

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU - 572 103

(Autonomous Institution affiliated to VTU, Belagavi)

Department: CHEMISTRY

Semester B.E.

(For ME/IEM/CH Branches)

Syllabus from the Academic year 2025-26 onwards

**Applied Chemistry for Advanced Metal Protection and Sustainable Energy Systems
(ME Stream)**

Contact Hours/ Week:	03+ 02	Credits:	04
Total Lecture Hours:	40+ 26	CIE Marks:	50
Course Code:	1BCHEM	SEE Marks:	50

Course objectives:

This course will enable students to:

1.	Master the knowledge of lubricants, coolants, and application of instrumentation techniques for the determination of different types of analyses present in effluents.
2.	Gain the knowledge on the battery concept, construction and working of batteries, fuel cells, nanomaterials preparation, graphene and applications in energy storage.
3.	Master the knowledge on the importance of polymers, preparation of engineering polymeric materials, carbon fiber and 3-D printing materials.
4.	Learn the corrosion mechanism, corrosion control and coating technologies.
5.	Learn the basic concepts of artificial fuels, biofuels and green fuels used for combustion engines.

UNIT I

SENSOR TECHNOLOGIES AND ADVANCED FLUIDS

Sensing Technologies: Introduction, Optical sensors: Colorimetry - Principle and statement of Beer-Lambert's law, Numerical problems. Electrochemical sensors: Potentiometry - Principle, instrumentation and application in the estimation of iron in steel industry effluents (ex. redox titration of FAS against $K_2Cr_2O_7$). pH sensor- principle and its application in the estimation of pKa of acid electrolyte. Conductometric sensors: Principle, instrumentation and applications of conductometric titrations in industrial effluents - strong acid against strong base, mixture of acids (strong acid + weak acid) against a strong base.

Lubricants: Introduction, classification, properties and industrial applications of lubricants. Lubricant testing - experimental determination of viscosity.

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

Industrial effluents: Introduction, determination of chemical oxygen demand (COD) and numerical problems.

8 Hours

UNIT II

ADVANCED ENERGY AND NANOMATERIALS

Energy storage devices: Introduction, classification of batteries, characteristics (capacity, power density, cell balancing and cycle life). Construction, working and applications of Lead acid battery and Lithium-ion battery.

Fuel cells and renewable energy: Introduction, construction and working of solid oxide fuel cells (SOFCs) for Auxiliary Power Units (APUs) applications. Difference between fuel cell and battery, Photovoltaic cells-construction, working, advantages, limitations and applications.

Nanochemistry: Introduction, size dependent properties of nanomaterials (surface area, catalytic and electrical), types of nanomaterials - based on composition (carbon based, metal based, composite and dendrimers). Production of nanomaterials – top down and bottom up approaches. Synthesis of nanometal oxides-semiconducting nano ZnO by solution combustion method and nano TiO₂ by hydrothermal method.

Graphene: Synthesis by chemical vapor deposition (CVD) method, properties and engineering applications. Role of carbon nanotubes (CNT) in energy devices.

8 Hours

UNIT III

ADVANCED MATERIALS FOR ENGINEERING APPLICATIONS

Engineering Polymers: Introduction, classification - based on occurrence, structure and effect of heat on polymer. Number average and weight average molecular weight - definition and numerical problems. Synthesis, properties and applications of PVC and PMMA. Glass transition temperature-Definition and factors affecting T_g (flexibility, molecular weight, inter molecular force).

Polymer composites: Introduction, fiber-reinforced polymer (FRPS) Kevlar-synthesis, properties and industrial applications.

Carbon fiber: Preparation from poly acrylonitrile (PAN), properties and applications.
3-D printing materials: Introduction, synthesis, properties and applications of poly lactic acid (PLA) resin.

8 Hours

UNIT IV

CORROSION SCIENCE AND COATING TECHNOLOGY

Corrosion Chemistry: Introduction, electrochemical theory of corrosion, types of corrosion- differential metal and differential aeration corrosion (waterline and pitting corrosion). Corrosion Penetration Rate (CPR)- numerical problems. Corrosion control: Metal coatings – galvanization. Surface conversion coating: Inorganic coatings- anodization of Aluminium, Cathodic protection - Impressed voltage method and Sacrificial anode method.

Coating Technology: Introduction, technological importance, Electroplating of chromium (hard and decorative). Electroless plating - electroless plating of nickel. Difference between electroplating and electroless plating.

8 Hours

UNIT V

ADVANCED SYNTHETIC AND GREEN FUELS

Fuels: Introduction, calorific value, determination of calorific value using bomb calorimeter, numerical problems on GCV and NCV. Knocking in internal combustion engines, knocking mechanism and anti-knocking agents, Methyl tertiary butyl ether (MTBE) and Ethyl tertiary butyl ether (ETBE), importance of octane and cetane rating of fuel.

Bio fuels: Introduction, power alcohol-advantages and disadvantages, synthesis of biodiesel by Trans-esterification method, advantages and its applications.

Green Fuels: Introduction, examples, Water splitting-Definition, Production of green hydrogen by photocatalytic water splitting (TiO_2) method and its advantages.

Hydrogen storage: Introduction, advantages, limitations of metal hydride and ammonia as chemical hydrogen carriers.

8 Hours

TEXT BOOK

1	Suba Ramesh and S. Vairam.	Engineering Chemistry - A text book of Chemistry for Engineers, Wiley India, 2020.
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REFERENCE BOOKS		
1	D. A Skoog, F. J. Holler and Stanley R. Crouch	Instrumental Analysis, Cengage Learning India Pvt. Ltd., 2010.
2	Colin Tong	Introduction to Materials for Advanced Energy Systems, Springer Nature Publication, 2019.
3	Charles C Hermant	Polymer Chemistry, Oxford Book Company, 2018.
4	Pietro Pedferri	Corrosion Science and Engineering, Springer Nature Publication, 2018.
5	A. Pratap Singh, DhananjayKumar, Avinash Kumar Agarwal	Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines, Springer Nature Publication, 2021

Course Outcomes:	
Upon completion of this course the student will be able to:	
CO1	Extend the concept of lubricants and coolants to combustion engine, application of sensor technology to the detection of trace concentration and also the conductivity of the solution using conductometric sensor.
CO2	Apply the knowledge of electrochemistry for the construction of batteries, fuel cells and also preparation of nanomaterials by different methods.
CO3	Apply the knowledge on the preparation of advanced polymers, carbon fiber, 3-D printing materials
CO4	Apply the electrochemical theory of corrosion of metals/alloys, corrosion control methods and coating technology.
CO5	Explain the importance of fuel includes synthetic fuels, bio fuels and green fuels

Course Articulation Matrix

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	
COs	CO1		✓												
	CO2		✓												
	CO3	✓													
	CO4	✓													
	CO5	✓													

PRACTICAL MODULE

Course objectives: This course will enable students to:	
1.	The use of pH sensor for the determination of pK_a of given soft drinks.
2.	The construction and use of electrochemical cell as sensor for the determination of emf /concentration of redox species.
3.	The usage of optical sensor (colorimeter) for the estimation of metals in various matrices.
4.	The use of conductivity meter for the determination of conductance in electrolytic solutions.
5.	The application of volumetry in the analysis of water quality parameters.

A – Instrumental Methods of Analysis

A1. Determination of pK_a of given sample of soft drink using pH sensor and its graphical interpretation using origin software.

A2. Estimation of iron present in stainless steel solution using electrochemical sensor and its graphical interpretation using origin software.

A3. Optical sensor for copper determination from e - waste sample (printed circuit board) and its graphical interpretation using origin software.

A4. Estimation of HCl using standard NaOH conductometrically and its graphical interpretation using origin software.

B - Volumetric Methods of Analysis

B1. Determination of total hardness of water for drinking purpose.

B2: Determination of Chemical Oxygen Demand (COD) of the given industrial waste water sample.

B3. Redox titration - Determination of iron in the given TMT bars by external indicator method.

B4. Determination of alkalinity of given water sample.

C – Demonstration Experiments: (Any two)

C1. Synthesis of semiconducting nano ZnO by combustion method.

C2. Green synthesis of conductive inks for flexible electronic applications

C3: Doping of electronic material (ZnO) with dopants (Cu/Ni) to increase the conductivity of material.

C4. Synthesis of polyaniline as a conducting polymer.

D - Open Ended Experiments (any two):

TEXT BOOK:

Vogel : Quantitative Inorganic Analysis and Elementary Instrumental Analysis: ELBS,
Longmann Group, 5th Edition, 1989.

Course Outcomes:	
Upon completion of this course the student will be able to:	
CO1	Determine the electrode potential of newly constructed electrodes; calculate the voltage of galvanic cell and batteries and determination of pH of water and other liquid samples.
CO2	Estimate the amount of metal(s) in effluents by potentiometer.
CO3	Determine the metals/pollutants in water and alloys using colorimeter.
CO4	Measure the conductance of solutions/electrolytes which in turn can be used for the determination of its characteristics.
CO5	Use the knowledge of volumetric analysis for estimation of metals and water samples.

Mapping of Course Outcomes with Program outcomes

1. Ability to apply knowledge of science to engineering problems.
2. Ability to analyze problems using the principles of science.

Program Articulation Matrix:

POs												
	1	2	3	4	5	6	7	8	9	10	11	12
CO1		√										
CO2		√										
CO3		√										
CO4		√										
CO5		√										