SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU-572103

(Autonomous Institution Affiliated to VTU, Belagavi)

Department: **CHEMISTRY**

II Semester B.E.

(For Civil Engineering Branch)

Syllabus from the Academic year 2025-26 onwards

Applied Chemistry for Sustainable Structures and Material Design

(CV Stream)

Contact Hours/ Week:	3+2	Credits:	4
Total Lecture Hours:	40+26	CIE Marks:	50
Course Code:	1BCHEC	SEE Marks:	50

Course objectives: This course will enable students to:	
1.	Utilize the principles of water quality assessment and analytical techniques to evaluate and interpret water characteristics.
2.	Apply the understanding of cement quality parameters and implement the concepts of artificial concrete in the context of green building practices.
3.	Demonstrate proficiency in the synthesis of polymers, polymer composites, nanomaterials and apply their applications in civil engineering structures.
4.	Understand the properties of metals, alloys and analyze the corrosion phenomena relevant to building construction.
5.	Employ the construction, working principles, advancements in batteries and emerging energy storage technologies.

UNIT I

WATER CHEMISTRY AND ANALYTICAL TECHNIQUES

Water quality parameters: Introduction: Types of water and impurities in water. Water quality parameters: pH, turbidity, dissolved oxygen, chlorides and alkalinity for environmental and construction applications.

Waste water analysis: Chemical Oxygen Demand (COD): Definition, determination and numerical problems. Hardness of water: Definition, types and its determination by rapid EDTA method.

Analytical Techniques: Potentiometric Sensors: Principle, instrumentation and application in the estimation of iron in industrial effluents (FAS against $K_2Cr_2O_7$). Conductometric Sensors: Principle, instrumentation and applications of conductometric titrations in industrial effluents: Strong acid against strong base and mixture of strong acid and weak acid against a strong base.

Optical Sensors: Colorimetry – Principle, instrumentation and numerical problems. Application of colorimetry in the estimation of copper in brass alloy.

8 Hours

UNIT II

CONVENTIONAL AND SUSTAINABLE CONSTRUCTION MATERIALS

Cement: Introduction, chemical composition and types. Manufacturing of cement by Kiln process, Setting and hardening of cement.

Sustainability issues in cement manufacturing: Environmental impact of cement – CO_2 emissions and energy consumption. Concept of carbon footprint and greenhouse gas mitigation.

Supplementary Cementitious Materials: Fly ash and Ground Granulated Blast-furnace Slag (GGBS) - Origin, Chemistry and its applications.

Green cements and alternatives: Geopolymer Concrete: Introduction, mechanism of geopolymerization and manufacturing process of geopolymer concrete. Advantages over Ordinary Portland Cement (OPC) concrete.

Piezoelectric cement composites: Piezoelectric materials in cement composites and its applications in civil engineering.

Bioconcrete: Introduction, self-healing property and advantages.

8 Hours

UNIT III

MATERIALS FOR STRUCTURAL INTEGRITY

Polymers: Introduction: Definition and types of polymerization. Molecular weight of polymers: Number and weight average molecular weight of polymers. Numerical problems. Synthesis, properties and engineering applications of PVC, PMMA, Kevlar and Epoxy Resins.

Biopolymers: Polylactic acid: Synthesis, properties and its applications.

Nanomaterials: Introduction: Definition and classification based on composition. Size dependent properties: Surface area, water absorption and permeability, thermal properties and antimicrobial activity. Synthesis of TiO_2 by hydrothermal process. Concrete as composite material and composition of nano-concrete. Industrial applications of carbon-based reinforced composites graphene/carbon nano tube as fillers.

8 Hours

UNIT IV

CORROSION SCIENCE AND SURFACE PROTECTION

Metals and Alloys: Introduction, classification of metals: ferrous and non-ferrous. Iron and its alloys: Wrought Iron, Cast Iron, Pig iron and Steel - composition, properties and applications. Aluminum and its alloys: Duralumin and Magnalium - composition, properties, and applications.

Corrosion: Introduction, electrochemical corrosion of steel. Types of corrosion - Differential metal corrosion, Differential aeration corrosion – waterline corrosion and pitting corrosion, and Stress corrosion in civil structures. Corrosion control by coatings: Galvanization and anodization. Corrosion control by cathodic protection: Impressed voltage method and sacrificial anode method. Introduction to corrosion penetration rate. Numerical problems.

Metal finishing: Introduction, technological importance of metal finishing, Electroplating of Chromium - Decorative and hard coating.

8 Hours

UNIT V

ENERGY SYSTEMS AND GREEN FUELS

Electrochemistry: Introduction, Electrode potential, Nernst equation (basic overview), Construction and working of concentration cell. Numerical problems on Nernst equation and concentration cell.

Energy systems: Introduction: Definition, classification of batteries. Battery characteristics: capacity, power density, cell balancing and cycle life. Construction and working of Lithium-ion battery and its applications.

Fuel cells: Definition, difference between battery and fuel cell. Construction, working, and applications of solid-oxide fuel cell.

Solar Energy: Construction and working of silicon solar cell. Advantages, applications and limitations.

Green Fuels: Introduction, green hydrogen production by TiO_2-photocatalytical method and applications.

8 Hours

TEXT BOOK

Sl. No.	Author/s	Title, Publisher, Edition, Year
1	Suba Ramesh and S. Vairam	Engineering Chemistry - A text book of Chemistry for Engineers. Wiley India 2020.

REFERENCE BOOKS		
Sl. No.	**Author/s**	**Title, Publisher, Edition, Year**
1	S. S. Dara	A text book of Environmental Chemistry and pollution and pollution control, 2004.
2	N. Subramanian	Building Materials. Oxford Higher Education, 2019. ISBN: 9780199497218, 9780199497218
3	Bharath Bhushan	Hand book of nanotechnology, Spinger-Verlag Berlin Heidelberg, New York, 2010.
4	S.K. Dhawan and Hema Bhandari	Corrosion Preventive Materials and Corrosion Testing, CRC Press, 2020.
5	Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich	Electrochemical Power Sources Batteries, Fuel Cells, And Supercapacitors. Wiley Publishing Inc. 2015.

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Analyze water quality parameters and metal ion concentration through wet and instrumental methods and modify the quality of water quality by RO.
CO2	Apply the knowledge of chemistry principles to improve the quality of cement, concrete and eco-friendly concrete.
CO3	Identify differences in traditional and advanced polymer/nanocomposites and their influence on engineering applications.
CO4	Implement suitable techniques to control corrosion of ferrous, nonferrous metals, alloys and protect metals through metal finishing process.
CO5	Illustrate the functioning of electrodes, energy storage and conversion systems, such as Li-ion battery, solid-oxide fuel cell and silicon solar cell.

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 sensors (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 pKa of given sample of soft drink using pH sensor and its graphical interpretation using origin software.

A2. Estimation of iron present in stainless steel 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 by bars external indicator method.

B4. Determination of CaO in cement by rapid EDTA method.

C – Demonstration Experiments (Any two):

C1. Synthesis of nano SiO_2 by combustion method.

C2. Determination of alkalinity of water using standard NaOH solution.

C3. Preparation of urea formaldehydye resin.

C4. Determination of viscosity coefficient of a lubricant using Ostwald's viscometer.

D – Open Ended Experiments (Any two):

TEXT BOOK:

Sl. No.	Author/s	Title, Publisher, Edition, Year
1.	Arthur I. 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 the engineering problems.
2. Ability to analyze the problems using the principles of science.

Course Articulation Matrix

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