KFT 232/3 Physical Chemistry II

Course Objectives:

1) To explain the origin of the spontaneity of the physical and chemical changes.
2) To introduce the second and third laws of thermodynamics.
3) To introduce the thermodynamic description of mixing.
4) To introduce the principles and applications of ionic interaction and electrochemical systems.

Topic	**Content**	**Number of lecture hours**	**Expected outcome – upon completion of the course, the student should be able to:**
1. First Law of Thermodynamics	• Basic concepts: work, heat and internal energy • The first law of thermodynamics • Enthalpy change • Heat capacities • Reversible and irreversible processes with ideal gases	4	• Understand the first law of thermodynamics and know the terms used in the topic. • Apply the definition of heat capacity under constant volume and constant pressure conditions. • Distinguish between reversible and irreversible processes. • Calculate various thermodynamic quantities for these processes.
2. Second and Third Laws of Thermodynamics	• Entropy as a state function • The second law of thermodynamics • Entropy changes in reversible and irreversible processes • The third law of thermodynamics • Absolute entropies	4	• Understand the second law of thermodynamics and the definition of entropy. • Calculate the entropy change for ideal gas under different conditions. • Understand the concept of absolute entropy.
3. Free Energy and Chemical Potential	• Spontaneity conditions • Gibbs free energy and Helmholtz energy • Maxwell relations and applications • Thermodynamic equations of state • Gibbs-Helmholtz equation • Chemical potential and other partial molar quantities • Fugacity and activity	5	• List the criteria for spontaneous processes based on entropy and free energy changes. • Derive and apply the thermodynamic equation of state in determining the changes of internal energy and enthalpy for ideal gases. • Understand the concepts of fugacity and activity and their uses. • Understand the Gibbs-Helmholtz equation and its application.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of the course, the student should be able to:
4.Thermodynamics for Open Systems	• Partial molar quantity • Basic equations for open systems • Mixing rule for partial molar quantity • Determination of partial molar properties	5	• Understand the concept of partial molar quantity of solution. • Derive the equations and calculate the partial molar quantities of a mixture. • Derive the equations of extensive thermodynamic properties of a system as a function of pressure, temperature and number of moles for each component in the system. • Derive the equation for any extensive property of a system consisting of a mixture of gases or solutions. • Apply graphical and analytical methods in determining partial molar quantities.
5. System of Gases and Real Solution	• Chemical potential of ideal gases • Fugacity and chemical potential of real gases • Real solution • Activity and activity coefficient and their determinations • Mixing process for ideal and real solutions	3	• Understand the concept of chemical potential. • Derive the equation and calculate the chemical potential of a gas mixture. • Derive the equation and calculate the actual pressure of real gases and the ratio of pressure between real and ideal gases. • Understand the concept of real solution. • Understand the characteristics of the real solution based on Raoult, Dalton and Henry's laws. • Explain and determine the activity and activity coefficient for volatile and non-volatile solutes. • Derive equations for extensive thermodynamic properties for a mixture of gases or liquids.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of the course, the student should be able to:
6. Phase Equilibria	• Equilibrium between phases • One-component system • Clausius-Clapeyron equation • Vapour-liquid equilibrium of a two-component system	3	• Understand the concept of phase equilibria between solid-liquid, liquid-gas and solid-gas. • Understand the concept of a two component system of a volatile solution.
7. Ionic Interaction	• The nature of electrolytes • Ionic activity • Ion-ion and ion-solvent interaction • The electrical potential in the vicinity of an ion • Electrical potential and thermodynamic functions. The Debye-Huckel equation • Limiting and extended forms of the Debye-Huckel equation • Applications of the Debye-Huckel equation	4	• Understand the different theories required for solutions of weak and strong electrolytes. • Explain an ionic atmosphere, relaxation or the asymmetry effect and the electrophoretic effect. • Understand the Debye-Huckel theory which focuses attention on the distribution of positive and negative ions in solution as a result of the electrostatic forces. • Explain the limiting and extended forms of Debye-Huckel equations. • Understand how the Debye-Huckel theory interprets the activity coefficients of ions in solution. • Calculate the thermodynamic equilibrium constant using Debye-Huckel equation.
8. Reversible (equilibrium) Potentials	• Comparison of chemical and electrochemical reactions • Reversible electrode potentials • The hydrogen scale • Other reference electrodes • Electrochemical concentration cells • Concentration cells without liquid junctions • Concentration cells with liquid junctions	4	• Understand the electrochemical systems. • Explain how electrochemical cells, such as the Daniel cell, functions. • Apply thermodynamic principles to electrochemical cells, including the derivation of the Nernst equation. • Understand the concept of the standard hydrogen electrode and describe other reference electrodes. • Understand the cell emf in IUPAC convention. • Discuss the concentration cells without liquid junction and calculate the cell potentials. • Calculate the transference number and liquid junction potential.

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9. Applications of Reversible Potentials	• Thermodynamics of cell potentials • Determination of standard potentials and mean ionic activity coefficients • Determination of transport numbers • Determination of equilibrium constants • Determination of pH • Other ion-selective electrodes	4	• Calculate the thermodynamic functions from the cell emf. • Obtain activity coefficients and equilibrium constants from emf measurements. • Determine transport number by comparison of the emf of the cells with and without transport. • Determine pH by using hydrogen and glass electrodes.
TOTAL		**36**	