Applied Chemistry for Smart Systems (CSE stream)		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)	**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 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, difference 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 its applications.

Display Systems: Introduction, liquid crystals (LCs)- classification, properties and its applications in Liquid Crystal Displays (LCDs), construction, working principle and applications of LEDs, 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 and applications of Cd-Se Quantum dots by wet chemical method, quantum dot sensitized solar cells (QDSSCs)-construction, working principle and applications.

Polymer: Introduction, molecular weight of polymers - number and weight average molecular weight of polymers, numerical problems, structure-property relationship of polymers, synthesis and properties of nylon-12 advantages in 3D printing applications, synthesis and properties of PVC and PMMA for device applications.

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

Number of Hours**: 08**

Module-3 Sustainable Chemistry for Energy Devices

Batteries: Introduction, basic overview of Nernst equation, concentration cell and numerical problems, classification of batteries, construction, working and applications of Li-Ion battery.

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

Clean Energy Chemistry: Introduction, fuel cell, 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 using TiO_2 method and its advantages.

Number of Hours: **08**

Module-4 Chemical Sensors and Corrosion Control

Sensors: Introduction, terminologies- Transducer, Actuators and Sensors, working principle and applications- conductometric sensor and colorimetric sensor, electrochemical gas sensors for the detection of NOx & SOx in air sample, Biosensor-principle and working mechanism for detection of glucose in biofluids.

Corrosion: Introduction, electrochemical theory of corrosion, types-differential metal and differential aeration corrosion, corrosion control- Galvanization and anodization, vapour corrosion inhibitors for protecting computer circuit boards, corrosion penetration rate (CPR)- definition, importance 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, biosynthesis and properties of glycerol trioleate ester for server and IT infrasrtrure applications. Green synthesis of ZnO nanoparticles for magnetic Radio Frequency Identification (RFID) & Internet of Nano Things (IONT) system applications

Biomaterials: Introduction, synthesis and properties of polylactic Acid (PLA) and polyethylene glycol (PEG) for touch screen applications, synthesis and properties of Alginate Hydrogel for 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 and its applications, extraction of gold from e-waste by bioleaching method, direct recycling method of lithium-ion batteries.

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.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. 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, PO5, PO11)	Provides a comprehensive and insightful analysis of the structural, electrical, and optical properties of functional materials, with advanced applications in memory and display technologies.	Analyzes key properties of functional materials and explains their applications in memory and display systems.	Demonstrates a basic understanding of material properties and gives general applications in memory or display technologies.	Shows limited analysis of material properties; applications in memory and display systems are mentioned with minimal explanation.	Fails to analyze properties or applications of functional materials in memory and display technologies
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO5, PO11)	Demonstrates deep and clear understanding of the properties, behavior, and technological relevance of quantum materials and polymers.	Shows solid understanding of key concepts related to quantum materials and polymers.	Demonstrates a basic understanding of quantum materials and polymers.	Shows limited or unclear understanding of quantum materials or polymers.	Fails to demonstrate understanding of quantum materials and polymers.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO6, PO11)	Effectively applies sustainable chemistry principles with innovative approaches to the design and development of energy storage and conversion devices.	Applies key sustainable chemistry principles in the development of energy storage and conversion systems.	Demonstrates basic application of sustainable chemistry concepts; shows general understanding of their role in energy device.	Provides minimal application of sustainable chemistry, weak link to energy storage and conversion devices.	Fails to apply sustainable chemistry principles; no relevance to energy storage or conversion device.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO4, PO5, PO11)	Demonstrates advanced ability to design and critically evaluate chemical sensors and corrosion control methods with clear applicability to both industrial and environmental systems.	Clearly designs and evaluates chemical sensors and corrosion control methods, showing appropriate understanding of their industrial and environmental relevance.	Shows basic design and evaluation of chemical sensors or corrosion control methods with limited application details and minimal technical depth.	Provides minimal or unclear design or evaluation; weak understanding of applications in industrial or environmental contexts.	Fails to design or evaluate relevant sensors or corrosion control methods; lacks understanding of industrial and environmental applications
Performance Indicator 5 (CO5 - PO1, PO2, PO3, PO4, PO6, PO11)	Thoroughly assesses a wide range of green materials and proposes innovative, effective strategies for e-waste reduction and management.	Clearly evaluates green materials and implements appropriate strategies for e-waste reduction and management with a solid understanding of sustainability concerns.	Demonstrates a basic assessment of green materials and outlines general e-waste management strategies, though lacking in depth.	Shows limited understanding of green materials or provides weak strategies for e-waste reduction with minimal practical relevance.	Fails to assess green materials or suggest meaningful e-waste management strategies & lacks awareness of sustainability.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO3, PO5, PO11)	Provides a comprehensive and insightful analysis of the structural, electrical, and optical properties of functional materials, with advanced applications in memory and display technologies.	Analyzes key properties of functional materials and explains their applications in memory and display systems.	Demonstrates a basic understanding of material properties and gives general applications in memory or display technologies.	Shows limited analysis of material properties; applications in memory and display systems are mentioned with minimal explanation.	Fails to analyze properties or applications of functional materials in memory and display technologies
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO5, PO11)	Demonstrates deep and clear understanding of the properties, behavior, and technological relevance of quantum materials and polymers.	Shows solid understanding of key concepts related to quantum materials and polymers.	Demonstrates a basic understanding of quantum materials and polymers.	Shows limited or unclear understanding of quantum materials or polymers.	Fails to demonstrate understanding of quantum materials and polymers.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO6, PO11)	Effectively applies sustainable chemistry principles with innovative approaches to the design and development of energy storage and conversion devices.	Applies key sustainable chemistry principles in the development of energy storage and conversion systems.	Demonstrates basic application of sustainable chemistry concepts; shows general understanding of their role in energy device.	Provides minimal application of sustainable chemistry, weak link to energy storage and conversion devices.	Fails to apply sustainable chemistry principles; no relevance to energy storage or conversion device.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO4, PO5, PO11)	Demonstrates advanced ability to design and critically evaluate chemical sensors and corrosion control methods with clear applicability to both industrial and environmental systems.	Clearly designs and evaluates chemical sensors and corrosion control methods, showing appropriate understanding of their industrial and environmental relevance.	Shows basic design and evaluation of chemical sensors or corrosion control methods with limited application details and minimal technical depth.	Provides minimal or unclear design or evaluation; weak understanding of applications in industrial or environmental contexts.	Fails to design or evaluate relevant sensors or corrosion control methods; lacks understanding of industrial and environmental applications
Performance Indicator 5 (CO5 - PO1, PO2, PO3, PO4, PO6, PO11)	Thoroughly assesses a wide range of green materials and proposes innovative, effective strategies for e-waste	Clearly evaluates green materials and implements appropriate strategies for e-waste reduction and management with a solid understanding	Demonstrates a basic assessment of green materials and outlines general e-waste management strategies, though lacking in depth.	Shows limited understanding of green materials or provides weak strategies for e-waste reduction with minimal practical relevance.	Fails to assess green materials or suggest meaningful e-waste management strategies & lacks awareness of sustainability.

	reduction and management.	of sustainability concerns.			

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO3, PO5, PO11)	Provides a comprehensive and insightful analysis of the structural, electrical, and optical properties of functional materials, with advanced applications in memory and display technologies.	Analyzes key properties of functional materials and explains their applications in memory and display systems.	Demonstrates a basic understanding of material properties and gives general applications in memory or display technologies.	Shows limited analysis of material properties; applications in memory and display systems are mentioned with minimal explanation.	Fails to analyze properties or applications of functional materials in memory and display technologies
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO5, PO11)	Demonstrates deep and clear understanding of the properties, behavior, and technological relevance of quantum materials and polymers.	Shows solid understanding of key concepts related to quantum materials and polymers.	Demonstrates a basic understanding of quantum materials and polymers.	Shows limited or unclear understanding of quantum materials or polymers.	Fails to demonstrate understanding of quantum materials and polymers.
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO6, PO11)	Effectively applies sustainable chemistry principles with innovative approaches to the design and development of energy storage and conversion devices.	Applies key sustainable chemistry principles in the development of energy storage and conversion systems.	Demonstrates basic application of sustainable chemistry concepts; shows general understanding of their role in energy device.	Provides minimal application of sustainable chemistry, weak link to energy storage and conversion devices.	Fails to apply sustainable chemistry principles; no relevance to energy storage or conversion device.
Performance Indicator 4 (CO4 - PO1, PO2, PO3, PO4, PO5, PO11)	Demonstrates advanced ability to design and critically evaluate chemical sensors and corrosion control methods with clear applicability to both industrial and environmental systems.	Clearly designs and evaluates chemical sensors and corrosion control methods, showing appropriate understanding of their industrial and environmental relevance.	Shows basic design and evaluation of chemical sensors or corrosion control methods with limited application details and minimal technical depth.	Provides minimal or unclear design or evaluation; weak understanding of applications in industrial or environmental contexts.	Fails to design or evaluate relevant sensors or corrosion control methods; lacks understanding of industrial and environmental applications
Performance Indicator 5 (CO5 - PO1, PO2, PO3, PO4, PO6,	Thoroughly assesses a wide range of green materials and	Clearly evaluates green materials and implements appropriate	Demonstrates a basic assessment of green materials and outlines general e-	Shows limited understanding of green materials or provides weak	Fails to assess green materials or suggest meaningful e-waste

PO11)	proposes innovative, effective strategies for e-waste reduction and management.	strategies for e-waste reduction and management with a solid understanding of sustainability concerns.	waste management strategies, though lacking in depth.	strategies for e-waste reduction with minimal practical relevance.	management strategies & lacks awareness of sustainability.

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