CHEM3016: PHYSICAL CHEMISTRY

Effective Term
Semester A 2024/25

Part I Course Overview

Course Title
Physical Chemistry

Subject Code
CHEM - Chemistry
Course Number
3016

Academic Unit
Chemistry (CHEM)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
4

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

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
CHEM2008/BCH2008 Principles of Physical Chemistry

Equivalent Courses
BCH3016 Physical Chemistry

Exclusive Courses
Nil

Part II Course Details

Abstract
This course aims to:

- examine the nonelectrolytic solutions in terms of partial molar quantities;
- examine the electrolytic solutions in terms of conductances and ionic activities;
- describe the basic principles of electrochemistry and the application to chemical systems;
- describe the principles of kinetics, surface chemistry and macromolecules;
- extend the treatment of thermodynamics to chemical equilibria and phase equilibria;
- perform a deeper treatment of environmental chemistry in the areas of atmospheric chemistry and the interactions between liquids, solids and gases in aquatic chemistry.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain the thermodynamics of mixing, the real solution, and the principles of distillation and azeotropes.	11		x	
2	Compare and contrast the systems between nonelectrolyte and electrolyte, the origin of conductance in solution and the different behaviours of colligative properties of these two solution systems.	22.5			x
3	Critically evaluate simple and complex cases in chemical equilibrium and chemical kinetics, including effects of pressure, temperature, catalysts and enzymes.	22.5		x	x
4	Design an electrolytic cell of a selected category and evaluate its application based on their operation principles.	22		x	x
5	Critically evaluate surface phenomena in terms of Gibbs energy, principles of catalysis, and characteristics of micelles and colloids. Explain thermodynamics and phase equilibria with Gibbs free energy.	22		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	Group activities	Students will engage in group activities to explore thermodynamics in various types of mixing. They will observe real solutions and investigate the processes involved in distillation, promoting collaborative learning and hands-on experience.	1	
2	Group activities and practical sessions	Students will participate in group activities to explore the differences between nonelectrolyte and electrolyte systems. Complementary practical sessions will allow them to independently differentiate these systems with guidance, fostering hands-on learning and collaboration.	2	
3	Group activities and practical sessions	Students will engage in group activities to evaluate cases in chemical equilibrium and chemical kinetics. Complementary practical sessions will enable them to present examples and techniques under guidance, encouraging collaborative learning and hands-on experience.	3	
4	Laboratory class	Students will work in small groups to design electrolytic cells of different categories. They will have access to commercially available electrolytic cells for reference and comparison, enabling them to assess their applicability and efficiency through hands-on exploration.	4	

5	Group activities, written assignments, and complementary video presentations	Students will engage in group activities, complete written assignments, and watch complementary video presentations to explore surface phenomena and the characteristics of micelles and colloids.	5	
6	Group activities	Students will engage in group activities and collaborate on assessments of the properties of macromolecules and solid polymers. They will then present their findings to the class, promoting peer learning and interaction.	5	
7	Group activities	Students will engage in group activities to deepen their understanding of thermodynamics and phase equilibria. They will collaborate to prepare presentations and share their insights with the class, fostering peer learning and discussion.	5	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Tutorial Assignments & Quizzes	1, 2, 3, 4, 5	15	
2	Practicals	2, 3, 4	8	
3	Group Presentations	1, 5	7	

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)

3

Additional Information for ATs

Starting from Semester A, 2015-16, students must satisfy the following minimum passing requirement for courses offered by CHEM: "A minimum of 40% in both coursework and examination components."

Assessment Rubrics (AR)

Assessment Task
Tutorial Assignments & Quizzes

Criterion
Ability to express, explain and apply the core concepts and equations in the covered subjects of physical chemistry.

Excellent (A+, A, A-)
Able to demonstrate an excellent understanding of the principles of physical chemistry

Good (B+, B, B-)
Able to describe and explain the principles of various topics of physical chemistry

Fair (C+, C, C-)
Able to describe and explain some key principles of selected topics of physical chemistry

Marginal (D)
Able to briefly describe isolated principles of selected topics of physical chemistry

Failure (F)
Fail to accurately describe and explain relevant principles of any topics of physical chemistry

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Assessment Task
Practicals

Criterion
Ability to integrate the principles and the practicals and accomplish the objectives of the designed experiments.

Excellent (A+, A, A-)
Able to demonstrate excellent practice of various topics of physical chemistry

Good (B+, B, B-)
Able to demonstrate good practice of the selected topics of physical chemistry

Fair (C+, C, C-)
Able to demonstrate good practice in experiments on selected topics of physical chemistry

Marginal (D)
Able to briefly describe experiments on isolated principles of selected topics of physical chemistry

Failure (F)
Fail to accurately describe and explain relevant experiments of any topics of physical chemistry

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Assessment Task
Group Presentations

Criterion
Clear presentation indicative of critical and logical thinking.

Excellent (A+, A, A-)

Able to deliver fluent, well organized and well-prepared presentations to demonstrate an excellent understanding of physical chemistry

Good (B+, B, B-)

Able to deliver fluent presentations, with evidence of proper preparation, to describe and explain the principles of the selected topics of physical chemistry

Fair (C+, C, C-)

Able to deliver presentations, with evidence of proper preparation, to describe and explain some key principles of the selected topics of physical chemistry

Marginal (D)

Able to deliver comprehensible presentations to briefly describe isolated principles of the selected topics of physical chemistry

Failure (F)

Fail to present relevant principles of any topics of physical chemistry in coherent and comprehensible manners

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Assessment Task

Examination

Criterion

Ability to tackle the designer problems on physical chemistry utilizing the firm grip on the acquired core concepts and topical contents.

Excellent (A+, A, A-)

Able to demonstrate excellent understanding of the principles and practice of various topics of physical chemistry

Good (B+, B, B-)

Able to describe and explain the principles of the selected topics of physical chemistry

Fair (C+, C, C-)

Able to describe and explain some key principles of selected topics of physical chemistry

Marginal (D)

Able to briefly describe isolated principles of selected topics of physical chemistry

Failure (F)

Fail to accurately describe and explain relevant principles of any topics of physical chemistry

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Part III Other Information

Keyword Syllabus

Nonelectrolyte Solutions
Concentration units. Partial molar quantities. Thermodynamics of mixing. Binary mixtures of volatile liquids. Real solutions. Distillation: pressure-temperature and composition diagrams. Azeotropes. Colligative properties.

Electrolyte Solutions
Electrical conduction in solutions: degree of dissociation, ionic velocities, applications of conductance measurements. Ions in aqueous solution. Ionic activities. Debye-Hückel theory of electrolytes. Colligative properties of electrolyte solutions: the Donnan effect.

Chemical Equilibrium

Chemical equilibrium in ideal and real gaseous systems. Reactions in solution. Heterogeneous equilibria. Influence of pressure, temperature and catalyst on the equilibrium constant. Fugacity, activity and activity coefficients.

Electrochemistry
Thermodynamics of electrochemical cells: Nernst equation. Types of electrodes. Single-electrode potential. Temperature-dependence of emf. Types of cells: concentration and fuel cells. Application of emf measurements. Potentiometric titrations. Biological oxidation. Membrane potential. Electrolysis, overpotentials, polarography. Corrosion. Industrial application of cells.

Chemical Kinetics
Composite, stepwise and complex reaction. Effect of temperature on reaction rate. Potential energy surfaces. Theories of reaction rates. Kinetic isotopes effect. Reactions in solution. Fast reactions in solution: flow and relaxation methods. Molecular beams. Homogeneous catalysis. Enzyme kinetics.

Surface Chemistry and Colloids
Adsorption of gases on solids. physical adsorption and chemisorption. Theories of adsorption: Langmuir, BET. Determination of surface areas and porosity of solids. Heterogeneous catalysis and kinetics. Factors affecting the choice of catalysts and examples. Surface energy. Gibbs adsorption equation. Surface films, interfacial potentials, double layer theories. Electrokinetic phenomena. Emulsions, micelles, colloids.

Macromolecules
Determination of the size, shape and molar mass of macromolecules. Bond distances and angles. Macromolecular conformations. Physical properties of solid polymers.

Thermodynamics
Gibbs free energy and phase equilibria. Clapeyron and Clausius-Clapeyron equations.

Chemical Interactions Involving Solids, Liquids and Gases in the Environment
Surface sorption. Sediment formation. Colloidal particles. Coagulation and flocculation. Cation exchange. Sorption of organic compounds and gases.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Atkins’ Physical Chemistry, Atkins & de Paula, Oxford University Press, 9th Ed., 2010. Website: www.oup.com/
2	Student's solution manual to accompany Atkins’ Physical Chemistry, P. W. Atkins, Oxford University Press, 9th Ed., 2010.
3	Physical Chemistry, Engel & Reid, Pearson, 2nd Ed., 2010 Website: www.chemplace.com
4	Physical Chemistry, I. N. Levine, Mc Graw Hill, 5th Ed., 2002.
5	Physical Chemistry, J. W. Moore, Prentice Hall, 5th Ed., 1972.
6	Physical Chemistry with Applications to Biological System, R. Chang, Macmillan Publisher, 2nd Ed., 1977.
7	Online Resources: Website: www.oup.com/ Website: www.aw-bc.com