



Department of Chemistry
Forman Christian College (A Chartered University)
Spring 2023

Instructor: Dr. Muhammad Tariq Qamar

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Class & Discussion Timings: 03:00-03:50 (M, W & F), Classroom: S-312

Lab Work & Discussion Timings: 09:00-10:50 (Tuesday), Lab: S-148

Course Information

CHEM 270: Thermodynamics & Equilibrium (3+1 Credits)

Prerequisite: Open for those who studied chemistry at intermediate or A- Level






1. Introduction

This course is designed to enable students to study the concepts pertaining to thermodynamics of chemical reactions, chemical equilibrium and solution chemistry and applicability of these concepts to real systems. This course enhances the skill of students in handling of various experiments in the chemistry laboratory.

2. Learning Objectives and Outcomes

Course Objectives	Course Outcomes	Assessment
The course objectives are: To educate students in building of foundational concepts about chemical thermodynamics, chemical equilibrium and solution chemistry.	At the end of course students will be able to: Explain the fundamentals and basic terminologies related to chemical thermodynamics, equilibrium and solution chemistry.	Written Exam, Quizzes, Written Assignment, Class Participation and presentations
To study the thermodynamics of few chemical reactions using the studied concepts.	Apply the concept of thermodynamics on various chemical reactions to find the extent of reaction.	
To understand the role of chemical equilibrium in determining the properties and assessing the response of chemical reactions.	Apply the concept of chemical equilibrium in determining the properties and response of chemical reaction	
To develop the critical and analytical skills related to solution chemistry and thermodynamics	Understand and interpret the solution and thermodynamics properties of chemical reactions.	
To educate students about the laboratory methods/technique to execute few experiments.	Perform and communicate few experiments related to chemical thermodynamics, chemical equilibrium and solution chemistry.	Lab Reports, Written Lab Exam and Lab Viva

3. Textbooks

-  Atkin's Physical Chemistry by Peter Atkin and Julio De Paula, 11th Editions
-  Physical Chemistry by Ira N. Levine, 6th Edition
-  Physical Chemistry by Gilbert W. Castellan 3rd Edition
-  Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7th Edition
-  Chemistry by Chang & Goldsby, 12th Edition

4. Grading System and Weightage

Weightage and Grading:

Activity	Weightage	A	4.00	93-100%	C	2.00	73-76%
		A-	3.70	90-92%	C-	1.70	70-72%
• Quizzes	: 10%	B+	3.30	87-89%	D+	1.30	67-69%
• Mid Term Exam	: 20%	B	3.00	83-86%	D	1.00	60-66%
• Final Exam	: 30%	B-	2.70	80-82%	F	0.00	59 or below
• Assignment/Presentation	: 10%	C+	2.30	77-79%			Failing
• Lab Exam (Lab reports & Performance + Viva)	: 25% (15% +10%)						
• Class Participation	: 05%						

5. Other Rules

- This course is designed for those who studied chemistry at intermediate or A- Level.
- It is recommended to attend at least 80% classes and in-time submission of assigned work is highly desirable.
- The similarity with the internet content and any other source/person will be highly discouraged while doing the assignment and quizzes. The use of these practices will put a negative impression (deduction of marks). Moreover, try to explain the things in your own words/way.
- A student has the option to take make up test for missed exams if he or she has genuine reasons.

6. Logistics and Office Hours

We will interact and discuss the things through F2F classroom teaching mainly and using MOODLE, ZOOM, WHATSAPP, E-MAIL and GOOGLE MEET (if needed) during the class and discussion timings as mentioned above. Moreover, students are welcome to share the problems and queries from 02-04 PM on Tuesday.

7. Lesson Plan

DATE/WEEK	TOPICS
1 st and 2 nd Week	Thermodynamic terms and basic concepts: system, boundary and surroundings, Types of thermodynamic systems, Intensive and extensive properties, State of a system. Thermodynamic processes. Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6 th Edition (Chapter 01) Soft copy of e-book: Chemistry by Chang & Goldsby, 12 th Edition (Chapter 06) Soft copy of e-book: Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7 th Edition (Chapter 12)
3 rd and 4 th Week	Spontaneous processes. Enthalpy, entropy, and spontaneous processes with examples. Second and third laws of thermodynamics. Standard molar entropies and standard entropies of reaction and calculations. Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6 th Edition (Chapter 02 & 03) Soft copy of e-book: Chemistry by Chang & Goldsby, 12 th Edition (Chapter 17) Soft copy of e-book: Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7 th Edition (Chapter 13)
5 th and 6 th Week	(QUIZ 1) Free energy to predict the spontaneous processes. Interpretation of reactions spontaneity with the help of $\Delta G = \Delta H - T\Delta S$ along with calculations. Concept of Helmholtz energy function. Chemical potential, system of variable compositions and concept of partial molar quantities. Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6 th Edition (Chapter 04) Soft copy of e-book: Chemistry by Chang & Goldsby, 12 th Edition (Chapter 17) Soft copy of e-book: Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7 th Edition (Chapter 13). Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6 th Edition (Chapter 04)

7 th and 8 th Week	<p>Extent of reaction using equilibrium constant, Factors affecting the direction of equilibrium and equilibrium constant. Equilibrium constant (K) and reaction quotient (Q), Feasibility of reactions based on Q and K. Spontaneity and equilibrium.</p> <p>Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6th Edition (Chapter 04 & 11)</p> <p>Soft copy of e-book: Chemistry by Chang & Goldsby, 12th Edition (Chapter 14)</p> <p>Soft copy of e-book: Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7th Edition (Chapter 14)</p> <p style="text-align: center;">(QUIZ 2)</p>
9 th and 10 th Week	<p>Phase equilibrium: Clapeyron equation, solid-liquid, liquid-gas, and solid-gas equilibria. Concept of phase rules and Phase diagrams (H₂O and CO₂)</p> <p>Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6th Edition (Chapter 07 & 12)</p> <p>Soft copy of e-book: Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7th Edition (Chapter 10)</p> <p style="text-align: center;">(Mid-Term Examination on April 14, 2023)</p>
11 th and 12 th Week	<p>Solution Chemistry: types of homogeneous mixtures, energy changes and solution process. Preparation of solutions (molarity), Preparation of solutions (mole fraction, mass percent, molality), Ideal and non-ideal solutions, Raoult's law and its applications.</p> <p>Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6th Edition (Chapter 09 & 12)</p> <p>Soft copy of e-book: Chemistry by Chang & Goldsby, 12th Edition (Chapter 12)</p> <p>Soft copy of e-book: Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7th Edition (Chapter 11).</p>
13 th and 14 th Week	<p>Colligative properties of solution and thermodynamic parameters. Determination of molecular weight by using lowering of vapor pressure. Determination of molecular weight by using elevation of boiling point, depression in freezing point, osmotic pressure.</p> <p>Exercise based on colligative properties.</p> <p>Soft copy of e-book: Physical Chemistry by Ira N. Levine, 6th Edition (Chapter 09 & 12)</p> <p>Soft copy of e-book: Chemistry by Chang & Goldsby, 12th Edition (Chapter 12)</p> <p>Soft copy of e-book: Principles of Modern Chemistry by Oxtoby Gillis and Campion, 7th Edition (Chapter 11).</p> <p style="text-align: center;">(QUIZ 3)</p>
15 th Week	<p>Concept of straight-line equation and its application in solving of Arrhenius equation, Clapeyron equation and van't Hoff equation.</p> <p>https://www.youtube.com/watch?v=dpB6GUOYYu8&t=63s</p>
16 th Week	<p>A set of numerical problems will be assigned to each student and the student will be expected to solve the numerical questions. The solved problems will be returned by June 02, 2023.</p>
17 th Week	<p>An assignment will be assigned to the students. The students will be required to send the written assignment and 3-4 minutes video of what he or she has perceived from the assignment by June 09, 2023.</p>
June 12- Jun 21, 2023	Final Examination

Lab Experiments

Experiment No.	Title of Experiment
01	Preparation of molar, normal, % and ppm solutions of HCl and NaCl.
02	Determination of unknown concentration of a liquid by viscosity method.
03	Verification of Lambert-beer's law, calibration graph, calculation of molar absorptivity.

04	Determination of lambda max and unknown concentration of KMnO_4 by using spectrophotometer.
05	Determination of unknown concentration of $\text{K}_2\text{Cr}_2\text{O}_7$ using spectrophotometer.
06	Determination of the molecular weight of the given compound by elevation of boiling point.
07	Determination of the molecular weight of a compound by depression in freezing point.
08	Determination of the partition coefficient of benzoic acid between benzene and water (two immiscible liquids).
09	To determine the heat of solution by solubility method.
10	Determination of heat of neutralization of strong acid and strong base by calorimeter.