

## ENERGY SYSTEMS AND ADVANCED MATERIALS

### I Year B. Tech. I Semester

(Common to ECE, ECE (VLSI), EEE, EEE (EV))

Course Code:

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 2 | 4 |

**Course Outcomes:** At the end of the course the student shall be able to

**CO1:** Explain the working of batteries, fuel cells

**CO2:** Describe the principles and applications of electrochemical and biosensors.

**CO3:** Identify suitable polymers and smart materials for engineering applications.

**CO4:** Apply green chemistry principles for sustainable engineering.

**CO5:** Explain the applications of biomaterials, biomedical sensors and medical imaging.

#### UNIT-I (9 Hours)

**Electrochemical Cells:** Nernst equation for single-electrode potential and cell potential; reference electrodes - calomel electrode and silver/silver chloride electrode.

**Electrochemical Principles of Batteries:** Primary cells - Zn-MnO<sub>2</sub> alkaline cell; secondary cells - batteries used in electric vehicles, including lithium-ion and sodium-ion batteries; metal-air batteries.

**Fuel Cells:** Introduction; merits and demerits of fuel cells; hydrogen-oxygen fuel cell (AFC); polymer electrolyte membrane fuel cell (PEMFC).

**Hydrogen as the Fuel of the Future:** Challenges associated with hydrogen storage and transportation.

#### Learning Outcomes:

At the end of this unit, the student will be able to

1. Explain the principles of electrochemical cell.
2. Describe the working of batteries and fuel cells.
3. Compare different energy storage systems.

#### UNIT II (9 Hours)

##### Electrochemical sensors

Electrochemical sensors – Working Principle and components; Potentiometric sensors – working principle of pH electrode and Fluoride ion sensor; Amperometric sensors – working principle of Clark Oxygen Sensor, Nitric oxide sensor; Conductometric sensors – working principle of Urea sensor.

#### Learning Outcomes:

At the end of this unit, the student will be able to

1. Explain the basic principles of electrochemical sensing.
2. Describe the working of potentiometric, amperometric and conductometric sensors.
3. Explain the working and applications of common biosensors.

#### UNIT- III (9 Hours)

##### Engineering materials

**Polymers:** Definition and classification of polymers; polymerization methods: addition polymerization, condensation polymerization, and copolymerization; effect of polymer structure on properties; effect of heat on polymers.

**Plastics:** Thermoplastics (recyclable) and thermosetting plastics (non-recyclable); plastic waste management; plastic-to-fuel conversion; use of plastics in construction materials and composite materials.

**Conducting Polymers:** Preparation, properties, and applications of polyacetylene and polyaniline.

**Smart Materials:** Introduction, types, characteristics, and applications of piezoelectric materials, shape memory alloys (SMAs), electrochromic, and photochromic materials.

#### **Learning Outcomes:**

At the end of this unit, the student will be able to

1. Classify polymers and explain their polymerization methods.
2. Relate material structure with properties and applications.
3. Explain the applications of conducting polymers and smart materials.

### **UNIT- IV**

**(9 Hours)**

#### **Green Chemistry and Sustainable Engineering**

**Green Chemistry:** Importance of green chemistry; need for sustainable chemical processes and materials; the Twelve Principles of Green Chemistry; atom economy and E-factor.

**Applications of Green Chemistry:** CO<sub>2</sub> utilization and carbon capture; conversion of CO<sub>2</sub> into methanol, methane, and formic acid.

**Environmental Impact of Electronic Devices:** e-waste generation and management; recycling and recovery of electronic waste using the hydrothermal method.

#### **Learning Outcomes:**

At the end of this unit, the student will be able to

1. Explain the principles of green chemistry and sustainable engineering.
2. Apply atom economy and E-factor to chemical processes.
3. Describe CO<sub>2</sub> utilization and e-waste management approaches.

### **UNIT- V**

**(9 Hours)**

**Biomaterials:** Properties, biocompatibility, and testing of metals, ceramics, polymers, and composites used in biomedical applications, such as artificial joints, dental implants, and heart valves.

**Biomedical Instrumentation:** Basic principles of sensors, transducers, and signal acquisition used for monitoring physiological parameters such as temperature, blood pressure, glucose levels, and cardiac activity.

**Medical Imaging and Systems:** Basic principles and applications of X-ray, CT, MRI, ultrasound, and PET/SPECT imaging. Introduction to medical image processing, including image enhancement, segmentation, and 3D visualization for healthcare applications.

#### **Learning Outcomes:**

At the end of this unit, the student will be able to

1. Explain the properties and applications of biomaterials.
2. Describe biomedical sensors and instrumentation.
3. Explain the basic principles and applications of medical imaging techniques.

**Text Books:**

1. Jain & Jain, "A text book of Engineering Chemistry", 17th Edition, Dhanapat Roy Publishing Company, 2023.
2. J. Enderle, S. Blanchard, and J. Bronzino, *Introduction to Biomedical Engineering*, 2nd ed. Burlington, MA, USA: Elsevier Academic Press, 2005.

**Reference Books:**

1. D. T. Sawyer, A. Sobkowiak, and J. L. Roberts, Jr., *Electrochemistry for Chemists*, 2nd ed. New York, NY, USA: John Wiley & Sons, 1995.
2. F.-G. Bănică, *Chemical Sensors and Biosensors: Fundamentals and Applications*. Chichester, U.K.: John Wiley & Sons, 2012.
3. A. P. F. Turner, I. Karube, and G. S. Wilson, Eds., *Biosensors: Fundamentals and Applications*. Oxford, U.K.: Oxford University Press, 1987.
4. A. S. Matlack, *Introduction to Green Chemistry*. New York, NY, USA: Marcel Dekker, 2001.
5. Sasichawla, "Engineering Chemistry", 9th Edition, Dhanapat Roy Publishing Company, 2013.

## LIST OF EXPERIMENTS

**Course Outcomes:** At the end of the Course the student shall be able to

**CO1:** Perform electrochemical and potentiometric experiments.

**CO2:** Analyse chemical samples using instrumental methods.

**CO3:** Determine physical properties of liquids experimentally.

**CO4:** Prepare polymers and nanomaterials using laboratory methods.

**CO5:** Analyse food and water samples using chemical methods.

1. Determination of sulphuric acid concentration in lead acid battery
2. Construction of an electrochemical cell and determination of its emf.
3. Determination of Fe(II) by potentiometric method
4. Determination of acid strength in soft drinks by pH-metric method
5. Determination of acid strength in citrus fruit by conductometric method
6. Verification of Beer-Lamberts Law and determination of concentration of food color by UV-Visible spectrophotometry
7. Spectrophotometric determination of Fe(III) in a given sample
8. Determination of viscosity of a liquid Ostwald viscometer
9. Determination of surface tension of a liquid by Stalagmometer
10. Preparation of ZnO nanoparticles
11. Preparation of a polymer
12. Determination of total hardness of water by EDTA method
13. Determination of Glucose content in a sample by iodometric titration using hypo
14. Gravimetric determination of calcium in milk

**Reference Books:**

1. N.K Bhasin and Sudha Rani, Laboratory Manual on Engineering Chemistry, 3rd edition, Dhanpat Rai & Sons, New Delhi, 2007.
2. A.I.Vogel, A Textbook of quantitative chemical analysis, 6th edition, Pearson Education Pvt. Ltd, 2002.