

ELECTROCHEMICAL AND RENEWABLE ENERGY

ENCH 365

Lecture : 3

Tutorial : 2

Practical : 1

Year : III

Part : II

Course Objectives:

The objective of this course introduces the fundamentals of electrochemical system and different types of renewable energy resources and their uses for public good.

1 Electrochemical System: Production and Storage (10 hours)

- 1.1 Electrode system: Three electrode, two electrode and electrochemical cell
- 1.2 Fuel cell thermodynamics, kinetics and ion transport
- 1.3 Batteries: Fundamentals of charge storage mechanisms in battery, challenges, strategies of battery development and recycling system
- 1.4 Supercapacitor, electrode materials, electrolytic materials, compatibility, current collector and manufacturing
- 1.5 Water splitting, design, function, and working principles of water splitting (Electrolysis), electrolyzer, hydrogen energy production

2 Principles of Renewable Energy (4 hours)

- 2.1 Energy and sustainable development
- 2.2 Fundamentals
- 2.3 Scientific principles of renewable energy
- 2.4 Technical implications
- 2.5 Standards and regulations
- 2.6 Social implications

3 Solar Energy (8 hours)

- 3.1 Extraterrestrial solar radiation
- 3.2 Components of radiation
- 3.3 Atmospheric transmission, absorption and reflection
- 3.4 Measuring solar radiation
- 3.5 Solar water heater
- 3.6 Photovoltaic (PV) power technology
- 3.7 Solar thermal applications (Air heaters, crop driers and solar concentrators)

4 Wind Energy (6 hours)

- 4.1 Wind resource
- 4.2 Turbine types and terms

- 4.3 Linear and angular momentum theory
- 4.4 Electricity generation
- 4.5 Mechanical power

5 Bioenergy Technologies (10 hours)

- 5.1 Biofuel classification
- 5.2 Direct combustion for heat
- 5.3 Pyrolysis and thermochemical processes
- 5.4 Alcohol fermentation
- 5.5 Anaerobic digestion for biogas
- 5.6 Biodiesel from vegetable oils and algae

6 Geothermal Energy (2 hours)

- 6.1 Geophysics
- 6.2 Dry rock and hot aquifer analysis
- 6.3 Harnessing geothermal resources
- 6.4 Ground-source heat pumps

7 Hydropower (5 hours)

- 7.1 Principles of hydropower
- 7.2 Assessing the resource
- 7.3 Impulse turbines
- 7.4 Reaction turbines
- 7.5 Hydroelectric systems
- 7.6 Pumped hydro storage

Tutorial (30 hours)

- 1. Design of a solar photovoltaic system to cover the electricity of a small family members
- 2. Estimate hydropower potential at a site
- 3. Estimate wind power at a site depending on wind speed
- 4. Design a household biogas reactor to generate energy
- 5. Operations of ground-source heat pumps

Practical (15 hours)

- 1. Preparation of activated carbon electrode using the drop-casting technique for supercapacitor application
- 2. Electrochemical evaluation of electrode materials for supercapacitors by potentiostat
- 3. Demonstrate and explanations of performance of super capacitors
- 4. Measurement/data analysis of wind energy potential using wind speed data of anemometer
- 5. Measurement/data analysis of solar energy potential using solarimeter devices

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	10	14
2	4	6
3	8	10
4	6	8
5	10	14
6 and 7	7	8
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Twidell, J., Weir, T. (2006). Renewable energy resources. Taylor & Francis.
2. Bockris, J. O'M. (1998). Modern electrochemistry (Vols. 1–3) (Latest Edition). Plenum Press.
3. Bard, A. J., Faulkner, L. R., White, H. S. (2022). Electrochemical methods: Fundamentals and applications. John Wiley & Sons.
4. Duffie, J. A., Beckman, W. A. (2013). Solar engineering of thermal processes. Wiley.
5. Masters, G. M. (2004). Renewable and efficient electric power systems (Latest Edition). Wiley.

FOOD AND BEVERAGE

ENCH 366

Lecture : 3
Tutorial : 2
Practical : 1

Year : III
Part : II

Course Objectives:

This course introduces food science, its related constituents and technologies in order to elaborate their significance in global or national context for chemical engineers. The contents of this course help in developing a concept of sustainable food system.

- 1 Food Chemistry and Nutrition (6 hours)**
 - 1.1 Chemical composition, physical properties and classifications of food materials
 - 1.2 Glycemic index, dietary standards, food fortification
 - 1.3 Food additives: Coloring and texturing agents, additives safety and regulation
 - 1.4 Effect of processing and cooking, brewing in food, rancidity

- 2 Food and Beverage Preservation Techniques (7 hours)**
 - 2.1 Preservation Technology: General methods, concept of thermal death curve.
 - 2.2 Food Microbiology: Microbial spoilage of foods, sources of contamination
 - 2.3 Hurdles concept of food preservation
 - 2.4 Principle of food fermentation and non-conventional methods of food preservation

- 3 Sanitation and Safety in Food and Beverage Production Facility (5 hours)**
 - 3.1 History and overview of food safety, Basic food toxicology: Contaminants microbial
 - 3.2 Toxicants introduced during food processing, food adulteration
 - 3.3 Safety and regulation in food processing facility, concept of critical control points
 - 3.4 Hygienic design of food processing equipment, sanitary requirement, sanitary pipes and fittings, CIP, COP, disinfection, odor abatement, Nepal standards

- 4 Food and Beverage Processing Equipment (6 hours)**
- 4.1 Post-harvest Operations, material handling machines and conveyors
 - 4.2 Baking, frying, roasting operations; Freeze drying, dehydration
 - 4.3 Evaporation, drying, thermal processes, non-thermal processes, alternative processes, other unit processes and unit operation
 - 4.4 Engineering properties of food materials, rheology and texture of food materials
- 5 Food Biotechnology (6 hours)**
- 5.1 Physiological characteristics of microorganisms, aseptic techniques during the handling of microorganisms, methods of sterilization
 - 5.2 Isolation and preservation of industrially important microorganisms
 - 5.3 Fermentation process, types of fermentation, fermented products, fermenter designs
 - 5.4 Concept of biotechnology: Scope and importance, risk and hazards of biotechnology, Biotechnological processes for manufacture of functional foods, GMOs
- 6 Beverage Technology (3 hours)**
- 6.1 Beverage: Classification, ingredients, additives, preservatives
 - 6.2 Production of fermented beverages, carbonated beverages, and packaged drinking water
- 7 Packaging Technology (4 hours)**
- 7.1 Factors affecting shelf life of food material during storage
 - 7.2 Selection criteria for packaging materials
 - 7.3 Economics of plastic packaging
 - 7.4 Testing methods for flexible, rigid and semi rigid materials
- 8 Waste Management (4 hours)**
- 8.1 Importance, utilization and economic possibilities of waste
 - 8.2 Generation, accumulation, identification and control of waste
 - 8.3 Methods of disposal, utilization, valorization, and energy recovery
 - 8.4 Waste management and treatment methodologies
- 9 Total Quality Management (4 hours)**
- 9.1 Quality control, quality management and quality assurance.
 - 9.2 Good manufacturing practice (GMP), quality circles, statistical quality control (SQC), ISO system
 - 9.3 Hazard analysis and critical control point (HACCP)
 - 9.4 Food safety management system (FSMS)

Tutorial**(30 hours)**

1. Drying calculations: Moisture content (Wet and dry basis), drying time calculation, energy requirement, dryer selection
2. Thermal processing and sterilization: D-value, Z-value problems, Pasteurization time calculation, F-value calculation
3. Packaging design and shelf life estimation: Water vapor transmission rate, Oxygen transmission rate, shelf-life prediction models, MAP calculations
4. HACCP and quality control design: Identify CCP in dairy plant, prepare simplified HACCP chart, GMP audit checklist, ISO documentation structure
5. Waste management in food packaging industries
6. Waste treatment methodologies
7. GMP: Mind-mapping the GMP for food industry
8. FSMS: Documentation and certification process, report preparation

Practical**(15 hours)**

1. Wastewater Analysis from Food Industry: Tests: BOD, COD, Total solids, pH, Oil and grease
2. Determination of oil oxidation: Acid value (Free fatty acid test) and peroxide value (PV test) of used ghee/oil
3. Determination of moisture content and drying rate curve for fruit slices using tray dryer: Drying rate curve (Constant rate and falling rate period); Calculation of effective moisture diffusivity and plot drying kinetics
4. To detect the factors affecting microbial growth: Temperature, atmospheric pressure, hydrogen ion concentration (pH), miscellaneous physical requirement i.e. light and salt
5. Application of equipment in microbiology for sterilization: Structure and method of working of: Hot air oven, autoclave, incubator, UV- safety hood, steam sterilizer
6. Study of thermal processing and D-value determination: Sterilization studies after treating the sample in autoclave
7. Packaging material testing: Testing methods for flexible materials, rigid materials and semi rigid materials; Tests (Thickness measurement, tensile strength, water vapor transmission test, Oxygen permeability)

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	6	8
2	7	8
3	5	6
4	6	8
5	6	8
6	3	4
7	4	6
8	4	6
9	4	6
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Heldman, D. R., & Singh, R. P. (2008). Introduction to food engineering. Academic Press/Elsevier.
2. Lee, F. A. (2012). Basic food chemistry. Springer.
3. DeMan, J. M. (2018). Principles of food chemistry. Aspen Publishers.
4. Hanlon, J. F. (1998). Handbook of package engineering. CRC Press. (Latest Edition)
5. Stanbury, P., & Whitaker, A. (2016). Principles of fermentation technology. Elsevier.
6. Hershendorfer, S. M. (2012). Quality control in the food industry. Academic Press.
7. Knechtges, P. L. (2011). Food safety: Theory and practice. Jones & Bartlett Learning.
8. Foster, T., & Vasavada, P. C. (2003). Beverage quality and safety. CRC Press.
9. Arvanitoyannis, I. S. (2008). Waste management for the food industries (1st ed.). Elsevier Academic Press.

NANOTECHNOLOGY

ENCH 367

Lecture : 3

Tutorial : 2

Practical : 1

Year : III

Part : II

Course Objectives:

The objectives of this course are to equip students with the ability to understand, synthesize, and characterize nanomaterials and nanoscale phenomena, and apply the knowledge to various chemical engineering applications.

1 Introduction to Nanomaterials and Nanotechnology (3 hours)

- 1.1 Introduction, interdisciplinary nature of nanotechnology, effect of particle sizes on properties of nanomaterials, surface volume ratio.
- 1.2 Classification of nanomaterials based on the number of dimensions: 0D, 1D, 2D and 3D nanomaterials, approaches in nanomaterial synthesis: Bottom-up approach, top-down approach.
- 1.3 Carbon-based nanomaterials, graphene, carbon nanotubes, fullerene, carbon nanocomposites, nanofibres, nanodiscs, nanodiamonds

2 Physical Methods of Synthesis (5 hours)

- 2.1 Mechanical ball milling
- 2.2 Physical vapor deposition
- 2.3 Spray conversion processing
- 2.4 Sputtering
- 2.5 Laser ablation
- 2.6 Electric arc discharge
- 2.7 Lithographic processes

3 Chemical Methods of Synthesis (8 hours)

- 3.1 Vapor-phase deposition methods: Chemical vapor deposition, atomic layer deposition
- 3.2 Solution based methods: Chemical precipitation and co-precipitation, wet chemical synthesis (Self-assembly), Sol-gel synthesis
- 3.3 High-pressure and energy-assisted methods: Hydrothermal, solvothermal method, electrospinning, microwave-assisted synthesis, sonochemical-assisted synthesis, photochemical synthesis

- 4 Biological and Green Synthesis Methods (3 hours)**
- 4.1 Use of bacteria, fungi, actinomycetes for nanoparticle synthesis, magnetotactic bacteria for natural synthesis of magnetic nanoparticles, viruses as components/templates for nanostructured materials
 - 4.2 Green synthesis of NPs, application of biowaste
 - 4.3 Use of Nepalese herbal extracts in nanoparticle synthesis
- 5 Characterization and Analysis of Nanomaterials (10 hours)**
- 5.1 Microscopy: Electron microscopy (Transmission electron microscopy, scanning electron microscopy), scanning probe microscopy (Atomic force microscopy, scanning tunneling microscopy)
 - 5.2 Spectroscopy: X-ray photoelectron spectroscopy, energy-dispersive X-ray spectroscopy, Fourier transform infrared spectroscopy, UV-Vis (Band gap measurements)
 - 5.3 Thermal analysis: Thermogravimetric analysis, differential thermal analysis
 - 5.4 Other methods: Dynamic light scattering, X-ray diffraction, Brunauer-Emmett-Teller surface area analysis
- 6 Applications in Chemical Engineering (12 hours)**
- 6.1 Nanotechnology in daily life
 - 6.2 Nano-catalysis and reaction engineering
 - 6.3 Nanoscale separations (Membranes and adsorption)
 - 6.4 Nanofluids and enhanced heat/mass transfer
 - 6.5 Advanced nanomaterials and composites in process Industries
 - 6.6 Energy applications (Batteries, fuel cells, solar cells)
 - 6.7 Biofuels and sustainable chemical production
 - 6.8 Biomedical and environmental applications
- 7 Scale-up and Professional Practice (4 hours)**
- 7.1 Industrial scale-up challenges and bottlenecks
 - 7.2 Process safety, health hazards and environmental remediation
 - 7.3 Ethics, regulations, and societal/economic implications
 - 7.4 Recycling and waste management of nanomaterials
- Tutorial (30 hours)**
1. Numerical problems related to nanoparticle size and study of effect of particle size on properties of nanomaterials
 2. Study of mechanism for different routes of nanomaterial synthesis
 3. Analysis of nanomaterials using various microscopic images
 4. Spectroscopical data analysis for nanomaterials
 5. Nanocatalysis and reaction engineering problems
 6. Nanoscale separations, nanofluids and enhanced heat/mass transfer problems

7. Research study on advanced nanomaterials and composites in process industries
8. Study of suitable synthesis process for various nanomaterials based on required properties
9. Research study on energy applications of nanomaterials
10. Case studies on scale-up and professional practice in context of nanomaterials

Practical

(15 hours)

1. Green synthesis and characterization of silver nanoparticles
2. Synthesis and characterization of oxide nanoparticles using hydrothermal/sol gel process
3. Synthesis and characterization of nanofibers by electrospinning technique
4. Synthesis and characterization of activated carbon from bio-waste
5. Application of nano-photocatalyst in dye removal: Degradation of methylene blue and kinetic analysis
6. Preparation of oxide nanoparticle based nanofluid and evaluation of its thermophysical properties (Stability, viscosity, and thermal conductivity)

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	3	4
2	5	6
3	8	10
4	3	4
5	10	14
6	12	16
7	4	6
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Goyal, R. K. (2018). Nanomaterials and nanocomposites: Synthesis, properties, characterization techniques, and applications. CRC Press.
2. Pottathara, Y. B. (2019). Nanomaterials synthesis: Design, fabrication, and applications. Elsevier.
3. Poinern, G. E. J. (2014). A laboratory course in nanoscience and nanotechnology. CRC Press.
4. Rao, C. N. R. (2010). Nanoworld: An introduction to nanoscience and nanotechnology. JNCASR, Bangalore.

WASTE TO ENERGY

ENCH 368

Lecture : 3

Tutorial : 2

Practical : 1

Year : III

Part : II

Course Objectives:

The objective of this course is to introduce waste management and characterization concepts and waste-to-energy technologies. It familiarizes students with energy recovery from urban, rural and industrial wastes and evaluates environmental and regulatory aspects in Nepal.

- 1 Introduction (8 hours)**
 - 1.1 Principles of waste management and waste utilization, waste management hierarchy and 3R principle of reduce, reuse and recycle, waste as a resource and alternative energy source
 - 1.2 Classification of waste on source, physical state, biodegradability and hazard
 - 1.3 Characterization of waste for energy utilization, waste selection criteria

- 2 Energy Potential from Urban Waste (7 hours)**
 - 2.1 Energy from municipal solid waste and sewage sludge, fuel from non-recyclable plastic waste and energy analysis
 - 2.2 Landfill gas collection and recovery, refuse derived fuel, briquettes, pellets.
 - 2.3 Alternate fuel resource- Production and use in various industries
 - 2.4 Domestic/municipal/industrial wastewater for the cultivation of algal biomass- the next-generation fuel

- 3 Energy Potential in Rural Areas (5 hours)**
 - 3.1 Agriculture waste for the generation of liquid and gaseous fuel
 - 3.2 Conversion of agro-industry and food processing industry waste to by-products and fuel generation
 - 3.3 Biochar production and soil amendment

- 4 Waste to Energy Technologies (12 hours)**
 - 4.1 Thermo-chemical conversion: Combustion, incineration and heat recovery, pyrolysis, gasification, plasma arc technology, hydrothermal liquefaction
 - 4.2 Biochemical conversion: Energy production from organic waste through anaerobic digestion and fermentation, design of anaerobic digester
 - 4.3 Hybrid technology: Bio-electrochemical conversion- microbial fuel cells, electrolytic cells

- 5 Centralized and Decentralized Waste to Energy Plants (7 hours)**
- 5.1 Waste activities: Collection, segregation, transportation, and storage requirements, location and siting of waste to energy plants
 - 5.2 Industry specific applications: In-house use- sugar, distillery, pharmaceuticals, pulp and paper, mining (Shale and coal waste)
 - 5.3 Centralized and decentralized energy production, distribution, comparison and their operations

- 6 Environmental and Health Impacts (6 hours)**
- 6.1 Environmental and health impacts of waste to energy conversion, waste to energy- potentials and constraints in Nepal
 - 6.2 Government regulations on waste and laws in Nepal
 - 6.3 Environmental protection act
 - 6.4 Eco-technological alternatives for waste to energy conversions: Rules related to the handling, treatment and disposal of municipal solid waste and biomedical waste in Nepal

- Tutorial (30 hours)**
1. Characterization of wastes to calculate energy potential
 2. Calculation of energy recovery through pyrolysis from plastic waste
 3. Design of an anaerobic digester
 4. Study of potential of algal biomass from wastewater for biofuel production
 5. Production of biochar from agricultural and forest residues
 6. Case study on waste to energy plants

- Practical (15 hours)**
1. Proximate analysis of biomass/municipal solid waste
 2. Determination of calorific value of fuel
 3. Prepare or segregate refuse derived fuel from waste sample
 4. Estimate biochar yield from biomass

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	8	10
2	7	10
3	5	8
4	12	14
5	7	10
6	6	8
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Rogoff, M. J., Screve, F. (2011). Waste to energy: Technologies and project implementation. Elsevier.
2. Desai, A. V. (1990). Non-conventional energy (Latest Edition). Wiley Eastern Ltd.
3. Singh, R., Prashad, V., Vaish, B. (2016). Waste to energy technologies. CRC Press.
4. El-Halwagi, M. M. (1984). Biogas technology: Transfer and diffusion (Latest Edition). Elsevier Applied Science.
5. Srivastava, M., Srivastava, N., Singh, R. (2019). Bioenergy research: Biomass waste to energy. Springer.
6. Mondal, P., Dalai, A. K. (2018). Sustainable utilization of natural resources. CRC Press.
7. Harker, J. H., Backhurst, J. R. (1981). Fuel and energy (Latest Edition). Academic Press.