K. S. INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU, Approved by AICTE

Department of Chemistry

FIRST/SECOND SEMESTER SYLLABUS

Course: **Applied Chemistry for CSE Stream : Applied Chemistry for Smart Systems**		**Semester**	**I/II**
Course Code	**25BCHCS102/202**	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)	Theory		

Course objectives:

- To understand principles, structures, and working mechanisms of advanced engineering materials in sensing, energy, green chemistry, quantum, and memory applications.
- To apply concepts to design and evaluate materials and devices for sustainable, energy-efficient, and eco-friendly engineering solutions.
- To develop problem-solving and interdisciplinary skills to address industrial, environmental, and technological challenges with innovative materials.

Teaching-Learning Process Pedagogy

These are sample Strategies; teachers can use to accelerate the attainment of the various course outcomes.

- Tutorial & remedial classes for needy students (not regular T/R)
- Conducting Makeup classes / Bridge courses for needy students
- Demonstration of concepts either by building models or by industry visit
- Experiments in laboratories shall be executed in blended mode (conventional or non–conventional methods)
- Use of ICT – Online videos, online courses
- Use of online platforms for assignments / Notes / Quizzes (Ex. Google classroom)

Module-1: Engineering Materials in Chemical Sensing and Corrosion Control

Sensors: Introduction, terminologies- Transducer, Actuators and Sensors, working principle and applications – Electrochemical sensor, 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, Factors affecting the rate of corrosion

(Nature of the metal, Surface area, Cathode/Anode Area Ratio, Temperature), types-differential metal and differential aeration corrosion, corrosion control- Galvanization and anodization, vapour corrosion inhibitors for protecting computer circuit boards. **(8 hours)**

Self-learning: Tactile Sensors, Optoacoustics, SAW Sensors, Microbial Influenced Corrosion, Stress Corrosion Cracking (SCC), Hydrogen Embrittlement.

Text 1: Ch-2, pp 45-78, Ch-6, pp 213-248, **Text 2:** Ch-4, pp 112-154, **Text 3**: Ch-2, pp 36-70, **Text 4:** Ch-8, pp. 204-232.

Module-2: Sustainable Chemistry for Energy Systems

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 iron-based (iron-air or iron-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. **(8 hours)**

Self-learning: Hydrogen Mobility, Flow Batteries, Supercapacitors, Photocatalysis

Text 5: Section 1, pp 1-20, Section 3, pp 3-80. Section 5, pp 5-35. **Text 6:** Ch-1, pp 1-16, Ch-2, pp 17-60, **Text 7:** Ch-3, pp 65-110, Ch-7, pp 215-260.

Module-3: 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 infrastructure applications. Green synthesis of ZnO nanoparticles by precipitation method 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. **(8 hours)**

Self-learning: Green Solvents, Nano-Green Synthesis, Biodegradable Polymers, Bioleaching, AI Recycling Systems.

Text 9: Ch-3, pp 45-78, **Text 10:** Ch-6, pp 152-185, **Text 11:** Ch-5, pp 101-132, **Text 12:** Ch-7, pp 215–248, **Text 13:** Ch-2, pp 23–59, **Text 14:** Ch-6, pp 139–172.

Module-4: Quantum Materials and Industrial 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. **(8 hours)**

Self-learning: Graphene Quantum Dots in Bioimaging, Shape Memory Polymers and Their Applications, Polypyrrole in Supercapacitors, PEDOT: PSS for Flexible Electronics.

Text 15: Ch-8, pp 215–250, **Text 16:** Ch-5, pp 143–182, **Text 17:** Ch-7, pp 201–236.

Module-5: Chemicals of Digital and Memory Materials

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), principle, construction, working and applications of LEDs, OLEDs, Active-Matrix Organic Light Emitting Diodes (AMOLEDs) and Quantum Light Emitting Diodes (QLEDs). **(8 hours)**

Self-learning: Pentacene-Based Organic Chips, Sol–Gel TiO_2 Nanostructures, OLED photonics, Micro LEDs, Spintronics, Flex Memory, Bio Memory, Active-Matrix Technology.

Text 18: Ch-7, pp 201–238, **Text 19:** Ch-12, pp 341–372, **Text 20:** Ch-8, pp 221–264.

List of Laboratory experiments (2 hours/week per batch/ batch strength 20) 10 lab sessions + 1 repetition class + 1 Lab Assessment.

Practical Module

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 precipitation 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.

Course Outcome:

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

CO 1: Apply sensor and corrosion control principles for environmental and industrial monitoring.
CO 2: Evaluate next-generation energy systems, fuel cells, and green hydrogen technologies.
CO 3: Apply green chemistry and biomaterial concepts for eco-friendly and high-performance applications.
CO 4: Analyze quantum materials, conducting polymers, and their roles in energy and electronic systems.
CO 5: Understand the structure, synthesis, and applications of functional materials in memory and display devices.

Assessment Details (both CIE and SEE)

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).

CIE for the theory component of the IC:

- There are 25 marks for the CIE for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 35-40% of the coverage of the syllabus, second test will be administered after 65-70%, and the third test will be administered after 90-100% of the coverage of the syllabus. The average of the three tests shall be scaled down to 15 marks.
- Two assignments (average is scaled down to 10 marks)/mini project/Quiz/Seminar are conducted for 10 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**.

CIE for the Lab component of the IC*:*

Every experiment in the laboratory will be evaluated for **15** marks for conducting the experiment and of the laboratory record. Another **10** marks shall be for the test conducted at the end of the semester.

Semester End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject **(duration 03 hours)**

- The question paper shall be set for 100 marks. The medium of the question paper shall be English). The duration of SEE is 03 hours.
- The question paper will have 10 questions. Two questions per module. Each question is set for 20 marks. The students have to answer 5 full questions, selecting one full question from each module. The student has to answer for 100 marks and **marks scored out of 100 shall be proportionally reduced to 50 marks.**

There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub questions), should have a mix of topics under that module.

Suggested Learning Resources

Books

- **Text 1:** Chemical Sensors and Biosensors: Fundamentals and Applications (Ch-2 - Principles of Electrochemical and Conductometric Sensors - pp. 45-78, Chapter 6 - Optical & Thermometric Sensors - pp. 213-248).
- **Text 2:** Handbook of Optical Sensors - Spectroscopy and Surface Plasmon Techniques (Chapter 4 - Surface Plasmon Resonance Sensors – pp. 112–154)
- **Text 3:** Chemistry For Engineering Students by Dr B S Jai Prakash, Prof R Venugopal, Dr Shivakumaraiah. Chapter 2 - Corrosion Science - pp. 36-70).
- **Text 4:** Theory and Applications of Green Corrosion Inhibitors (Chapter 8 - Green Vapor-Phase Corrosion Inhibitors for Electronics - pp. 204-232).
- **Text 5:** Fuel Cell Handbook, (Section 1 - Fuel Cell Fundamentals, pp. 1-1–1-20), (Section 3 - PEM and SOFC Chemistry & Design, pp. 3-45–3-80), (Section 5 - Electrolyzers & Hydrogen

Production, pp. 5-10-5-35).

- **Text 6:** Fuel Cells: Theory and Practice, (Chapter 1 - Introduction & Types, pp. 1-16), (Chapter 2 - PEM Fuel Cell Operation, pp. 17-60).
- **Text 7:** Rechargeable Lithium Batteries: Advanced Technologies and Applications. (Chapter 3 - Lithium-Ion Construction & Chemistry, pp. 65-110), (Chapter 7 - Iron-Air & Flow Batteries, pp. 215-260).
- **Text 9:** Green Chemistry: Fundamentals and Applications – Anju Srivastava (Chapter 3 – Green Solvents and Applications - pp. 45-78).
- **Text 10:** Green Chemistry and Sustainable Development - V. K. Ahluwalia & M. Kidwai (Chapter 6 - Nanomaterials and Green Synthesis - pp. 152-185).
- **Text 11:** Biomaterials: Principles and Applications - J. B. Park & R. S. Lakes (Indian Adaptation by S. Ramakrishna) (Chapter 5 - Biodegradable Polymers - pp. 101-132).
- **Text 12:** Biomaterials Science and Tissue Engineering – S. K. Bhat (Chapter 7 - Hydrogels in Biomedical Applications - pp. 215-248)
- **Text 13:** E-Waste Management: From Waste to Resource - R. K. Singh & R. K. Tiwari (Chapter 2 - Sources, Composition, and Hazards of E-Waste - pp. 23–59).
- **Text 14:** Electronic Waste Management in India - Abhijit Das & P. S. Kumar (Chapter 6 - Recovery of Metals and Recycling Technologies - pp. 139-172).
- **Text 15:** Nanoscience and Nanotechnology - M. S. Ramachandra Rao & Shubra Singh (Chapter 8 - Quantum Dots: Properties, Synthesis, and Applications - pp. 215-250).
- **Text 16:** Textbook of Polymer Science and Technology - M. S. Bhatnagar (Chapter 5 - Structure–Property Relationship in Polymers - pp. 143-182).
- **Text 17:** Functional Polymers: Design, Synthesis, and Applications - Dr. Sabu Thomas & Raghvendra Kumar Mishra (Chapter 7 - Conducting Mechanisms in Polymers - pp. 201-236).
- **Text 18:** Organic Semiconductors: Synthesis, Properties and Applications - K. S. Narayan (Chapter 7 - Pentacene and Perfluoropentacene in Organic Memory - pp. 201-238)
- **Text 19:** Introduction to Nanoscience and Nanotechnology - K. K. Chattopadhyay & A. N. Banerjee (Chapter 12 - Sol-Gel Synthesis of Oxide Nanomaterials for Memory – pp. 341-372)
- **Text 20:** Optoelectronics: Materials and Devices - S. P. Sukhatme (Chapter 8 - LEDs, OLEDs, AMOLEDs, and QLEDs - pp. 221-264).

Web links and Video Lectures (e-Resources):

- https://youtu.be/1TGTVQbMlIc
- https://www.youtube.com/watch?v=IzWONUYlQ5E&t=56s

- https://youtu.be/3j0jLuOs0v4
- https://youtu.be/CeZxn8CyM6Q
- https://youtu.be/om0gppRTKoU
- https://youtu.be/_ubwkG7uCFA
- https://youtu.be/0EokkhdppgE?si=L6Znx5yXYjI9EVlw
- https://youtu.be/hT2yCPnNEoI
- https://www.youtube.com/watch?v=EE35ICGthR8
- https://www.youtube.com/live/CMyIb58vd4Q
- https://www.youtube.com/watch?v=YsZcSnqV9lg
- https://youtu.be/xrsK9FUdvRE?si=prlzf7fRocxxygJr
- https://youtu.be/OEDapr-9lNE?si=CYdVhq3d5ffzdXUC
- https://youtu.be/QNKPaZkWC9Q?si=PyI4sQUL75340I9i
- https://youtu.be/0Citdpy92EE
- https://youtu.be/zaNdJ9I21YA
- https://youtu.be/YAW7nMf8j0A
- https://www.youtube.com/watch?v=FXGNQqdRBzc
- https://www.youtube.com/watch?v=KvmqgAYO0MI
- https://www.youtube.com/watch?v=SvlrAFDHOLc
- https://youtu.be/kUCVBhSka2Q
- https://www.youtube.com/watch?v=Ic5TEuKxj8M
- https://www.youtube.com/watch?v=ATn92XwdgC4

Activity-Based Learning (Suggested Activities in Class)/Practical-Based Learning

- Quizzes
- Assignments
- Seminar
- Activity based learning
- Virtual Labs