

# SEE4115: ENERGY CATALYSIS AND REACTION ENGINEERING

---

## Effective Term

Semester A 2025/26

## Part I Course Overview

### Course Title

Energy Catalysis and Reaction Engineering

### Subject Code

SEE - School of Energy and Environment

### Course Number

4115

### Academic Unit

School of Energy and Environment (E2)

### College/School

School of Energy and Environment (E2)

### Course Duration

One Semester

### Credit Units

3

### Level

B1, B2, B3, B4 - Bachelor's Degree

### Medium of Instruction

English

### Medium of Assessment

English

### Prerequisites

SEE3101 Engineering Thermofluids II

### Precursors

SEE3102 Power Plant Engineering

### Equivalent Courses

Nil

### Exclusive Courses

Nil

## Part II Course Details

### Abstract

The course aims to educate students on the basic and creative aspects of Energy-related catalysis. By establishing necessary basics and fundamentals in reaction engineering, the course further looks into the core catalytic processes in typical oil and gas refineries, which are currently our biggest source of energy. Lectures will also be given on the production of ultraclean fuels through gas-to-liquid and coal-to-liquid processes, which hold the future of fossil fuel utilisation. Importantly, the future of fossil fuel and its integration as part of clean Energy future is discussed. This shall provide students with an unbiased and holistic view of fossil fuel utilisation. Further Energy-related catalytic processes such as that in fuel cells, photocatalytic water splitting, biofuel conversion and carbon dioxide reduction will also be taught. The knowledge gained from the course shall provide students with essential knowledge in innovative catalytic processes, as well as their importance in securing a clean energy future.

### Course Intended Learning Outcomes (CILOs)

| CILOs | Weighting (if app.)  | DEC-A1 | DEC-A2 | DEC-A3 |
|-------|--|--------|--------|--------|
| 1     | Describe the importance of fossil fuel and its relevance to future clean Energy future.  | 10     | x      | x      |
| 2     | Measure and analyse kinetics of reactions from the point of reaction orders; Describe the different types of reaction models such as Langmuir-Hinshelwood and shrinking core model.  | 25     |        | x      |
| 3     | Describe various innovative catalysts synthesis techniques and catalytic processes in oil and gas refineries such as reforming, partial oxidation, water-gas-shift, methanol synthesis, methanation, Fischer-Tropsch synthesis, gas-to-liquid (conversion of natural gas to syngas and further to liquid fuels) and coal-to-liquid (conversion of coal to syngas and further to liquid fuels). | 25     |        | x      |
| 4     | Design functional heterogeneous catalysts for various innovative catalytic processes based on established fundamental properties such as surface acidity/basicity, reducibility and hydrogen spillover, oxygen mobility.   | 15     | x      | x      |
| 5     | Describe the application of advanced catalysis in creative energy technologies and relevant environmental remediation.   | 25     | x      | 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    | Lecture              | Students will engage in lectures with facilitated discussion to gain key concepts, such as principles related to reaction engineering fundamentals for energy catalysis.                                | 1, 2, 3, 4, 5 |                            |
| 2    | Tutorial             | Students will be given tutorials to consolidate the skills of students in reaction engineering and energy catalysis.  | 1, 2, 3, 4, 5 |                            |
| 3    | Lab-based experiment | Students will form subgroups to conduct experiments on the topic of energy-related catalytic reactions in lab.  | 2, 3, 5       |                            |
| 4    | Test                 | Students will have in-class test at the end of semester to assess the ability of students in describing the fundamentals and applications of reaction engineering in solving energy catalysis problems. | 1, 2, 3, 4, 5 |                            |

**Assessment Tasks / Activities (ATs)**

| ATs | CILO No.            | Weighting (%) | Remarks ("- " for nil entry) | Allow Use of GenAI? |     |
|-----|---------------------|---------------|------------------------------|---------------------|-----|
| 1   | Assignments         | 1, 2, 3, 4, 5 | 60                           | -                   | Yes |
| 2   | Lab work and report | 2, 3, 5       | 20                           | -                   | Yes |
| 3   | Class test          | 1, 2, 3, 4, 5 | 20                           | -                   | No  |

**Continuous Assessment (%)**

100

**Examination (%)**

0

**Minimum Continuous Assessment Passing Requirement (%)**

30

**Additional Information for ATs**

Examination duration: N/A Percentage of continuous assessment, examination, etc.: 100% by continuous assessment To pass a course, a student must do ALL of the following: 1) obtain at least 30% of the total marks allocated towards continuous assessment (combination of assignments, pop quizzes, term paper, lab reports and/ or quiz, if applicable); 2) obtain at least

30% of the total marks allocated towards final examination (if applicable); and 3) meet the criteria listed in the section on Assessment Rubrics.

**Assessment Rubrics (AR)**

**Assessment Task**

1. Assignments

**Criterion**

Ability to apply mathematical skills in solving various reaction engineering and energy catalysis problems

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

---

**Assessment Task**

2. Lab work and report

**Criterion**

Ability to apply hands-on skills in designing catalysts and assessing energy-related catalytic reactions, and further report writing

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

---

**Assessment Task**

3. Class test

**Criterion**

Oral examination to assess the ability of students in describing the fundamentals and applications of reaction engineering in solving energy catalysis problems

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

## Part III Other Information

**Keyword Syllabus**

Reaction engineering; catalysts design; advanced catalysis; fossil fuel; ultraclean fuel; gas-to-liquid; coal-to-liquid; fuel cells; photocatalysis; biofuel conversion; carbon dioxide reduction.

**Reading List****Compulsory Readings**

| Title |   |
|-------|---|
| 1     | Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice Hall PTR, 2006  |
| 2     | Niemantsverdriet, J.W., Spectroscopy in Catalysis: An Introduction, Wiley-VCH, Weinheim, 2000   |
| 3     | Chorkendorff, I., Niemantsverdriet, J.W., Concepts of Modern Catalysis and Kinetics, Wiley-VCH, Weinheim, 2007  |
| 4     | Kamat, P.V. Meeting the clean energy demand. Nanostructure architectures for solar energy conversion, J. Phys. Chem. C, 2007, 111, 2834.  |
| 5     | Somorjai, G.A., Frei, H., Park, J.Y. Advancing the frontiers in nanocatalysis, biointerfaces and renewable energy conversion by innovations of surface techniques, J. Am. Chem. Soc., 2009, 131, 16589. |

**Additional Readings**

| Title |     |
|-------|-----|
| 1     | Nil |