Course Outcomes : Chemistry

Place of teaching the Course	**Katwa College**
Department	**Chemistry**
Name of the Course	**Core Course 1 (under CBCS)**
Semester	**1st**
Course Title	**Organic Chemistry-I (Theo): Basics of Organic Chemistry**
Main Topics of the Course	1. ***Bonding and Physical Properties*** 2. ***General Treatment of Reaction Mechanism I*** 3. ***Stereochemistry-I***
Mentors	**Dr. Saptarshi Biswas, Prof. Siddhartha Maji**

Upon completion of these topics, students should be able to

- **CO 1** Classify and identify different types of organic reactions.
- **CO 2** Gain concepts about hybridization, resonance and hyperconjugation.
- **CO 3** Calculate formal charges and degree of unsaturation (DBE or IHD) in organic compounds.
- **CO 4** Draw orbital diagram of different types of bonding in organic compounds.
- **CO 5** Get knowledge about various electronic displacement phenomena *e.g.* inductive effect, field effect, mesomeric effect, electromeric effect, steric effect, steric inhibition of resonance (SIR).
- **CO 6** Understand the concept of aromaticity and Hückel's rules.
- **CO 7** Differentiate among aromatic, anti-aromatic, non-aromatic and homo-aromatic organic compounds.
- **CO 8** Get elementary idea about σ, σ*, π, π *, n – Mos and Frontier MOs (FMO).
- **CO 9** Sketch π MOs of conjugated diene, triene, allyl and pentadienyl systems.
- **CO 10** Identify HOMO, LUMO and SOMO in ground state & excited state and interactions between HOMO and LUMO.
- **CO 11** Draw Frost diagram of cyclic aromatic compounds.
- **CO 12** Get elementary idea about α and β and calculate delocalization energies in terms of β.

- **CO 13** Get idea about bond dissociation energy (BDE), bond energy, concept of bond angle strain (Baeyer's strain theory) in small ring systems.

- **CO 14** Conceptualize melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular and intramolecular forces.

- **CO 15** Explain relative stabilities of isomeric hydrocarbons in terms of heat of hydrogenation, heat of combustion and heat of formation.

- **CO 16** Identify mechanistically ionic, radical and pericyclic reactions.

- **CO 17** Draw curly arrow symbol in representation of mechanistic steps of organic reactions.

- **CO 18** Get idea about organic reactive intermediates *e.g.* carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes, nitrenes and benzynes.

- **CO 19** Write down different procedures for the generation of the above mentioned reactive intermediates and rationalize their stability & electrophilic/nucleophilic behavior.

- **CO 20** Exemplify different organic reactions involving various reactive intermediates.

- **CO 21** Represent the molecules in different projection formulae (e.g. Fischer, sawhorse, flying-wedge and Newman).

- **CO 22** Exemplify the chirality, symmetry elements and point groups.

- **CO 23** Illustrate the asymmetric and dissymmetric molecules; enantiomers and diastereomers.

- **CO 24** Describe relative and absolute configuration: D/L, E/Z and R/S descriptors; erythro/threo; syn/anti nomenclatures.

- **CO 25** Describe optical rotation, specific rotation and molar rotation.

- **CO 26** Elucidate racemic compounds, racemisation and resolution of acids, bases and alcohols *via* diastereomeric salt formation.

- **CO 27** Epitomize optical purity and enantiomeric excess.

- **CO 27** Recognize the natural amino acids and nucleosides are enantiomerically pure as these are the basis of all life *via* DNA and/or RNA.

- **CO 28** Understand the high price of single enantiomeric drugs.

Place of the Course	**Katwa College**
Department	**Chemistry**
Name of the Course	**Core Course 2 (under CBCS)**
Semester	**1st**
Course Title	**Physical Chemistry-I (Theo)**
Main Topics of the Course	1. Kinetic Theory & Gaseous State 2. Chemical Thermodynamics 3. Chemical Kinetics
Mentors	**Dr. Kedar Nath Mitra, Dr. Goutam Nandi, Dr. Dinesh Maity**

Upon completion of the course students will be able to

KINETIC THEORY AND GASEOUS STATE

- **CO 1** Explain the concept of pressure and temperature from Kinetic Theory of gases.
- **CO 2** State the postulates of kinetic theory of gas.
- **CO 3** Write and derive equations of states for an ideal gas and a real gas.
- **CO 4** Describe physical basis for the kinetic theory of gases.
- **CO 5** Derive gas laws from kinetic theory.
- **CO 6** State the assumptions for Maxwell's law of distribution of molecular speed.
- **CO 7** Explain the relationship between partial pressures and the total pressure as described in Dalton's law of Partial Pressure.
- **CO 8** Define and derive different kinds of speed of gases.
- **CO 9** Describe transport properties of gas.
- **CO 10** Establish Boltzmann distribution law from Maxwell's distribution law.

THERMODYNAMICS

- **CO 1** Explain with suitable examples that laws of thermodynamics are based on the experiences gathered from natural phenomena.
- **CO 2** Justify the necessity of the knowledge of calculus in dealing with the laws of thermodynamics and their application.
- **CO 3** Exemplify the idea of system, surrounding and boundary.
- **CO 4** Mention salient features of different thermodynamic processes.

- **CO 5** Classify different properties as extensive and intensive; also make a correlation among the two.
- **CO 6**. Explain that a thermodynamic function is called a state function only if it is a perfect differential.
- **CO 7** Write a brief review on internal energy.
- **CO 8** Explain why dq and dw are not state function but their sum is a state function.
- **CO 9** Interpret 1st law of thermodynamics while applying to different processes.
- **CO 10** State the outcomes of Joule's experiment.
- **CO 11** Derive expression for work involved with different processes.
- **CO 12** Criticise: It is more convenient to use change in enthalpy with compare to the change in internal energy.
- **CO 13** Mention the importance of considering FRICTIONLESS WEIGHTLESS PISTON and THERMOSTAT.
- **CO 14** State the difference between SINGLE /FINITE STEP process and QUASI STATIC/INFINITE STEP process.
- **CO 15** Derive expression of work involved with different thermodynamic processes for ideal and real gases.
- **CO 16** Compare between work involved with different thermodynamic processes.
- **CO 17** Represent the concept of SPECIFIC HEAT and explain how these have been used in thermodynamic derivations.
- **CO 18** State the reason for the change in enthalpy during chemical reactions and physical processes.
- **CO 19** Define with examples various types of enthalpy change associated with chemical reactions and physical changes. Also comment on their temperature dependence.
- **CO 20** Justify the necessity of the 2^{nd} law of thermodynamics.
- **CO 21** Explain the concept of engine.
- **CO 22** Understand the conclusions drawn from Carnot Cycle.
- **CO 23** Prove Carnot theorems.

- **CO 24** Grasp the idea of refrigeration and differentiate between the functioning of a refrigerator and a heat pump.
- **CO 25** Differentiate between reversible and irreversible engines.
- **CO 26** Apply the idea of Clausius inequality in explaining different thermodynamic phenomena.

CHEMICAL KINETICS

- Upon completion of this topic, students should be able to:
- List reasons for studying chemical kinetics.
- Discuss the factors that affect the rate of chemical reactions.
- Differentiate between order and molecularity of a chemical reaction.
- Describe the general form of a (differential) rate law and how the rate of a chemical reaction depends on the concentrations of species that appear in the rate law.
- Determine the "overall reaction order" for a chemical reaction using the (differential) rate law.
- Derive a general expression for the unit of rate constant and to find the unit of rate constant for zero, 1st, 2nd and 3rd order reaction.
- State the basis for the “Collision Model” and “Transition State Model” of Chemical Kinetics.
- Explain why reactant molecules must have a certain minimum amount of kinetic energy when they collide in order for a chemical reaction to occur.
- Describe "activation energy" and how it can be experimentally determined.
- Define a catalyst and describe the effect of a catalyst on the energy requirements for a reaction.
- Sketch a potential energy profile showing the activation energies for the forward and reverse reactions and show how they are affected by the addition of a catalyst.
- Exemplify „kinetically controlled and thermodynamically controlled“ product.
- Explain how enzymes act as biological catalysts and how they interact with specific substrate molecules.

Course Outcomes : Chemistry

Place of the Course	**Katwa College**
Department	**Chemistry**
Name of the Course	**Core Course 3 (For Honours Students)**
Main Topics of the Course	**1. *Extra Nuclear Structure of Atom*** **2. *Chemical Periodicity*** **3. *Acid-Base Reactions*** **4. *Redox Reactions and Precipitation Reactions***
Mentors	**Dr. Kedar Nath Mitra, Dr. Goutam Nandi, Dr. Dinesh Maity**

Extra Nuclear Structure of Atom

Upon completion of this topic, students should be able to:

- Outline the historical developments of atomic theory.
- Describe the structure of the atom.
- Write the postulates of different atomic theory.
- Derive the Rydberg equation using Bohr's atomic model.
- Determine the wavelength and frequency of radiation of emission spectrum.
- Write Heisenberg's uncertainty principle and its significance.
- Write Scrodinger's wave equation and significance of Ψ and Ψ^2.
- Describe four quantum numbers and their significance.
- Draw s, p, d and f orbitals.
- Write Pauli's exclusion principle, Hund's rules of maximum multiplicity, Aufbau principle.
- Write the electronic configuration of atoms.
- Derive the term symbols of atoms.

ACID-BASE

After completion of the course the student will be able to -

- **CO 1** Write down auto-ionization equilibrium of liquid sulfur dioxide, liquid ammonia and liquid hydrogen fluoride. Also discuss the neutralization reactions occur in these solvents.
- **CO 2** Define acid and base as enumerated in different concepts on acid-base.
- **CO 3** State the merits and demerits of different concepts on acid-base.
- **CO 4** Exemplify the following terms: amphi-protic solvent, conjugate acid-base pair, differentiating and leveling solvents, co-solvating agent.
- **CO 5** Justify the statement, "conjugate base of a weak acid is strong and vice versa".
- **CO 6** Classify the following as acid, base and neutral species according to electronic theory of acid-base: N_2, BCl_3, NH_4^+, SO_2, DMF, DMSO, RCN
- **CO 7** Explain the utility of acidity function. State its relation with pH of dilute solution.
- **CO 8** Write the equation taking care of the ionic and covalent contribution in relation to the acid-base interaction. State the significance of the equation.
- **CO 9** Enumerate the rules used to predict the successive pK_a values and thus the acid strength of the oxy-acids. Give examples how these rules could be used to predict the structure of oxy-acids.
- **CO 10** Comment on the statement, "Steric factors and dative Π-bond formation have significant influence on acid-base behavior of certain species".
- **CO 11** Correlate the hard and soft nature of donor and acceptor atoms with their polarizing power and polarizability.
- **CO 12** Explain the SHAB principle in the light of FMO diagram.
- **CO 13** Describe briefly the periodic variation of acid-base behavior with plausible explanation.
- **CO 14** Explain with suitable examples: hardness of transition metal ions vary with oxidation state.
- **CO 15** Arrange the order of acidity of the acids with composition (a) HXO_n (X = halogen other than 'F', n = 1. 2. 3. 4), (b)H_3YO_n(Y= P, n = 2, 3, 4), (c) HX (X = F, Cl, Br, I)
- **CO 16** Clarify the statement with suitable examples, "Acidity of aqua ions are function of their charge and radius".
- **CO 17** Explain with the help of suitable concept on acid-base, the distribution of different elements in the nature.
- **CO 18** State how catalytic behavior of certain could be related with the Lewis and Brönsted acid nature of certain oxides.

REDOX AND PRECIPITATION REACTIONS

- **CO 1** Describe briefly the electronic theory of oxidation and reduction with suitable examples.
- **CO 2** State the difference between electrolytic cell and galvanic cell.
- **CO 3** Define the terms: Positive electrode, Negative electrode, Standard potential, and Formal potential.
- **CO 4** Narrate a brief account on salt bridge.
- **CO 5** Construct the galvanic cell and write electrode reactions, from there derive the cell reaction and determine the value of cell emf, and equilibrium constant from given standard electrode potential values.
- **CO 6** Derive the Nernst equation for any galvanic cell.
- **CO 7** Show how concentration affects the direction of reaction in a galvanic cell.
- **CO 8** Explain the effect of change of pH, precipitation and complex formation on formal potential of different redox couples using appropriate examples.
- **CO 9** Follow the course of a redox titration and to calculate the potential values at different stages of the titration.
- **CO 10** Justify the role of a redox indicator and the use of phosphoric acid in the titration of ferrous iron by potassium permanganate and potassium dichromate.
- **CO 11** Enumerate different information that is got from Latimer and Frost diagrams.
- **CO 12** Comment on the possibility of comproportionation and disproportionation reactions.
- **CO 13** Understand the terms, solubility product, common ion effect, lattice energy and solvation energy and their relation with the solubility of different compounds.
- **CO 14** Clarify the possibility and condition of precipitation.
- **CO 15** Explain the steps of group analysis in relation to inorganic qualitative analysis.

Place of teaching the Course	**Katwa College**
Department	**Chemistry**
Name of the Course	**Core Course 4 (under CBCS)**
Semester	**2nd**
Course Title	**Organic Chemistry-II (Theo)**
Main Topics of the Course	1. ***Stereochemistry-II*** 2. ***General Treatment of Reaction Mechanism II*** 3. ***Substitution and Elimination Reactions***
Mentors	**Dr. Saptarshi Biswas, Prof. Siddhartha Maji**

Upon completion of these topics, students should be able to

- **CO 1** Get knowledge about various thermodynamic parameters e.g. equilibrium, free energy, enthalpy and entropy factor of a chemical reaction.
- **CO 2** Calculate enthalpy change of a chemical reaction *via* bond dissociation energy (BDE).
- **CO 3** Apply the involvement of the thermodynamic parameters in case of intermolecular & intramolecular reactions.
- **CO 4** Concept of organic acids and bases.
- **CO 5** Understand the effect of structure, substituent and solvent on acidity and basicity of organic molecules.
- **CO 6** Compare between gas-phase and solution phase acidity and basicity of organic molecules.
- **CO 7** Compare between nucleophilicity and basicity.
- **CO 8** Apply HSAB principle in various chemical reactions.
- **CO 9** Explain thermodynamic principles in acid-base equilibria.
- **CO 10** Illustrate different types of tautomerism including prototropy,anionotropy, ring-chain tautomerism and valence tautomerism.
- **CO 11** Prove the presence of both keto and enol forms in solution.
- **CO 12** Apply thermodynamic principles in tautomeric equilibria.

- **CO 13** Get idea about various parameters in reaction kinetics – representation of rate law of a chemical reaction, rate constant, free energy of activation, order and molecularity of a reaction.

- **CO 14** Draw free energy profile diagrams for one-step, two-step and three-step chemical reactions.

- **CO 15** Draw energy profile diagrams for a catalyzed and uncatalyzed reaction and explain the role of a catalyst in a chemical reaction.

- **CO 16** Explain electrophilic and nucleophilic catalysis with proper examples.

- **CO 17** Make out kinetic control and thermodynamic control of reactions.

- **CO 18** Elaborate both primary and secondary kinetic isotopic effect with evidences.

- **CO 19** Describe principle of microscopic reversibility.

- **CO 20** Carry out halogenation of alkanes *via* free radical mechanism.

- **CO 21** Explain the formation of one regioisomer over the other in the light of Hammond's postulate.

- **CO 22** Learn nucleophilic substitution reactions at sp^3 centre with mechanism.

- **CO 23** Explain the effects of solvent, substrate structure, leaving group and nucleophiles on substitution reactions.

- **CO 24** Explain the involvement of NGP in the treatment of cancer.

- **CO 25** Describe the role of crown ethers and phase transfer catalysts in nucleophilic substitution reactions.

- **CO 26** Perform synthesis of alkenes and alkynes involving different kinds of elimination reaction with mechanism.

- **CO 27** Explain the conditions leading to the formation of Saytzeff & Hofmann elimination products.

- **CO 28** Compare between substitution and elimination reactions.

- **CO 29** Represent the chirality arising out of stereoaxis.

- **CO 30** Exemplify the atropisomerism, buttressing effect and prostereoisomerism.

- **CO 31** Illustrate the concept of (pro) n-chirality: topicity of ligands and faces.
- **CO 32** Represent the pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-r and pro-s descriptors of ligands.
- **CO 33** Describe conformational nomenclature.
- **CO 34** Elucidate eclipsed, staggered, gauche, syn and anti; dihedral angle, torsion angle; Klyne-Prelog terminology; P/M descriptors.
- **CO 35** Determine the conformation of conjugated systems (s-cis and s-trans)
- **CO 36** Describe gauche-butane interaction.
- **CO 37** Epitomize pro-r and pro-s descriptors of ligands on propseudoasymmetric centre.

Course Outcomes : Chemistry

Place of teaching the Course	**Katwa College**
Department	**Chemistry**
Name of the Course	**Core Course 7 (under CBCS)**
Semester	**3rd**
Course Title	**Organic Chemistry-III (Theo)**
Main Topics of the Course	1. ***Chemistry of alkenes and alkynes*** 2. ***Aromatic Substitution*** 3. ***Carbonyl and Related Compounds*** 4. ***Organometallics***
Mentor	**Prof. Siddhartha Maji**

Upon completion of these topics, students should be able to

- **CO 1** Learn different types of regioselective and stereoselective electrophilic addition to C=C bonds with plausible mechanisms such as halogenations, iodolactonisation, hydrohalogenation etc.

- **CO 2** Gain concepts about different types of hydration pathways to C=C bonds including acid-catalyzed hydration, oxymercuration-demercuration, hydroboration-oxidation.

- **CO 3** Form small-membered rings such as cyclopropanes & epoxides *via* electrophilic addition to C=C bonds and opening of the corresponding rings using suitable electrophiles and nucleophiles.

- **CO 4** Learn practical applications of epoxide ring formation and its re-opening in our daily life.

- **CO 5** Get knowledge about tunability of reagents between bromination across C=C bonds and allylic bromination reactions.

- **CO 6** Learn about 1, 3-diploar addition across C=C bonds initiated by 1, 3-dipolar molecules such as ozone, nitrile oxide etc.

- **CO 7** Assign reagents/conditions for syn and anti-hydroxylation of C=C bonds.

- **CO 8** Get idea about interconversion of E and Z-alkenes.

- **CO 9** Compare different types of regioselective & stereoselective electrophilic addition to C≡C bonds and hydration reactions with that of C=C bonds.

- **CO 10** Acquire information about dissolving metal reduction methods of benzenoid aromatics as well as C≡C bonds.

- **CO 11** Learn about 1, 3-diploar addition across C≡C bonds initiated by 1, 3-dipolar molecules such as ozone, nitrile oxide and etc.

- **CO 12** Get elementary idea about '**click reactions**' and its practical applications.

- **CO 13** Get idea about interconversion of terminal and internal alkynes.

- **CO 14** Be conceptualize with different types of electrophilic aromatic substitution reactions with evidences in favour of the proposed mechanisms such as nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction, chloromethylation, Gatterman-Koch, Gatterman, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt reactions.

- **CO 15** Get idea about nucleophilic aromatic substitution reactions along with evidences in favour of addition-elimination and elimination-addition mechanisms.

- **CO 16** Learn about ipso and cine-substitution.

- **CO 17** Learn about mechanism for nucleophilic addition to C=O bonds and understanding the mechanistic approach in terms of Burgi-Dunitz trajectory and molecular orbital theory (MOT).

- **CO 18** Get information about applications of formation of hydrates, cyano-hydrins and bisulphite adduct.

- **CO 19** Convert carbonyl group into other functionalities including benzoin condensation, Cannizzaro, Tischenko reaction, Wittig reaction and reduction & oxidation reaction of carbonyl compounds such as Clemmensen reduction, Wolff-Kishner reduction, $LiAlH_4$, $NaBH_4$, MPV reduction, Oppenauer oxidation, Bouveault-Blanc reduction, acyloin condensation etc.

- **CO 20** Form carbonyl functionality *via* the oxidation of alcohols with PCC & PDC and oxidation of 1, 2-diols with periodic acid & lead tetraacetate.

- **CO 21** Exploit the acidity of α-H of C=O to form carbon-carbon bonds using aldol condensation, Robinson annulation, benzoin condensation, Mannich reaction, Perkin reaction, Michael addition, Stork-enamine synthesis, Claisen-Schmidt condensation, Favorskii rearrangement etc.

- **CO 22** Exploit the acidity of α-H of ester functionality in the formation of carbon-carbon bonds utilizing Claisen ester condensation, Dieckmann cyclisation, acyloin condensation, Darzens glycidic ester condensation etc.

- **CO 23** Be familiar with compounds containing active methylene group *e.g.* diethyl malonate, ethyl acetoacetate, ethyl cyanoacetate & acetylacetone and their utility in organic synthesis exploiting Stobbe condensation, Knoevenagel condensation and Doebner modification.

- **CO 24** Synthesize α-oxidation products of carbonyl compounds (*e.g.* α-bromination, Riley oxidation) and carboxylic acids (*e.g.* HVZ reaction).

- **CO 25** Gain idea about 'acyl-cation' and 'acyl-anion' synthons and their corresponding synthetic equivalents.

- **CO 26** Get familiar with disproportionation reaction of carbonyl compounds (*e.g.* Cannizzaro reaction) and reactions of aldehydes with Tollens' reagent and Fehling's solution.

- **CO 27** Use α, β-unsaturated carbonyl compounds as dienophiles in Diels-Alder reaction.

- **CO 28** Recognize the products leading to the formation of KCP & TCP in the formation of enolates and electrophilic addition to conjugated dienes.

- **CO 29** Get elementary concept about various types of mechanisms for hydrolysis of esters such as $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ etc.

- **CO 30** Get familiar with the concept of 'umpolung' and its application in the formation of various organometallic reagents e.g. Grignard reagent, organolithiums, organocuprates and organozinc reagents.

- **CO 31** Exploit the enhanced nucleophilicity of Grignard reagents and alkyl/aryl lithiums in the formation of carbon-carbon bonds.

- **CO 32** Utilize the moderate nucleophilicity of Gilman cuprates in the formation of carbon-carbon bonds such as Corey-House synthesis, reaction with aldehyde and acid chlorides.

- **CO 33** Utilize the electrophilic behaviour of zinc-carbenoids to form highly strained cyclopropane molecules.

- **CO 34** Get familiar with the abnormal behaviour of Grignard reagents and the concept of base-nucleophile dichotomy in case of organometallic reagents.

Place of the Course	**Katwa College**
Department	**Chemistry**
Name of the Course	**Core Course 6 (For Honours Students)**
Main Topics of the Course	1. ***Chemical Bonding-I*** 2. ***Chemical Bonding-II*** 3. ***Radioactivity***
Mentors	**Dr. Kedar Nath Mitra, Dr. Goutam Nandi, Dr. Dinesh Maity, Dr. Saptarshi Biswas**

Ionic Bond

Upon completion of this topic, students should be able to:

- **CO 1** Outline the general characteristics of ionic bonds.
- **CO 2** Describe the radius ratio rule and its applications.
- **CO 3** Find out the geometry of the cation and anion in an ionic crystal using radius ratio rule.
- **CO 4** Describe the packing (hcp or ccp) of ions in crystal.
- **CO 5** Calculate the packing efficiency of different types of packing.
- **CO 6** Derive the Born-Lande equation for determining the lattice energy of the ionic compounds.
- **CO 7** Draw the Born-Haber cycle and determine the thermodynamic parameters for different ionic compounds.
- **CO 8** Define the salvation energy and its application in dissolution process.

Radioactivity

On completion of the course, students are able to:

- **CO 1** Describe Nuclear forces and nuclear binding energy.
- **CO 2** Distinguish between the different types of nuclear model.
- **CO 3** Elucidate the nuclear reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation.
- **CO 4** know how to determine of age of rocks and minerals, radio carbon dating.

- **CO 5** understood and realize the radiation hazard and radiation safety.

Place of the Course	**Katwa College**
Department	**Chemistry**
Name of the Course	**Core Course 5 (under CBCS)**
Semester	**3rd**
Course Title	**Physical Chemistry-II (Theo)**
Main Topics of the Course	1. Transport Processes 2. Application of Thermodynamics – I 3. Foundation of Quantum Mechanics
Mentors	**Dr. Kedar Nath Mitra, Dr. Goutam Nandi, Dr. Dinesh Maity, Dr. Saptarshi Biswas**

Transport Processes

On completion of the course, students are able to:

- **CO 1** Describe different transport properties, Fick's law and phenomenological coefficients.
- **CO 2** Distinguish between the different types of fluid flow.
- **CO 3** Able to establish Newton's equation, viscosity coefficient; Poiseuille's equation.
- **CO 4** Recognize cell constant, specific conductance, molar conductance; specific conductance, equivalent conductance.
- **CO 5** Illustrate the Ostwald's dilution law; Ionic mobility and conductance measurement.
- **CO 6** Determine the solubility product and ionic product of water.
- **CO 7** Elucidate the principles of Hittorf's and Moving-boundary method.
- **CO 8** Describe Wien effect, Debye-Falkenhagen effect and Walden's rule.