sensing Methods: Introduction, principle and instrumentation of colorimetric sensors; its application in the estimation of copper in PCBs, principle and instrumentation of potentiometric sensors; applications in the estimation of iron in steel, conductometric sensors; its application in the estimation of acid mixture in 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, corrosion control-galvanization and anodization, cathodic protection and impressed current method, corrosion penetration rate (CPR)-definition, importance and numerical problems.

Metal Finishing: Introduction, difference between electroplating & electroless plating, electroplating of chromium for hard and decorative coatings, electroless plating of copper on PCBs.

E-waste: Introduction, need of e-waste management, sources & 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
FIXED SET 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 alkalinity of given boiler water sample. **5.** Green synthesis of copper nanoparticles for conductive ink applications. **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.** Smartphone-Based colorimetric estimation of total phenolic content in coffee products. **11**. Data analysis of pka of a week acid and its interpretation using origin software. **12.** Chemical structure drawing using software: Chem Draw/ Chem Sketch.
Suggested Learning Resources: (Text Book/ Reference Book/ Manuals): **Text books:** **1.** Engineering Chemistry, Suba Ramesh, Vairam, Ananda Murthy, 2011, Wiley India, ISBN: 9788126519880. **2.** Engineering chemistry, Shubha Ramesh et.al., Wiley India, 1st Edition, 2011, ISBN: 9788126519880. **3.** Chemistry for Engineering Students by Dr B S Jai Prakash, Prof R Venugopal, Dr Shivakumaraiah.
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. Project-Based Learning (PBL): Students gain knowledge by working on complex, real-world projects over time.

Example: Building prototypes, developing community solutions, research presentations.

2. Flipped Classroom: Students learn theoretical content at home (videos, readings) and engage in problem-solving or discussions in class.

Assessment Structure:

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 30 marks and CIE Practical component will be 20 marks.

The CIE Theory component consists of IA tests for 25 marks and Continuous Comprehensive Assessments (CCA) for 5 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 5 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 30 marks**, i.e., **12 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 20 marks**, i.e., **08 marks**.
- 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 **successfully completed the course** if the **combined total of CIE (and SEE is at least 40 out of 100 marks)**.

Continuous Comprehensive Assessments(CCA): CCA will be conducted for a total of 5 marks. It is recommended to include any one learning activity aimed at enhancing the holistic development of students. This activity should align with course objectives and promote higher-order thinking and application-based learning. Learning Activity -1: (Marks- 5)
CIE Practical component: The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 5 marks. For laboratory test, the student is required to conduct one experiment each from both Part A and Part B.

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, PO11)	Analyze / Clearly explains the deep understanding of material properties and their impact on electronics/IoT performance.	Explains understanding of material properties and their impact on electronics/IoT performance with minimal gaps.	Basic understanding of material properties with limited applications.	Misinterprets material functions or uses incorrect applications.	Fails to explain material properties and their impact on electronics/IoT performance.
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO4, PO11)	Clearly analyzes nanomaterials and quantum dots for innovative applications for electronic systems.	Analyzes nanomaterials and quantum dots with some clarity, identifying relevant applications in electronic systems.	Provides a basic analysis of nanomaterials and quantum dots, with limited connection to their applications in electronic systems.	Demonstrates minimal understanding of nanomaterials and quantum dots; struggles to link them to electronic system applications.	Fails to analyze nanomaterials and quantum dots; shows no understanding of their relevance to electronic systems.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO11)	Effectively evaluates the use of functional polymers and hybrid composites in various electronic applications	Evaluates the use of functional polymers and hybrid composites with moderate clarity and relevance to electronic applications.	Provides a basic or partial evaluation of functional polymers and hybrid composites, with limited connection to electronic applications.	Demonstrates minimal evaluation of functional polymers and hybrid composites.	Fails to evaluate functional polymers and hybrid composites.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO4, PO11)	Effectively interprets the electrode systems and electrochemical sensors for real-time monitoring in diverse sectors.	Interprets electrode systems and electrochemical sensors with reasonable clarity for real-time monitoring.	Provides a basic or partial interpretation of electrode systems and electrochemical sensors.	Demonstrates minimal understanding of electrode systems or electrochemical sensors	Fails to interpret electrode systems and electrochemical sensors.
Performance Indicator 5 (CO5 - PO1, PO2, PO3, PO11)	Clearly Assess and comprehensive understanding of corrosion mechanisms and e-waste management strategies to enhance electronic device life and environmental safety.	Assesses corrosion mechanisms and e-waste strategies with moderate clarity.	Provides a basic assessment of corrosion and e-waste management.	Demonstrates minimal assessment of corrosion mechanisms or e-waste strategies.	Fails to assess corrosion mechanisms or e-waste management strategies.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO3, PO11)	Analyze / Clearly explains the deep understanding of material properties and their impact on electronics/IoT performance.	Explains understanding of material properties and their impact on electronics/IoT performance with minimal gaps.	Basic understanding of material properties with limited applications.	Misinterprets material functions or uses incorrect applications.	Fails to explain material properties and their impact on electronics/IoT performance.
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO4, PO11)	Clearly analyzes nanomaterials and quantum dots for innovative applications for electronic systems.	Analyzes nanomaterials and quantum dots with some clarity, identifying relevant applications in electronic systems.	Provides a basic analysis of nanomaterials and quantum dots, with limited connection to their applications in electronic systems.	Demonstrates minimal understanding of nanomaterials and quantum dots; struggles to link them to electronic system applications.	Fails to analyze nanomaterials and quantum dots; shows no understanding of their relevance to electronic systems.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO11)	Effectively evaluates the use of functional polymers and hybrid composites in various electronic applications	Evaluates the use of functional polymers and hybrid composites with moderate clarity and relevance to electronic applications.	Provides a basic or partial evaluation of functional polymers and hybrid composites, with limited connection to electronic applications.	Demonstrates minimal evaluation of functional polymers and hybrid composites.	Fails to evaluate functional polymers and hybrid composites.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO4, PO11)	Effectively interprets the electrode systems and electrochemical sensors for real-time monitoring in diverse sectors.	Interprets electrode systems and electrochemical sensors with reasonable clarity for real-time monitoring.	Provides a basic or partial interpretation of electrode systems and electrochemical sensors.	Demonstrates minimal understanding of electrode systems or electrochemical sensors	Fails to interpret electrode systems and electrochemical sensors.
Performance Indicator 5 (CO5 - PO1, PO2, PO3, PO11)	Clearly Assess and comprehensive understanding of corrosion mechanisms and e-waste management strategies to enhance electronic device life and environmental safety.	Assesses corrosion mechanisms and e-waste strategies with moderate clarity.	Provides a basic assessment of corrosion and e-waste management.	Demonstrates minimal assessment of corrosion mechanisms or e-waste strategies.	Fails to assess corrosion mechanisms or e-waste management strategies.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO3, PO11)	Analyze / Clearly explains the deep understanding of material properties and their impact on electronics/IoT performance.	Explains understanding of material properties and their impact on electronics/IoT performance with minimal gaps.	Basic understanding of material properties with limited applications.	Misinterprets material functions or uses incorrect applications.	Fails to explain material properties and their impact on electronics/IoT performance.
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO4, PO11)	Clearly analyzes nanomaterials and quantum dots for innovative applications for electronic systems.	Analyzes nanomaterials and quantum dots with some clarity, identifying relevant applications in electronic systems.	Provides a basic analysis of nanomaterials and quantum dots, with limited connection to their applications in electronic systems.	Demonstrates minimal understanding of nanomaterials and quantum dots; struggles to link them to electronic system applications.	Fails to analyze nanomaterials and quantum dots; shows no understanding of their relevance to electronic systems.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO11)	Effectively evaluates the use of functional polymers and hybrid composites in various electronic applications	Evaluates the use of functional polymers and hybrid composites with moderate clarity and relevance to electronic applications.	Provides a basic or partial evaluation of functional polymers and hybrid composites, with limited connection to electronic applications.	Demonstrates minimal evaluation of functional polymers and hybrid composites.	Fails to evaluate functional polymers and hybrid composites.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO4, PO11)	Effectively interprets the electrode systems and electrochemical sensors for real-time monitoring in diverse sectors.	Interprets electrode systems and electrochemical sensors with reasonable clarity for real-time monitoring.	Provides a basic or partial interpretation of electrode systems and electrochemical sensors.	Demonstrates minimal understanding of electrode systems or electrochemical sensors	Fails to interpret electrode systems and electrochemical sensors.
Performance Indicator 5 (CO5 - PO1, PO2, PO3, PO11)	Clearly Assess and comprehensive understanding of corrosion mechanisms and e-waste management strategies to enhance electronic device life and environmental safety.	Assesses corrosion mechanisms and e-waste strategies with moderate clarity.	Provides a basic assessment of corrosion and e-waste management.	Demonstrates minimal assessment of corrosion mechanisms or e-waste strategies.	Fails to assess corrosion mechanisms or e-waste management strategies.

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 & 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 &PO8)	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 &Analysis (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). Transitions between sections are smooth. (7-8)	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)

Note: Can add Engineering & 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

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play