Applied Chemistry for Advanced Metal Protection and Sustainable Energy Systems		Semester	I / II
Course Code	**1BCHEM102/202**	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 terms and processes involved in scientific and engineering applications

CO2: Apply the knowledge of chemistry to solve the problems in chemistry that are pertinent in engineering applications

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: Corrosion Science and Coating Technologies

Corrosion: Introduction, electrochemical theory of corrosion, types of corrosion-differential metal and differential aeration corrosion-waterline and pitting corrosion, corrosion control-metal coating; galvanization, surface conversion coating; anodization and cathodic protection; sacrificial anode method, corrosion penetration rate (CPR) - Introduction and numerical problems.

Coating Technologies: Introduction, technological importance, electroplating - electroplating of chromium-decorative and hard chromium, electro-less plating - electroless plating of Nickel, difference between electroplating and electroless plating.

Number of Hours: 08

Module-2: Sustainable Fuels

Fuels: Introduction, calorific value, determination of calorific value using bomb's calorimeter, numerical problems on GCV and NCV. Knocking in internal combustion (IC) engines - knocking mechanism in IC engines. Anti-knocking agents - methyl tertiary butyl ether (MTBE) and ethyl tert-butyl ether (ETBE). Importance of octane and cetane rating of fuel.

Green Fuels: Introduction, power alcohol – properties, applications and its limitations, biodiesel - synthesis by trans-esterification method, advantages and its applications. Production of green hydrogen by photocatalytic water splitting and its advantages, hydrogen storage – introduction, advantages and limitations of metal hydride and ammonia as chemical hydrogen carriers.

Number of Hours: 08

Module-3: Materials for Energy Systems

Nanomaterials: Introduction, synthesis of TiO_2 nanoparticles by sol-gel method and its uses in catalytic converter. Size-dependent properties of nanomaterial-surface area, catalytical, electrical and thermal conductivity. Graphene - Synthesis by chemical vapor deposition (CVD) method, properties and engineering applications. Role of carbon nanotubes (CNTs) in energy devices.

Energy Systems: Batteries - Introduction, classification of batteries, characteristics-capacity, power density, shelf life and cycle life. Construction, working and applications of Li-ion battery.

Fuel cells - Introduction, construction and working of solid oxide fuel cells (SOFCs) and its uses in auxiliary power units (APUs). Differences between fuel cell and battery. Solar photovoltaic cells (PV cells) - construction, working, advantages and limitations.

Number of Hours: 08

Module-4: Materials for Engineering Applications

Engineering Polymers: Introduction, molecular weight of polymers - number average and weight average molecular weight, numerical problems. Synthesis, properties and engineering applications of chlorinated polyvinyl chloride (CPVC), polymethyl methacrylate (PMMA). Structure-properties relationship of polymers (Crystallinity, Strength, Elasticity and chemical resistivity]. Glass transition temperature (Tg), factor affecting Tg and its significance.

Polymer Composites: Introduction, fiber-reinforced polymers (FRPs); Kevlar – Synthesis, properties and industrial applications. Carbon-fiber - Preparation from Polyacrylonitrile (PAN), properties and industrial applications.

3D Printing materials: Introduction, synthesis, properties and applications of polylactic acid (PLA) resin.

Number of Hours: 08

Module-5: Fluid Technology and Smart Sensors

Lubricants: Introduction, classification, ideal properties and applications. Lubricant testing; experimental determination of viscosity using Ostwald's viscometer.

Industrial Coolants: Introduction, types - water and oil-based coolants, properties and industrial applications.

Industrial effluents: Introduction, determination of COD and numerical problems.

Sensors: Introduction, potentiometric sensor - principle and its application in the estimation of iron in steel industry effluent. Conductometric sensor - principle and its application in the estimation of acid mixture in electrochemical bath effluent. pH sensor - principle and its application in the estimation of pKa of acid electrolyte.

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 wastewater
3. Estimation of iron in steel industry effluent by diphenyl amine indicator method
4. Determination of total alkalinity of given boiler water sample
5. Determination of acid value of biofuel
6. Estimation of acid mixture in electrochemical bath effluent using conductometric sensor (Conductometry)
7. Estimation of iron in rust sample by Potentiometric sensor (Potentiometry)
8. Determination of pKa of acid electrolyte using pH sensor (Glass electrode)
9. Estimation of copper present in e-waste by optical sensor (Colorimetry)
10. Determination of viscosity coefficient of lubricant using Ostwald's viscometer
11. Green synthesis of copper nanoparticles
12. Synthesis of polylactic acid (PLA)

Suggested Learning Resources: (Textbook/ Reference Book/ Manuals):

Textbooks:

1. Wiley Engineering Chemistry, Wiley India Pvt. Ltd. New Delhi, 2013- 2nd Edition.
2. A Textbook of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.
3. A Textbook of Engineering Chemistry, R.V. Gadag and Nityananda Shetty, I. K. International Publishing house. 2nd Edition, 2016.

Reference books:

1. Engineering Chemistry, Satyaprakash & Manisha Agrawal, Khanna Book Publishing, Delhi
2. Nanotechnology A Chemical Approach to Nanomaterials, G.A. Ozin & A.C. Arsenault, RSC Publishing, 2005.
3. Corrosion Engineering, M. G. Fontana, N. D. Greene, McGraw Hill Publications, New York, 3rd Edition, 1996.
4. Linden's Handbook of Batteries, Kirby W. Beard, Fifth Edition, McGraw Hill, 2019.
5. Applied Chemistry for Mechanical Engineering and Allied Branches, C Manasa, Vrushabendra B, Srikantamurthy N. ISBN: 978-93-58380-90-3, Astitva Prakashan.
6. Expanding the Vision of Sensor Materials. National Research Council 1995, Washington, DC: The National Academies Press. doi: 10.17226/4782.
7. Engineering Chemistry, Edited by Dr. Mahesh B and Dr. Roopashree B, Sunstar Publisher, Bengaluru, ISBN 978-93-85155-70-3, 2022
8. Polymer Science, V R Gowariker, N V Viswanathan, Jayadev, Sreedhar, Newage Int. Publishers, 4th Edition, 2021
9. Chemistry for Engineering Students, B. S. Jai Prakash, R. Venugopal, Sivakumaraiah & Pushpa Iyengar., Subash Publications, 5th Edition, 2014
10. Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler, Stanley R. Crouch Seventh Edition, Cengage Learning, 2020.

Web links and Video Lectures (e-Resources):

1. https://www.vturesource.com/post/1570/News/Bomb-calorimeter-construction-working-vtu-chemistry.html?utm_source
2. https://pubs.acs.org/doi/10.1021/acsomega.3c00963?utm_source
3. https://youtu.be/qTw_p9dkiVU
4. https://youtu.be/wdCYXj-bI-U
5. https://youtu.be/Y0EkLYK5i-c
6. https://youtu.be/tzTxMF7CDd4
7. https://youtu.be/YxrpQEX9ORA
8. https://youtu.be/Gxv4r9qoRf8
9. https://youtu.be/XIjDw5Sw9c4
10. https://youtu.be/j_rNjiIiBKE
11. https://youtu.be/GpbcjWstzEE
12. https://youtu.be/ygtbo5KDXeI
13. https://www.youtube.com/watch?v=ygtbo5KDXeI
14. https://youtu.be/y-7t-GdRTKA
15. https://pmc.ncbi.nlm.nih.gov/articles/PMC11085161/?utm_source
16. https://youtu.be/MeOD34QGu-I

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	Shows clear understanding of corrosion processes and applies relevant surface coating methods with	Provides a general understanding of corrosion mechanisms and applies basic surface	Displays minimal understanding of corrosion and surface coatings; application is unclear or inappropriate for	Fails to demonstrate understanding of corrosion or surface coating techniques; no evidence of

	surface coating techniques for effective material protection.	reasonable effectiveness for material protection.	coating techniques with limited accuracy.	material protection.	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,	Demonstrates a thorough analysis of sustainable	Clearly analyses key sustainable chemistry	Shows a basic understanding of sustainable	Demonstrates minimal understanding of	Fails to analyse sustainable chemistry

PO2, PO3, PO6, PO11)	chemistry principles and critically evaluates various green energy fuels with strong justification.	concepts and evaluates green energy fuels with appropriate relevance	chemistry and provides a general evaluation of green fuels, but lacks depth.	sustainable chemistry; evaluation of green fuels is weak.	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.

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	Student is able to run the	Student will be able to	Student will be able	Student will be

andAnalysis (5) (PO4)	program on various cases and compare the result with proper analysis. (5)	run the program for all the cases.(4)	to run the code for few cases and analyze the output(3)	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