Lahore University of Management Sciences

CHEM 311 – Chemical Thermodynamics

Spring (2023–2024)

Instructor	Falak Sher
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Secretary/TA	N/A
TA Office Hours	N/A
Course URL (if any)	N/A

Course Teaching Methodology (Please mention following details in plain text)

- Teaching Methodology: In-person
- Lecture details: In-person lectures in classroom

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	90 min
Recitation (per week)	Nbr of Rec (s) Per Week	N/A	Duration	N/A
Lab (if any) per week	Nbr of Session(s) Per Week	N/A	Duration	N/A
Tutorial (per week)	Nbr of Tut(s) Per Week	N/A	Duration	N/A

Course Distribution	
Core	For chemistry and biology majors
Elective	For SSE students
Open for Student Category	For SSE students
Closed for Student Category	N/A

COURSE DESCRIPTION

This course deals primarily with the equilibrium properties of macroscopic systems. Four thermodynamics laws are discussed and calculations involving work, heat, internal energy, heat capacities, enthalpy, entropy, the Gibbs function and chemical potentials are performed. Fundamental thermodynamic equations and Maxwell relations are discussed. It also covers phase equilibria of single and two component systems, Clausius-Clapeyron equation, ideal/non-ideal solutions, colligative properties. It includes discussions on chemical equilibria of reactions in gas and solution phases and effects of temperature and pressure on equilibrium compositions.

COURSE PREREQUISITE(S)

- CHEM 101
- MATH 101 or equivalent

COURSE OBJECTIVES

The students should learn

- four thermodynamics laws
- the equations of states which relate various properties of matter in the gas, liquid and solid phases.
- different forms of energy such as work, heat, internal energy, free energies etc. and their transformation from one form to the other.

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- the conditions of spontaneity in physical and chemical processes.
- simple phase diagrams, important relationships describing physical changes from one phase to the other, and characteristics of ideal/non-ideal solutions and effects of temperature, pressure and solute concentrations on their properties.
- the microscopic level understanding of the equilibrium properties of macroscopic systems.

Learning Outcomes

The students must be able to

- understand and analyze different forms of energy and their transformations during physical and chemical changes.
- derive correlations using thermodynamic laws and apply them for determining the unknown state functions/properties from the provided information.
- differentiate between spontaneous and no-spontaneous processes from the knowledge of enthalpy and entropy changes at a given temperature.
- apply fundamental principles of thermodynamic and relationships to understand the phase diagrams of simple systems.
- correlate macroscopic equilibrium properties with the microscopic energy levels of molecules in the given system.

Grading Breakup and Policy	
Assignment(s)/Home Work:	10% (practice questions)
Quiz(s):	20% (7-8 quizzes; mostly announced)
Class Participation:	5%
Attendance:	
Midterm Examination:	25%
Project:	
Final Examination:	40%

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: Duration: 90 min Preferred Date:
Final Exam	Yes/No: Yes Combine Separate: Combined Duration: 3 hrs

COURSE OVERVIEW

Week/ Lecture/ Module	Topics	Recommended Readings	Objectives/ Application
Week 1	Equations of Sates, compressibility factor, van der Waals equation, 0^{th} law of thermodynamics	Chapter 1	Units conversions and understanding behavior of real gases
Week 2	Work, heat, exact differential, internal energy and the 1^{st} law of thermodynamics	Chapter 2	Energy transformations
Week 3	Work of reversible/irreversible compression and expansion of gases in isothermal, isobaric, isochoric, adiabatic etc. processes, enthalpy and change of states at constant pressure	Chapter 2	Calculations of heat and work in different kind of processes
Week 4	Heat capacities at constant volume and pressure, heats of formations, Joule-Thomson expansion, calorimetry.	Chapter 2	Heat capacities and related processes

Week 5	Entropy as a state function, the second law of thermodynamics, entropy changes in reversible and irreversible processes, entropy of mixing	Chapter 3	Entropy changes and spontaneous processes
Week 6	Entropy and statistical probability, calorimetric determination of entropies, the third law of thermodynamics, heat engines	Chapter 3	Molecular level understanding of entropy
Week 7	Fundamental equation for the internal energy, Helmholtz and Gibbs energies, natural independent variables of various thermodynamic functions and Maxwell relations, effect of temperature and pressure on the Gibbs energy	Chapter 4	Fundamental thermodynamic equations
Week 8	Significance of chemical potential, Gibbs-Helmholtz equation, fugacity and activity, partial molar properties of ideal gases, Gibbs-Duhem equation	Chapter 4	Chemical potential and its applications
Week 9	General equilibrium expression, Gibbs energies of formation and equilibrium constants, effect of temperature and pressure on the equilibrium constants/ compositions	Chapter 5	Chemical equilibrium and effect of temperature and pressure on Gibbs energy
Week 10	Van't Hoff equation, phase diagrams of one-component systems, Gibbs energy and the phase diagram of a substance	Chapter 5/ Chapter 6	Phase rule and phase diagram for a single component
Week 11	Clapeyron and Clausius-Clapeyron equations, vapor-liquid equilibrium of binary liquid mixtures,	Chapter 6	Phase changes and related thermodynamic equations
Week 12	Raoult's law, vapor pressure and the Henry's law, activity coefficients, freezing point depression,	Chapter 6	Ideal liquid solutions and Raoult's law
Week 13-14	Boiling point depression and osmotic pressure, two component systems, vapor pressure and surface tension	Chapter 6	Colligative properties of solutions

Textbook(s)/Supplementary Readings

- Physical Chemistry by R. Silbey, R. Alberty and M. Bawendi ISBN-13: 978-0471215042 (2004).
- Physical Chemistry – A Molecular Approach, D. A. McQuarrie and J. D. Simon, (2008).

Academic Honesty

The principles of truth and honesty are recognized as fundamental to a community of teachers and students. This means that all academic work will be done by the student to whom it is assigned without unauthorized aid of any kind. Plagiarism, cheating and other forms of academic dishonesty are prohibited. Any instances of academic dishonesty in this course (intentional or unintentional) will be dealt with swiftly and severely. Potential penalties include receiving a failing grade on the assignment in question or in the course overall. For further information, students should make themselves familiar with the relevant section of the LUMS student handbook.

Harassment Policy

There is absolutely zero tolerance for any behaviour that is intended, or has the expected result of making anyone uncomfortable and negatively impacts the class environment, or any individual's ability to work to the best of his/her potential. In case a differently-abled student requires accommodations for fully participating in the course, students are advised to contact the instructor so that they can be facilitated accordingly.

If you think that you may be a victim of harassment, or if you have observed any harassment occurring in the purview of this class, please reach out and speak to the instructor. If you are a victim, it is strongly encouraged to reach out to the Office of Accessibility and Inclusion at *oai@lums.edu.pk* or the sexual harassment inquiry committee at *harassment@lums.edu.pk* for any queries, clarifications, or advice. You may choose to file an informal or a formal complaint to put an end to offending behaviour. You can find more details regarding the LUMS sexual harassment policy at: *https://mgshss.lums.edu.pk/lums-harassment-policy*. To file a complaint, please write to *harassment@lums.edu.pk*. In addition to LUMS resources, SSE's Council on Belonging and Equity is committed to

devising ways to provide a safe, inclusive and respectful learning environment for students, faculty and staff. To seek counsel related to any issue, please feel free to approach either a member of the council or email at *cbe.sse@lums.edu.pk*.