SYL-TPG (Interim)

Course Syllabus

offered by Department of Chemistry
with effect from Semester A 2024/25

This form is for the completion by the *Course Leader*. The information provided on this form is the official record of the course. It will be used for the City University's database, various City University publications (including websites) and documentation for students and others as required.

Please refer to the Explanatory Notes on the various items of information required.

Prepared / Last Updated by:

Name:	Prof. SHAN Jieqiong	Academic Unit:	Department of Chemistry
Phone/email:	3442 7794/ jieqshan@cityu.edu.hk	Date:	29 December 2023

City University of Hong Kong
Course Syllabus

offered by Department of Chemistry
with effect from Semester A 2024/25

Part I Course Overview

Course Title: Frontiers in Sustainable Energy Conversion and Storage

Course Code: CHEM6132

Course Duration: 1 Semester

Credit Units: 3 credits

Level: P6

Medium of Instruction: English

Medium of Assessment: English

Prerequisites:
(Course Code and Title) Nil

Precursors:
(Course Code and Title) Nil

Equivalent Courses:
(Course Code and Title) Nil

Exclusive Courses:
(Course Code and Title) Nil

Part II Course Details

1. Abstract

(A 150-word description about the course)

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.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Describe the basic concepts in the generation and storage of sustainable energy.	15%	√		
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%	√	√	
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%	√	√	
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.	15%	√	√	
5.	Through literature reviews and analysis, students will critically evaluate research articles and publications related to electrocatalytic applications and batteries, showcasing the ability to analyze problems and draw well-supported conclusions.	15%	√	√	
6.	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.	15%			√
	** If weighting is assigned to CILOs, they should add up to 100%.*	100%			

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 self-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.

3. Teaching and Learning Activities (TLAs)

(TLAs designed to facilitate students' achievement of the CILOs.)

TLA	Brief Description	CILO No.						Hours/week (if applicable)
		1	2	3	4	5	6	
Lectures	Fundamental principles of electrochemical energy conversion and battery techniques, challenges in the material design, mechanistic investigation, performance evaluation, and practical applications.	√	√	√	√	√	√	26 hours in total
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.	√	√			√	√	6 hours in total
Assignments	Assignments will be arranged for students to apply theoretical knowledge and skills to practical scenarios through individual and group projects. 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.	√	√	√	√	√	√	10 hours in total

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.						Weighting*	Remarks
	1	2	3	4	5	6		
Continuous Assessment: 100%								
Written assignments	√	√	√	√	√	√	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.
Small group presentation	√	√	√	√	√	√	40%	Two assessors will evaluate the performance of students.
Examination: 0%								
** The weightings should add up to 100%.*							100%	

Starting from Semester A, 2015-16, students must satisfy the following minimum passing requirement for CHEM courses:

<u>"A minimum of 40% in both coursework and examination components."</u>

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Written assignments	Ability to understand the basic concepts and electrochemical processes the basic principles of electrochemical energy conversion and storage.	Very high ability to understand the basic principles and analyze the problems.	Good ability to understand the basic principles and analyze the problems.	Basic ability to understand the basic principles and analyze the problems.	Not even reaching marginal levels.
2. Small group presentation	Ability to critically review literature, evaluate the research gap, and design material systems to promote the practical application of energy conversion and storage techniques.	Very high ability to address the practical problems.	Good ability to address the practical problems.	Basic ability to address practical problems.	Not even reaching marginal levels.

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

Basic 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
$Li-CF_x$. $Li-SOCl_2$. Alkaline batteries ($Zn-MnO_2$). 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).

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

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_xCoO_2, Journal of The Electrochemical Society 139, 2091-2097 (1992).

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

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.