Teaching Plan for B.Sc. (H) Chemistry, Semester III (Aug 2024 – Dec 2024)

DSC-9: Chemical Equilibrium, Ionic Equilibrium, Conductance and Solid State

Faculty Name: **Dr. Ankit Mittal**

S. No.	Month	Week	Topic
1.	Aug-24	1st	Quantitative aspects of Faraday's laws of electrolysis, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.
		2nd	Molar conductivity at infinite dilution. Kohlrausch's law of independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rule.
		3rd	Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, determination of transference number using Moving Boundary methods.
		4th	Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations (v) hydrolysis constants of salts.
2.	Sept-24	1st	Criteria of thermodynamic equilibrium, degree of advancement of reaction, Chemical equilibria in ideal gases, Thermodynamic derivation of relation between Gibbs free energy of a reaction and reaction quotient.
		2nd	Equilibrium constants and their dependence on temperature, pressure and concentration, Le Chatelier's Principle (Quantitative treatment), Free energy of mixing and spontaneity (qualitative discussion).
		3rd	Strong, moderate and weak electrolytes, Arrhenius theory of electrolytic dissociation, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water.
		4th	Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.
3.	Oct-24	1st	Internal Test 1/Practice Problems
		2nd	Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.
		3rd	Qualitative treatment of acid – base titration curves. Theory of acid–base indicators; selection of indicators and their limitations.
		4th	Mid-Semester Break
4.	Nov-24	1st	Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices.
		2nd	Elementary idea of symmetry, seven crystal systems and fourteen Bravais lattices.
		3rd	X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method.

		4th	Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Internal Test 2/Practice Problems

DISCIPLINE SPECIFIC CORE COURSE – 9 (DSC-9): Chemical equilibrium, Ionic equilibrium, conductance and solid state

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemical equilibrium, Ionic equilibrium, conductance and solid state (DSC-9)	**04**	**03**	**0**	**01**	**Passed Class XII with Physics, Chemistry and Mathematics**	**NIL**

Learning Objectives:

The Learning Objectives of this course are as follows:

- To make students understand the concept of chemical equilibrium and ionic equilibrium.
- To introduce the concept of electrolytes, ionization of various electrolytes, pH.
- To explain the applications of ionization in buffer, hydrolysis, acid-base titrations and indicators.
- To introduce the concept of electrolytic conductance with respect to strong and weak electrolytes and then extend it to understand concepts like ionic mobility, transference and related properties.
- To develop the advance concept of solid state with emphasis on crystal structures in general and cubic crystals in details.

Learning Outcomes:

By studying this course, students will be able to:

- Apply the concept of equilibrium to various physical and chemical processes.
- Derive and express the equilibrium constant for various reactions at equilibrium.
- Use Le Chatelier's principle to predict the thermodynamic conditions required to get maximum yield of a reaction
- Apply the concept of equilibrium to various ionic reactions.
- List different types of electrolytes and their properties related to conductance in aqueous solutions.
- Use conductance measurements for calculating many properties of the electrolytes.

- Prepare buffer solutions of appropriate pH.
- Explain the crystal properties and predict the crystal structures of cubic systems form the XRD.
- Use the instruments like pH-meter and conductivity meters.

SYLLABUS OF DSC-9

UNIT – 1: Chemical Equilibrium (6 Hours)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, Chemical equilibria in ideal gases, Thermodynamic derivation of relation between Gibbs free energy of a reaction and reaction quotient, Equilibrium constants and their dependence on temperature, pressure and concentration, Le Chatelier's Principle (Quantitative treatment), Free energy of mixing and spontaneity (qualitative discussion).

UNIT – 2: Ionic equilibrium (12 Hours)

Strong, moderate and weak electrolytes, Arrhenius theory of electrolytic dissociation, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves. Theory of acid–base indicators; selection of indicators and their limitations.

UNIT – 3: Conductance (12 Hours)

Quantitative aspects of Faraday's laws of electrolysis, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch's law of independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rule. Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, determination of transference number using Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations (v) hydrolysis constants of salts.

UNIT – 4: Solid state (15 Hours)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary idea of symmetry, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.

Practical component (30 Hours)
(Laboratory periods: 15 classes of 2 hours each)

pH metry:

1. Study the effect of addition of HCl/NaOH on pH to the solutions of acetic acid, sodium acetate and their mixtures.
2. Preparation of buffer solutions of different pH values
   a. Sodium acetate-acetic acid
   b. Ammonium chloride-ammonium hydroxide
3. pH metric titration of
   a. Strong acid with strong base
   b. Weak acid with strong base. Determination of dissociation constant of a weak acid.

Conductometry:

1. Determination of cell constant
2. Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:
   a. Strong acid vs. strong base
   b. Weak acid vs. strong base
   c. Mixture of strong acid and weak acid vs. strong base
   d. Strong acid vs. weak base

p-XRD *(p-XRD crystal pattern to be provided to the students)*

1. Differentiate and classify the given set of the diffraction pattern as crystalline materials or amorphous (Glass) substance.
2. Carry out analysis of a given set of p-XRD and determine the type of the cubic crystal structure
   a. NaCl
   b. CsCl
   c. KCl
3. Determination of approximate crystal size from a given set of p-XRD

Essential/recommended readings
Theory

1. Peter, A.; Paula, J. de. (2011), **Physical Chemistry**, 9th Edition, Oxford University Press.
2. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
3. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 2, 6th Edition, McGraw Hill Education.
4. McQuarrie, D. A.; Simon, J. D. (2004), **Molecular Thermodynamics**, Viva Books Pvt. Ltd.
5. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol 1, 6th Edition, McGraw Hill Education.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Suggestive readings

1. Levine, I.N. (2010), **Physical Chemistry**, Tata Mc Graw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.