Applied Chemistry for Smart Systems		Semester	I/II
Course Code	**1BCHES102/202**	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 the structure, synthesis, and applications of functional materials in memory and display devices.

CO2: Analyze quantum materials, conducting polymers, and their roles in energy and electronic systems.

CO3: Evaluate next-generation energy systems, fuel cells, and green hydrogen technologies.

CO4: Apply concepts of sensors, corrosion control, and green materials in sustainable electronics and e-waste management.

Module-1 Functional Materials for Memory and Display Systems

Memory Devices: Introduction, organic semiconductors; types of organic semiconductors used in memory devices, p-type semiconductor-pentacene and n-type semiconductor-perfluoropentacene. Differences between organic and inorganic memory devices. Construction, working and advantages of pentacene semiconductor chip.

Resistive RAM (ReRAM) Materials: Introduction, synthesis of TiO_2-RAM nanomaterial by sol-gel method, properties and applications.

Display Systems: Introduction, liquid crystals (LCs)-classification, properties and its applications. Construction, working principle and applications of Light Emitting Diodes (LEDs), Organic Light Emitting Diodes (OLEDs), Active-Matrix Organic Light Emitting Diodes (AMOLEDs) and Quantum Light Emitting Diodes (QLEDs).

Number of Hours: **08**

Module-2 Quantum Materials and Polymers

Quantum Dots: Introduction, size dependent properties-quantum confinement effect, surface-to-volume ratio & band gap. Synthesis of Cd-Se Quantum dots by wet chemical method and its applications. Construction, working principle and applications of quantum dot sensitized solar cells (QDSSCs).

Polymer: Introduction, number average and weight average molecular weight of the polymers and numerical problems. Structure-properties relationship of polymers [Crystallinity, Strength, Elasticity and chemical resistivity]. Synthesis and properties of nylon-6,6 and its advantages in 3D printing applications. Synthesis and properties of chlorinated polyvinyl chloride (CPVC), and polymethyl methacrylate (PMMA) and their uses in device applications.

Conducting polymers- Introduction, synthesis of polyaniline, conduction mechanism and its engineering applications.

Number of Hours: **08**

Module-3 Sustainable Energy Systems

Energy Systems: Introduction, basic overview of Nerns't equation, construction and working of concentration cell and numerical problems. Batteries-classification of batteries, construction, working and applications of Li-Ion battery.

Next-Generation Energy Devices: Introduction, construction and working of sodium ion battery for EV applications. Construction and working of ultra-small asymmetric super capacitor and its applications in IoT/wearable devices.

Sustainable Energy Devices: Introduction, fuel cells, difference between fuel cell and battery. Construction, working principle, applications and limitations of solid-oxide fuel cell (SOFCs) and solar photovoltaic cell (PV cell). Production of green hydrogen by photocatalytic water splitting by TiO_2 catalyst and its advantages.

Number of Hours: **08**

Module-4 Sensors and Corrosion Science

Sensors: Introduction, terminologies-Transducer, Actuators and Sensors. Conductometric sensor-principle, construction and its application in the estimation of acid mixture. Colorimetric sensor-principle, instrumentation and its application in the estimation of copper in PCB. Electrochemical gas sensors- principle, construction and its application in the detection of NOx and SOx in air sample. Biosensor-principle, construction and working for the detection of glucose in biofluids.

Corrosion: Introduction, electrochemical theory of corrosion, types of corrosion-differential metal and differential aeration corrosion-waterline and pitting corrosion. Corrosion control-galvanization and anodization. Vapour corrosion inhibitors for protecting computer circuit boards, corrosion penetration rate (CPR)-definition and numerical problems.

Number of Hours: **08**

Module-5 Green Materials and E-Waste Management

Green Chemistry: Introduction, properties and applications of green solvents for server heat management. Synthesis and properties of glycerol trioleate ester and its uses in IT infrastructure applications. Green synthesis of ZnO nanoparticles and its uses in magnetic Radio Frequency Identification (RFID) and Internet of Nano Things (IONT) system applications.

Biomaterials: Introduction, synthesis and properties of polylactic Acid (PLA) and polyethylene glycol (PEG) and its uses in touch screen applications. Synthesis and properties of Alginate Hydrogel and its uses in Brain-Computer Interfaces (BCIs) applications.

E-waste: Introduction, sources, composition of e-waste, effects of e-waste on environment and human health, Artificial intelligence in e-waste management, extraction of gold from e-waste by 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 acid value of solder flux using KOH
6. Estimation of acid mixture using conductometric sensor (Conductometry).
7. Estimation of iron in rust sample using potentiometric sensor (Potentiometry).
8. Determination of pKa of cooling fluids using pH sensor (Glass electrode).
9. Estimation of copper present in e-waste using optical sensor (Colorimetry).
10. Determination of viscosity coefficient of liquid coolant sample.
11. Interpretation of pka values of a cooling fluid 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. 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. Semiconducting Materials and Devices-Deepak Verma, ISBN: 978 9394777712, 2. Organic Thin Film Transistor Applications: Materials to Circuits-Brajesh K. Kaushik et al. ISBN 10: 9781498736534 3. High Quality Liquid Crystal Displays and Smart Devices – Ishihara, Kobayashi & Ukai (2019, IET), ISBN: 9781785619397 4. Quantum Dots and Polymer Nanocomposites: Synthesis, Chemistry, and Applications-yotishkumar Parameswaranpillai, Poushali Das, Sayan Ganguly, Publisher: CRC Press, 2022, ISBN 13: 978 1032210148 5. Green Carbon Quantum Dots: Environmental Applications; Vijay Kumar, Pardeep Singh, Devendra Kumar Singh (India), Springer Nature Singapore, Oct 2024, ISBN 13: 978 9819762026. 6. Conducting Polymers, Fundamentals and Applications: Including Carbon Nanotubes and Graphene: Prasanna Chandrasekhar (IIT Delhi alumnus), Springer, 2019 (2nd ed.), ISBN 13: 978 3030098858.
Web links and Video Lectures (e-Resources): 1.https://youtu.be/1TGTVQbMlIc 2. https://www.youtube.com/watch?v=IzWONUYlQ5E&t=56s 3. https://youtu.be/3j0jLuOs0v4 4. https://youtu.be/CeZxn8CyM6Q 5. https://youtu.be/om0gppRTKoU 6. https://youtu.be/_ubwkG7uCFA 7. https://youtu.be/0EokkhdppgE?si=L6Znx5yXYjI9EVlw 8. https://youtu.be/hT2yCPnNEoI 9. https://www.youtube.com/watch?v=EE35ICGthR8 10. https://www.youtube.com/live/CMyIb58vd4Q 11. https://www.youtube.com/watch?v=YsZcSnqV9lg 12. https://youtu.be/xrsK9FUdvRE?si=prlzf7fRocxxygJr 13. https://youtu.be/OEDapr-9lNE?si=CYdVhq3d5ffzdXUC 14. https://youtu.be/QNKPaZkWC9Q?si=PyI4sQUL75340I9i 15. https://youtu.be/0Citdpy92EE 16. https://youtu.be/zaNdJ9I21YA 17. https://youtu.be/YAW7nMf8j0A 18. https://www.youtube.com/watch?v=FXGNQqdRBzc 19. https://www.youtube.com/watch?v=KvmqgAYO0MI 20. https://www.youtube.com/watch?v=SvlrAFDHOLc 21. https://youtu.be/kUCVBhSka2Q

22. https://www.youtube.com/watch?v=Ic5TEuKxj8M
23. https://www.youtube.com/watch?v=ATn92XwdgC4
24. https://www.youtube.com/watch?v=ldlniZfA2X4
25. https://www.youtube.com/watch?v=C0K1XRT1myg
26. https://www.youtube.com/watch?v=iVcSgej7-K8

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,	Demonstrates an in-depth understanding of corrosion mechanisms and	Shows clear understanding of corrosion processes and applies relevant	Provides a general understanding of corrosion mechanisms	Displays minimal understanding of corrosion and surface coatings; application is	Fails to demonstrate understanding of corrosion or surface coating

PO11)	expertly applies appropriate surface coating techniques for effective material protection.	surface coating methods with reasonable effectiveness for material protection.	and applies basic surface coating techniques with limited accuracy.	unclear or inappropriate for material protection.	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 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 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 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	Clearly analyses key sustainable chemistry concepts and evaluates green energy fuels	Shows a basic understanding of sustainable chemistry and provides a general	Demonstrates minimal understanding of sustainable chemistry; evaluation of	Fails to analyse sustainable chemistry principles or evaluate green energy fuels.

	critically evaluates various green energy fuels with strong justification.	with appropriate relevance	evaluation of green fuels, but lacks depth.	green fuels is weak.	
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	The lab record is well-	The lab record is	The lab record lacks	The lab record is

(8) (PO9)	organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	organized, with clear sections, but some sections are not well-defined. (5-6)	clear organization or structure. Some sections are unclear or incomplete. (3-4)	poorly organized, with missing or unclear sections. (1-2)

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