| Applied Chemistry for Sustainable Structures and Material Design | | Semester | I/II |
|---|---|---|---|
| Course Code | **1BCHEC102/202** | 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:** Interpret the principles of chemistry related to engineering and technology.

**CO2:** Apply the knowledge of chemistry in solving engineering problems related to energy, materials, corrosion, analytical techniques and environmental contexts.

**CO3:** Analyze the appropriate chemical techniques suitable for engineering applications to reach the substantiated conclusions.

**CO4:** Apply the techniques of quantitative chemical analysis for engineering problems through experimental skills.

## Module-1: Energy Systems and Green Fuels

**Electrochemistry**: Introduction, electrode potential, overview of Nerns't equation, concentration cell, numerical problems on concentration cells.

**Energy systems**: Introduction, classification of batteries, characteristics of battery-capacity, power density, cell balancing and cycle life. Construction, working, and applications of Lithium-ion battery. Fuel cell-definition, difference between battery and fuel cell, construction, working and applications of solid oxide fuel, silicon solar cell.

**Green Fuels**: Introduction, production of green hydrogen by photocatalytic water splitting by $TiO_2$ catalyst and its advantages.

**Number of Hours: 08**

## Module-2: Materials for Structural Integrity

**Polymer**: Introduction, types of polymerization, synthesis, properties and engineering applications of chlorinated polyvinyl chloride (CPVC), polymethyl methacrylate (PMMA) and Kevlar fiber. Molecular weight of polymers: Number average and weight average molecular weight of polymers-numerical problems. Properties and industrial applications of carbon-based reinforced composites-graphene/carbon nanotubes as fillers.

**Nanomaterials**: Introduction, size dependent properties-surface area, catalytic property, thermal properties and antimicrobial activity. Concrete as composite material, composition of nano-concrete, synthesis of $TiO_2$ nanoparticles by sol-gel method for sensor applications.

**Number of Hours: 08**

## Module-3: Conventional and Sustainable Construction Materials

**Cement**: Introduction, composition, manufacturing process of cement-wet process, process of setting and hardening of cement, special cements-composition, properties and applications.

**Geopolymer concrete**: Introduction, mechanism of geopolymerization and manufacturing process of geopolymer concrete.

**Biopolymers**: Introduction, synthesis, properties and applications of polylactic acid (PLA).

**Photochromic coatings**: Introduction, spiropyran as photochromic coating, working principle with chemical reactions and applications in constructions.

**Piezoelectric cement composites**: Introduction, piezoelectric materials in cement composites and its applications in civil engineering.

**Number of Hours: 08**

**Module-4: Corrosion Science and Surface Protection**

**Metals and Alloys:** Introduction, classification of metals: ferrous and non-ferrous. Composition, properties, applications of iron alloys - wrought iron, cast iron, pig iron and steel; aluminium alloys-Duralumin and Magnalumin.

**Corrosion**: Introduction, electrochemical theory of corrosion of steel in concrete, types of corrosion-differential metal corrosion, differential aeration corrosion-waterline and pitting corrosion and stress corrosion in civil structures. Corrosion control by galvanization and anodization. Corrosion penetration rate (CPR)-introduction and numerical problems.

**Metal finishing**: Introduction, technological importance of metal finishing, electroplating of chromium-decorative and hard chromium.

**Number of Hours: 08**

**Module-5: Water Chemistry and Analytical Techniques**

**Water Chemistry**: Introduction, significance of water quality parameters-pH, turbidity, chlorides, dissolved oxygen and alkalinity for environmental and construction applications. Hard water: Introduction, types, determination of total hardness by EDTA method and numerical problems. Waste water- introduction, determination of dissolved oxygen by Winkler's method, determination of chemical oxygen demand (COD) and numerical problems.

**Analytical techniques:** Potentiometric sensors: Principle, instrumentation and application in the estimation of iron in industrial effluents. Conductometric sensors: Principle, instrumentation and application in the determination of acid mixture in industrial effluents. Colorimetric sensor: Principle, instrumentation and application in the estimation of copper in brass alloy.

**Number of Hours: 08**

**PRACTICAL COMPONENTS OF IPCC**

**LIST OF EXPERIMENTS**

1. Estimation of total hardness of given water sample by EDTA method
2. Determination of chemical oxygen demand (COD) of industrial effluents
3. Estimation of percentage of CaO in cement by complexometric method
4. Estimation of iron in TMT bar by diphenyl amine indicator method
5. Determination of total alkalinity of given water sample
6. Estimation of acid mixture using conductometric sensor
7. Estimation of iron in rust sample using potentiometric sensor
8. Determination of pKa value of vinegar solution using pH sensor
9. Estimation of percentage of iron in steel industry effluent by using optical sensor
10. Determination of viscosity coefficient of green fuel using Ostwald's viscometer
11. Colorimetric determination of phenolic content in wastewater using smartphone
12. Interpretation of pka values of a week acid using origin software.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**


**1.** Textbook of Engineering Chemistry: S. S. Dara & S. S. Umare, S. Chand Publishing, ISBN:9788121903593

**2.** Engineering Chemistry, Satyaprakash & Manisha Agrawal, Khanna Book Publishing, Delhi, 1st edition, 2012.

**3.** Engineering Chemistry: Jain & Jain, Publisher: Dhanpat Rai Publishing Company, ISBN: 978-935316118.


**Reference books / Manuals:**

1. Materials Science: S. K. Malik, Publisher: New Age International Publishers, ISBN: 978-8122418713.
2. Electrochemical Energy System: Dr. K. K. Rajeshwar (IIT Madras), Publisher: IIT Madras Open Courseware (Free PDF & videos), ISBN: N/A (Open Educational Resource).
3. Materials Science: S. K. Malik, Publisher: New Age International Publishers, ISBN: 978-8122418713.
4. "Applied Chemistry for Civil Engineering and Allied Branches" by Vrushabendra B, C Manasa and Srikantamurthy N, Publisher: Astitva Prakashan, ISBN: 9788119064465.


**Web links and Video Lectures (e-Resources):**

1. https://nptel.ac.in/courses/113/104/113104021/
2. https://nptel.ac.in/courses/103/102/103102103/
3. https://www.youtube.com/watch?v=JvzH4QQOfSw
4. https://www.youtube.com/watch?v=1F9Vjae7k60
5. https://www.youtube.com/watch?v=xrsK9FUdvRE
6. https://www.youtube.com/watch?v=QNKPaZkWC9Q
7. https://www.youtube.com/watch?app=desktop&v=dwUVMVNSO2k
8. https://www.youtube.com/watch?v=MzTiZp01_qs
9. https://nptel.ac.in/courses/103/102/103102014/
10. https://www.youtube.com/watch?app=desktop&v=4Ur3eqGiLzc
11. https://www.youtube.com/watch?v=nU3a8dA0Oc4
12. https://www.youtube.com/watch?v=570mPvlxqPg
13. https://www.youtube.com/watch?v=1SOtM_Vq8es
14. https://www.youtube.com/watch?v=_Y2ePj3wr8M
15. https://www.youtube.com/watch?v=eT34ypRodB0

**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 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 | 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 | Provides minimal explanation of synthesis, applications and shows limited understanding of nanomaterials in energy storage. | Fails to examine synthesis and application of nanomaterials. |

| | | | | | |
|---|---|---|---|---|---|
| | storage technologies. | | energy storage. | | |
| **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** | Effectively applies appropriate | Correctly applies functional | Shows basic application of functional | Applies functional materials | Fails to apply functional materials |

| | | | | | |
|---|---|---|---|---|---|
| **(CO4 - PO1, PO2, PO3, PO11)** | functional materials in diverse engineering applications with clear justification. | materials in relevant engineering contexts and shows reasonable understanding of their impact. | materials with limited understanding. | inaccurately and limited connection to performance. | 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 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 | Correctly applies functional materials in relevant engineering | Shows basic application of functional materials with limited understanding. | Applies functional materials inaccurately and limited | Fails to apply functional materials appropriately and no understanding |

| | | | | | |
|---|---|---|---|---|---|
| | engineering applications with clear justification. | contexts and shows reasonable understanding of their impact. | | connection to performance. | 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). 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 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