

CHEM6132: FRONTIERS IN SUSTAINABLE ENERGY CONVERSION AND STORAGE

Effective Term

Semester A 2025/26

Part I Course Overview

Course Title

Frontiers in Sustainable Energy Conversion and Storage

Subject Code

CHEM - Chemistry

Course Number

6132

Academic Unit

Chemistry (CHEM)

College/School

College of Science (SI)

Course Duration

One Semester

Credit Units

3

Level

P5, P6 - Postgraduate Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

Nil

Precursors

Nil

Equivalent Courses

Nil

Exclusive Courses

Nil

Part II Course Details

Abstract

This course explores the forefront of sustainable energy, centering on electrocatalytic applications and battery techniques. This course aims to enable the students to set up the basic concept of using renewable energy efficiently and reasonably, and to train the talents for the society in the field of renewable energy, towards the demands for sustainable energy supply. The principle, energy conversion process, the devices, and the practical utilization will be illustrated. Through a combination of theoretical lectures, and case studies, students will gain a comprehensive understanding of electrocatalysis and battery technologies. Emphasizing critical thinking and problem-solving skills, students will address real-world challenges in the field. By the end of the course, students will possess the knowledge and skills necessary to contribute meaningfully to the evolving landscape of sustainable energy, specifically in the realms of electrocatalytic applications and advanced battery systems.

Course Intended Learning Outcomes (CILOs)

CILOs		Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the basic concepts in the generation and storage of sustainable energy.	20	x		
2	Demonstrate a comprehensive understanding of electrochemical principles and current research progress of energy conversion techniques including water electrolysis, carbon dioxide reduction, and nitrogen reduction.	20	x	x	
3	Delve into the current landscape of existing battery systems to understand their present capabilities and limitations. Assess the most suitable battery technologies based on evolving energy storage needs and emerging technological advancements.	20	x	x	
4	Students will apply their knowledge to design and optimize electrocatalytic and battery systems for sustainable energy conversion and storage, showcasing proficiency in selecting suitable catalysts, materials, and operating conditions to enhance overall system performance.	20	x	x	
5	Students will solve complex problems related to sustainable energy conversion and storage, applying electrocatalytic and battery principles, and demonstrating creativity and adaptability in addressing real-world challenges.	20			x

A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Students will learn fundamental principles of electrochemical energy conversion and battery techniques, challenges in the material design, mechanistic investigation, performance evaluation, and practical applications.	1, 2, 3, 4, 5	26 hours in total
2	Small group presentation	Students will engage in collaborative problem-solving sessions, applying electrocatalytic and battery concepts to real-world challenges. Analyze case studies, fostering critical thinking and teamwork to address multifaceted problems in sustainable energy conversion and storage.	1, 2, 5	6 hours in total
3	Assignments	Students will apply theoretical knowledge and skills to practical scenarios through individual and group projects in the assignments. Students will demonstrate their understanding of the basic electrochemical principles and the problem-solving ability relevant to water splitting, carbon dioxide conversion, nitrogen conversion, lithium-ion batteries, sodium-ion batteries, and other advanced topics in energy conversion and storage.	1, 2, 3, 4, 5	10 hours in total

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Written assignments	1, 2, 3, 4, 5	60	Individual projects, including one assignment on green hydrogen production, one assignment on ammonia production, one assignment on rechargeable batteries, and one assignment on electrolyte design of batteries.	Yes
2	Small group presentation	1, 2, 3, 4, 5	40	Two assessors will evaluate the performance of students.	Yes

Continuous Assessment (%)

100

Minimum Continuous Assessment Passing Requirement (%)

40

Assessment Rubrics (AR)**Assessment Task**

Written assignments (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to understand the basic concepts and electrochemical processes the basic principles of electrochemical energy conversion and storage.

Excellent

(A+, A, A-) Very high ability to understand the basic principles and analyze the problems.

Good

(B+, B, B-) Good ability to understand the basic principles and analyze the problems.

Fair

(C+, C, C-) Moderate ability to understand the basic principles and analyze the problems.

Marginal

(D) Basic ability to understand the basic principles and analyze the problems.

Failure

(F) Not even reaching marginal levels.

Assessment Task

Small group presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to critically review literature, evaluate the research gap, and design material systems to promote the practical application of energy conversion and storage techniques.

Excellent

(A+, A, A-) Very high ability to address the practical problems.

Good

(B+, B, B-) Good ability to address the practical problems.

Fair

(C+, C, C-) Moderate ability to address the practical problems.

Marginal

(D) Basic ability to address practical problems.

Failure

(F) Not even reaching marginal levels.

Part III Other Information

Keyword SyllabusBasic concepts

Electrochemical processes. Electrocatalytic applications. Batteries. Catalyst design. Catalytic mechanism.

Electrocatalytic water splitting

Green hydrogen production. Hydrogen evolution reaction. Oxygen evolution reaction. Catalytic activity. Long-term stability.

Electrocatalytic carbon dioxide reduction

C2+ products. Selectivity of different products. Catalytic reaction pathway.

Electrocatalytic nitrogen reduction

Ammonia production. Nitrogen reduction. Nitrate reduction. Urea production. Selectivity and yield of ammonia.

Primary batteries

Li-CFx. Li-SOCl₂. Alkaline batteries (Zn-MnO₂). Voltage and energy density. Temperature conditions.

Rechargeable batteries

Lithium-ion battery. Lithium metal battery. Sodium-ion battery. magnesium and calcium metal batteries. Aluminium-ion battery.

Electrolytes and interphases

Aqueous electrolyte. Non-aqueous electrolyte. Gel electrolyte. Ionic liquids. Solid-state electrolyte. Solid-electrolyte-interphase (SEI). Cathode-electrolyte-interphase (CEI).

Reading List**Compulsory Readings**

Title	
1	Huggins, Robert. Advanced batteries: materials science aspects. Springer Science & Business Media, 2008.
2	Jan N. Reimers and J. R. Dahn, Electrochemical and in situ X - ray diffraction studies of lithium intercalation in Li _x CoO ₂ , Journal of The Electrochemical Society 139, 2091-2097 (1992).

Additional Readings

Title	
1	Allen J. Bard, Larry R. Faulkner and Henry S. White (2022) Electrochemical Methods: Fundamentals and Applications, 3rd Edition.

2	Balbuena, Perla B., and Yi Xuan Wang, eds. Lithium-ion batteries: solid-electrolyte interphase. World Scientific, 2004.
3	Jow, T. Richard, et al., eds. Electrolytes for lithium and lithium-ion batteries. Vol. 58. New York: Springer, 2014.