SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU- 572103

(Autonomous Institution affiliated to VTU, Belagavi)

Department: CHEMISTRY

I Semester B.E.

(For EC/EE/ET/EI Branches)

Syllabus from the Academic year 2025-26 onwards

APPLIED CHEMISTRY FOR EMERGING ELECTRONICS AND FUTURISTIC DEVICES

(EEE Stream)

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

Course objectives:
This course will enable students to:

1.	Learn the basic concepts of electrochemistry, electrode potentials that are essential to determine the battery voltage and the working principle, applications of analytical instruments.
2.	Learn the corrosion mechanism, corrosion control techniques and problems associated with E-waste.
3.	Explain the concepts of batteries, semiconductors and photovoltaic cells.
4.	Master the knowledge of synthesis, applications of nanomaterials and quantum dots for smart materials.
5.	Convey the necessity of advanced polymeric materials as conducting polymers, composites and stretchable devices.

UNIT I
ELECTRODE SYSTEM AND ELECTROCHEMICAL SENSORS

Electrochemical cells: Classification - galvanic cells and electrolytic cells with examples. Construction and working of a galvanic cell (e.g. Daniel cell). Single electrode potential, standard electrode potential and E.M.F of a cell – definition and Nernst equation (basic overview). Concentration cells – definition, construction, working and equation for E.M.F of a concentration cell. Numerical problems on Nernst equation and concentration cell. Electrodes: Reference electrodes – construction, working and applications of Calomel electrode. Ion-selective electrodes – construction, working and application of glass electrode for the determination of pH of a solution.

Sensing Techniques: Optical sensors: Colorimetry - principle, instrumentation and application in the estimation of copper in PCB's. Numerical problems. Electrochemical sensors: Potentiometry- Principle, instrumentation, and application in redox titration (e.g. FAS against $K_2Cr_2O_7$). Conductometric sensors: Principle, instrumentation and application in titrations of strong acid against a strong base and mixture of acids (strong acid + weak acid) against a strong base.

8 Hours

UNIT II
CORROSION SCIENCE AND E-WASTE MANAGEMENT

Corrosion Chemistry: Metallic corrosion, 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, Inorganic coatings- anodization, Cathodic protection - Impressed voltage method and Sacrificial anode method.

Metal finishing: Introduction, difference between Electroplating and Electroless plating, Electroplating of chromium (hard and decorative). Electroless plating of copper on PCBs.

E-waste Management: Introduction, sources, effects of E-waste on environment and human health, methods of disposal, advantages of recycling. Extraction of gold from E-waste by hydrometallurgy.

8 Hours

UNIT III
MATERIALS FOR ENERGY DEVICES

Semiconductors: Introduction, n-type and p-type semiconductor materials, difference between organic and inorganic semiconductors, organic photovoltaics – Poly (3-hexylthiophene) (P3HT) as a donor and Phenyl-C61-butyric acid methyl ester (PCBM) as an acceptor, construction, working and applications.

Energy Storage Devices: Introduction, classification of batteries-primary, secondary and reserve battery, characteristics (capacity, power density, cell balancing & cycle life), construction and working of lithium-ion battery advantages in EV applications, construction and working of ultra-small asymmetric super capacitor and its applications in IoT/wearable devices.

Energy Conversion Devices: Introduction, construction, working principle, advantages and applications of photovoltaic cell (PV cell), Introduction to MEMS-Based Energy Harvesters, working principle and applications.

8 Hours

UNIT IV
NANO AND QUANTUM DOT MATERIALS

Nanomaterials: Introduction, size dependent properties of nanomaterials (surface area, catalytic and electrical), types of nano materials – based on materials (carbon based, metal based, composites and dendrimers). Production of nanomaterials – definition of top down and bottom up process. Synthesis of nanometal oxides – semiconducting nano ZnO by solution-combustion method and nano TiO_2 by hydrothermal method. Carbon nanotubes – definition and synthesis by arc discharge method.

Quantum Dot Materials: Introduction to quantum dots, Types-inorganic and organic quantum dots. Optical and electronic properties of quantum dots (QDs).

Inorganic Quantum Dot Materials (IQDMs): Introduction, synthesis and properties of silicon based QDs by Sol-Gel method, CdSe quantum dots by hot injection method and applications in optoelectronic devices, quantum dot-based copper conductive ink by wet chemical reduction method, properties and applications.

Organic Quantum Dot Materials (OQDMs): Introduction, synthesis and properties of chitosan-carbon quantum dots hydrogel applications in next-generation flexible and wearable electronics, synthesis and properties of graphene quantum dots using citric acid method its applications in emerging electronics.

8 Hours

UNIT V
FUNCTIONAL POLYMERS AND HYBRID COMPOSITES IN FLEXIBLE ELECTRONICS

Polymers: Introduction, classification - based on occurrence, structure and effect of heat on polymer. Number average and weight average molecular weight - definition and numerical problems. Conducting polymers - mechanism of conduction in polyacetylene (oxidative doping). Synthesis and applications of Polyaniline.

Polymer Composites: Introduction, synthesis and properties of epoxy resin- Fe_3O_4 composite for sensors applications, synthesis of Kevlar Fiber Reinforced Polymer (KFRP)-properties and smart electronic devices applications.

Stretchable and Wearable Microelectronics: Introduction, basic principle and working of Lithography for micro-patterned copper deposition, synthesis, properties and applications of PDMS (Polydimethylsiloxane) in e-skin (electronic skin) and RFID (Radio Frequency Identification), synthesis and properties of Polyvinylidene Fluoride (PVDF) applications in E-nose devices.

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	Subhendu Bhandari and Arti Rushi	Materials for Chemical Sensors, CRC Press, 2023.
2	S.K. Dhawan and Hema Bhandari	Corrosion Preventive Materials and Corrosion Testing, CRC Press, 2020.
3	Anurag Gaur, A.L. Sharma, Anil Arya	Supercapacitors, batteries and hydroelectric Cells, CRC Press, 2021.
4	B. Viswanathan	Structure and properties of solid state materials, Narosa Publications, 2009.
5	Sabar D. Hutagalung	Materials science and technology, InTech Publishers, 2012.

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Explain the electrode potential of newly constructed electrodes and evaluate the voltage of electrochemical cells; colorimetric, potentiometric and conductometric sensors in chemical analysis.
CO2	Apply the concept of electrochemical theory of corrosion of metals, corrosion control methods and E-wastes disposal.
CO3	Apply the knowledge of semiconductors, batteries and photovoltaic cells as energy devices.
CO4	Describe the ideas of nanomaterials and applications of quantum dots for smart materials.
CO5	Apply the concepts of different polymers as conducting polymers, composites and stretchable devices.

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 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 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:

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 engineering problems.
2. Ability to analyze 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		√											