Semester –V: Inorganic Chemistry II (3L-0T-1P)

Graduate Attributes

i. ***Course Objective:***

This course focuses on further extending the concepts of coordination chemistry along with the chemistry of main group elements, noble gases and introduction to organometallics. Intermediate level quantitative analysis of metal ions is included to give a hands-on experience to the students.

ii. ***Learning outcome:***

Students shall learn about electronic and magnetic properties of coordination complexes. They shall understand the preparation, structure and properties compounds of main group elements and noble gases. Students will also learn about organometallic compounds, comprehend their bonding, stability and reactivity. The laboratory experiments shall enable the learners to separate and estimate individual ions in multicomponent systems.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. ***Particulars of Course Designer*** (Name, Institution, email id):

1) Dr. Apurba Kalita, B Barooah College, apurbakalitabbc@gmail.com

2) Dr. Sanchay Jyoti Bora, Pandu College, sanchay.bora@gmail.com

3) Dr. Sonit Kumar Gogoi, Gauhati University, skgogoi@gauhati.ac.in

Semester –V: Inorganic Chemistry II (3L-0T-1P)

Unit	Content	Contact Hrs
Unit I: Coordination Chemistry IV	Electronic spectra and magnetism of coordination compounds: microstates, free ion term symbols and their splitting in tetrahedral and octahedral fields, Racah parameters, selection rules and relaxation mechanisms (vibronic coupling and spin orbit coupling), Orgel diagrams and prediction of spectral transitions, Jahn-Teller effect on electronic spectra, charge-transfer spectra, calculation of spin only and orbital contribution to magnetic moments. Spin crossover.	12
Unit II: Main Group elements	Relative stability of different oxidation states, inert pair effect, diagonal relationship, and anomalous behaviour of main group elements. a) Preparation and properties of ortho and para hydrogen. b) Preparation, structure and properties of borane (bonding in diborane, brief idea of styx number, Wade's rule), boric acid, borax, borazine, phosphazine, S_4N_4. c) Preparation and properties of oxides, superoxides, peroxides, hydrides, hydroxides, halides and carbonates of alkali and alkaline earth metals. Reactions of alkali and alkaline earth metals with liquid ammonia. d) Allotropes of carbon, phosphorus, and sulphur. e) Oxides and oxoacids of nitrogen, phosphorus, sulphur, and chlorine. f) Interhalogen compounds, polyhalides, pseudo halogen g) Hydrates, clathrates and inclusion compounds. h) Preparation, structure and properties of silicates, aluminosilicates.	15
Unit III:Noble Gases	Occurrence and uses, rationalisation of inertness of noble gases, clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).	6

Unit IV: Organometallics I	Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands, 18 electron rule. Metal carbonyls: electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni. Pi -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic bonding effect and use of IR data to explain the extent of back bonding. Zeise's salt: preparation and structure, evidence of synergic effect and comparison of synergic effect with that in carbonyls.	12
Laboratory: Inorganic quantitative analysis	1. Estimation by volumetric method of any two of the following: a. Fe(III)- By standard $KMnO_4$ solution b. Fe(III) – By standard $K_2Cr_2O_7$ solution c. Cu(II) – By Iodometric method. 2. Estimation of Ni(II) by gravimetric method. 3. Separation and estimation of individual ions in two-component systems of a. Cu and Fe b. Fe and Ca c. Ca and Mg d. Cu and Ni and e. Cl^- and SO_4^{2-}.	30
Text/ reference Books	1. Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education. 2. Principles of Inorganic Chemistry, 7th edition, Puri, Sharma, Kalia, Vishal Publishing Co. 3. Concepts and Models of Inorganic Chemistry, 3rd edition, Bodie Douglas, Darl Mcdaniel, John Alexander, Wiley. 4. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Wiley. 5. Vogel's Quantitative Chemical Analysis 6th edition, J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivsankar, Pearson.	

Semester-V: Organic Chemistry II (3 L- 0 T- 1 P)

Graduate Attributes

i. ***Course Objective:***

This course aims at introducing students to stereo-chemical aspects of organic reactions and their mechanisms. Students will also learn the chemical aspects of carbohydrates and terpenoids.

Familiarize the students with qualitative analysis of carbohydrates and small organic compounds with functional groups. Further, to teach students methods for identifying functional groups using IR spectroscopy.

ii. ***Learning outcome:***

Students will be able to predict and recognize reactivity of organic molecules by their functional groups, and utilize this understanding for the construction of complex molecules.

Learners will be able to qualitatively analyse organic molecules and identify the functional groups by interpreting the IR spectra.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. ***Particulars of Course Designer*** (Name, Institution, email id):

1) Prof. Rupam Jyoti Sarma, Gauhati University, rjs@gauhati.ac.in

2) Dr. Diganta Choudhury, B Barooah College, digantachoudhury2008@gmail.com

Semester-V: Organic Chemistry II (3 L- 0 T- 1 P)

Unit	Content	Contact Hours
Unit I: Formation of carbon-carbon and carbon-heteroatom bonds	Wurtz Reaction, Wurtz-Fittig reaction, Simmons-Smith reaction; Free radical substitutions; Saytzeff and Hofmann eliminations; reagents of phosphorus, sulfur and boranes; stereospecific and stereoselective reactions; stereoselective reactions of alkenes: epoxidation reaction using mCPBA.	10
Unit II: Reactions of active methylene compounds	Active methylene compounds (keto-enol tautomerism): preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	8
Unit III: Reactions of enolates and enamines	Formation and stability of enolates and enamines; alkylation of enolates and enamines; aldol reaction: aldol and benzoin condensation; Claisen reaction, Claisen-Schmidt reaction, Knoevenagel condensation, Perkin reaction; Cannizzaro reaction, Wittig reaction, Favorskii reaction, Beckmann rearrangement, Benzil-Benzilic acid rearrangement; addition reactions of unsaturated carbonyl compounds; Michael addition, Wolff rearrangement.	8
Unit IV: Nucleophilic reactions on the C=O groups	Nucleophilic attack at the carbonyl group (geometrical aspects); concept of prochirality; stereoselective additions to carbonyl groups: Crams rule, Felkin-Anh model.	4
Unit V: Carbohydrate chemistry	Classification of monosaccharides; absolute configuration of glucose and fructose, epimers and anomers; mutarotation; determination of ring size of glucose and fructose; conformations of glucose (Fischer, Haworth and stereoscopic projections); interconversions of aldoses and ketoses; Killiani Fischer synthesis and Ruff degradation; disaccharides: structure elucidation of maltose, lactose and sucrose. Polysaccharides -structures of starch, cellulose and glycogen.	9
Unit VI: Terpenes	Occurrence of terpenes; structure and classification of terpenes, isoprene rule; synthesis of citral, neral and α-terpineol; biosynthesis of limonene, pinene, carvone (*via* isopentenyl pyrophosphate).	6

Lab Course	1. Qualitative analysis of carbohydrates: aldoses and ketoses, reducing and non-reducing sugars. 2. (a) Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, phenols, amines, nitro, carboxylic acids and carbonyl compounds). (b) Interpretation of infrared (IR) spectra of simple organic compounds. *The student is required to learn about identification of functional groups of simple organic compounds by interpreting the IR spectra. The spectra may be recorded and/or provided to the students from literature.*	30
Recommended books	1. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, 2nd Edition. 2. Principles of Organic Synthesis, R. O. C. Norman, J. M. Coxon, 3rd Edition. 3. Advanced Organic Chemistry, R. Bruckner. 4. Organic Chemistry, G. M. Loudon, 4th Edition. 5. Organic Chemistry, R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, 7th Edition. 6. Organic Chemistry, Volume 2, I. L. Finar, 5th Edition. 7. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012. 8. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press. 9. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.	

Semester-V: Reaction Dynamics (3L-0T-1P)

Graduate Attributes

i. ***Course Objective:***

The aim of this course is to teach students reaction dynamics with emphasis on order and molecularity of reactions, rate laws and rate equations, equilibrium and steady states, collision theory etc.

ii. ***Learning outcome***

Students shall learn how to mathematically model chemical reactions and evaluate the necessary rates of chemical reactions. They shall also be able to comprehend enzyme action in human physiology. Students hall be able to visualize complex reaction mechanisms via mathematical modeling and develop an analytical thinking ability.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. **Particulars of Course Designer (Name, Institution, email id):**

1) Dr. Dhriti Mahanta, Gauhati University, mdhriti@gauhati.ac.in

2) Dr. Dhruba Jyoti Kalita, Gauhati University, dhrubajyoti.kalita@gauhati.ac.in

Semester V – Reaction Dynamics (3L-0T-1P)

Unit	**Content**	**Contact Hrs**
Unit I: Kinetics I	Order and molecularity of reactions. Rate laws and rate equations for zero, first and second order reactions (2A→P, A+B→ P): their derivations, graphical representations and examples. Expressing the rate laws in terms of volume and pressure of reactants. Experimental determination of order of reactions (half-life method and initial rate method). Temperature dependence of reaction rate, energy of activation (its connection to Gibbs free energy). Arrhenius equation, energy of activation. Pre-exponential Factor and failure of Arrhenius Equation.	9
Unit II: Kinetics II	Difference between equilibrium and steady state. Limiting reagents, rate-determining step and steady-state approximation – explanation with suitable examples (eg. dissociation of HBr and acetaldehyde). Opposing reactions, consecutive reactions and parallel reactions (with examples and explanation of kinetic and thermodynamic control of products; all steps first order). Idea on explosive reactions. Enzyme catalysis: Derivation of Michaelis-Menten equation and interpretation of Lineweaver-Burk Plots. Eadie- Hofstee plot. Turn-over number. Oscillating reactions.	14
Unit III: Reaction Dynamics	Collision theory (detailed treatment). Modeling the Preexponential factor. Sphere of influence and collision cross section, Equivalence between Arrhenius and Collision theory. Failure of Collision theory. Physical interpretation of reaction co-ordinates and potential energy surfaces. Activated complex theory (detailed treatment). Thermodyamic formulation and derivation of Eyring equation. Evaluation of Arrhenius pre-exponential factor from transition state theory. Common examples where transition states have been experimentally identified or predicted. Chemically and Diffusion controlled reactions with examples. Primary and secondary salt effects with examples. Derivation of Bronsted-Bjerrum Equation and its graphical representation. Lindemann and Hinshelwood theory of unimolecular reaction and graphical representation.	22

Laboratory experiments	1. Determine the rate constant of the acid catalyzed hydrolysis of methyl acetate. 2. Determine the rate constant of saponification of ethyl acetate. 3. Determine the activation energy of the hydrolysis of methyl acetate catalyzed by hydrochloric acid. 4. Verify the Freundlich isotherm for the adsorption of oxalic acid on activated charcoal. 5. Verify the Langmuir isotherm for the adsorption of acetic acid on activated charcoal. Determine the critical micelle concentration of a surface-active agent by surface tension measurements. 6. Study the kinetics of the Iodide-persulphate reaction by Initial rate method. 7. Theory and computer aided linear curve-fitting techniques (eg. first order kinetics using least squares) and evaluation of errors and standard deviations.	30

Text Books:

1. Atkins' Physical Chemistry, Atkins, de Paula and Keeler
2. Chemical Kinetics and Reaction Dynamics, Paul L. Houston

Reference books:

1. A Textbook of Physical Chemistry, K. L. Kapoor, Volume V, Macmillan
2. Principles of Physical Chemistry, Puri, Sharma, Pathania, 48th edition, Vishal Publication.
3. Physical Chemistry: P C Rakshit
4. Physical Chemistry: A Molecular Approach by McQuarrie and Simon
5. Chemical Kinetics by Kaith J Laidler, McGraw-Hill

Semester-V: Light-Matter Interaction (3L-0T-1P)

Graduate Attributes

i. ***Course Objective:***

This paper is focused on fundamental theory and application of photochemistry and various spectroscopic techniques such as rotational, vibrational, electronic and Raman spectroscopy. The accompanying laboratory course aims to introduce the students to various computational/experimental tools.

ii. ***Learning outcome:***

Students shall learn about the theory of photochemistry, spectroscopy and their application in chemistry. They shall use the knowledge gained from the quantum theories to identify unknown chemical compounds using modern techniques. The experiments performed in the laboratory course shall enable the learners to analyze/estimate various analytes using different techniques.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. ***Particulars of Course Designer*** (Name, Institution, email id):

1) Dr. Himangshu Prabal Goswami, Gauhati University, hpg@gauhati.ac.in

2) Dr. Dhriti Mahanta, Gauhati University, mdhriti@gauhati.ac.in

Semester V – Light-Matter Interaction (3L-0T-1P)

Unit	Content	Contact Hrs
Unit I: Photochemistry:	Laws of photochemistry: Grotthus-Draper law, Stark-Einstein law of photochemical equivalence. Beer-Lambert law (for solids and liquids) and limitations. Quantum yield and its measurement for photochemical processes. Actinometry. Photostationary state. Photosensitized reactions (with examples). Jablonski diagrams: internal conversion, intersystem crossing, fluorescence and phosphorescence. Frank Condon principle. Primary and secondary processes in photochemical reactions.	10
Unit II: Spectroscopy	Spectroscopy and its importance in chemistry. Wave-particle duality. Link between spectroscopy and quantum chemistry. Electromagnetic radiation and its interaction with matter. Types of spectroscopy. Absorption cross section and Einstein's coefficients. Difference between atomic and molecular spectra. Born- Oppenheimer approximation. Separation of molecular energies into translational, rotational, vibrational and electronic degrees of freedom. Factors affecting intensities and width of spectral lines. Microwave (pure rotational) spectra of diatomic molecules. Selection rules and transition dipole moment. Structural information derived from rotational spectroscopy. IR Spectroscopy: Selection rules, IR spectra of diatomic molecules and organic compounds having functional groups. Structural information derived from vibrational spectra. Vibrations of polyatomic molecules. Group frequencies. Effect of hydrogen bonding (inter and intramolecular) and substitution on vibrational frequencies. Electronic Spectroscopy: electronic excited states and selection rules. Free electron model and its application to electronic spectra of polyenes. Vibronic and spin orbit coupling. Colour and constitution, chromophores, auxochromes, bathochromic and hypsochromic shifts. Woodward-Fieser rules. Qualitative treatment of Raman effect. Elements of rotational Raman spectra Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference. Rule of mutual exclusion.	35

Laboratory (minimum of seven to be performed)	1. Calculation of the rotational constant for simple diatomic systems (eg. N_2, F_2, O_2) via quantum chemistry softwares. 2. Calculation of the optimum bond length by hand (theoretical) from the rotational constant via the rigid rotor approximation for a diatomic molecule. 3. To perform a series of single point calculations above and below equilibrium bond distance to generate a potential energy surface (PES) followed by a frequency calculation on the optimized geometry. Use of the resulting fundamental frequency to calculate the force constant of the bond. 4. Simulating the IR spectra of simple nonlinear molecules (eg. water, ammonia, boron trifluoride etc) using quantum chemistry software and assign the spectra to the corresponding vibrational modes. 5. To study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in dil. H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV). 6. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$. 7. Record the 200-350 nm UV spectra of organic compounds (eg. acetone, acetaldehyde, 2-propanol, acetic acid) and interprete the spectra. Compare these experimental results with associated theoretical rules. 8. Complete spectral analysis of the given (or recorded) vibration-rotation spectrum of HCl (g). 9. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration 10. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture. 11. Study the kinetics of iodination of propanone in acidic medium. 12. Determine the amount of iron present in a sample using 1,10-phenathroline. 13. Determine the dissociation constant of an indicator (phenolphthalein). 14. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.	30

Text Books:

1. Fundamentals of Molecular Spectroscopy, C N Banwell, 4th Edition, McGraw-Hill
2. Atkins Physical Chemistry, P Atkins, J Paula and J Keeler, 11th Edition, Oxford University Press. 2018

Reference Books:

1. Introduction to Spectroscopy, DL Pavia, GL Lampman, GS Kriz and J R Vyvyan, 5th Edition, Cengage India Private Limited, 2015
2. Introduction to Molecular Spectroscopy: GM Barrow, McGraw Hill, 1992.
3. Basic Atomic and Molecular Spectroscopy, Vol 11, J M Hollas, Royal Society of Chemistry, 2002.
4. Symmetry and Spectroscopy: an introduction to vibrational and electronic spectroscopy, DC Harris and M D Bertolucci, 1989, Dover Publications
5. Molecular Spectroscopy, JL McHale, 2nd Edition, CRC Press
6. Atomic and Molecular Spectroscopy: Basic Concepts and Applications. Rita Kakkar, 2nd Edition, S Chand Publishing

Semester-VI: Inorganic Chemistry III (3L-0T-1P)

Graduate Attributes

i. ***Course Objective:***

This course aims at giving students the introduction to inorganic reaction mechanisms and bioinorganic chemistry. Moreover, this course emphasizes on organometallic chemistry with reference to transition metal-π bound complexes, metal-carbenes and organometallic catalysis. The laboratory course intends to introduce students to preparation and characterization of coordination complexes and double salts.

ii. ***Learning outcome:***

Students shall understand the mechanisms of inorganic reactions and the role of metal ions in biological processes and therapeutic activities. They will be acquainted with the synthesis, structure and reactivity of various organometallic compounds, and their application in organometallic catalysis. Furthermore, the students will understand the importance of organometallic catalysis in the synthesis of industrially important compounds. The laboratory experiments will enable the learners to synthesize metal complexes and double salts and their characterization by various analytical techniques.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. ***Particulars of Course Designer*** (Name, Institution, email id):

1) Dr. Sanfaori Brahma, Gauhati University, sanfaori@gauhati.ac.in

2) Dr. Apurba Kalita, B Barooah College, apurbakalitabbc@gmail.com

Semester VI- Inorganic Chemistry III **(3L-0T-1P)**

Unit	**Content**	**Contact Hrs**
Unit I Coordination Chemistry-V	Introduction to inorganic reaction mechanisms. Stepwise and overall formation constants, the chelate effect, thermodynamic and kinetic stability of complexes, chelate effect and its applications in analytical chemistry and biology. Substitution reactions in octahedral complexes, factors affecting the substitution reaction, effect of acid and bases on substitution reaction of octahedral complexes. Substitution reaction of square planar complexes, trans-effect, theories of trans effect, trans effect in synthesis of square planar complexes. Electron transfer reactions (elementary ideas only)	15
Unit II Organometallics II	Metal alkenes, alkynes and allyls: synthesis, structure, bonding and reactivity. Metal carbene: synthesis, structure, bonding and reactivity Ferrocene: preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene Fundamentals of organometallic reactions: oxidative addition, reductive elimination, insertion and β-hydride elimination reaction. Transition metals in catalysis. Study of the industrial processes and their mechanism: alkene hydrogenation (Wilkinson's Catalyst), hydroformylation (Co catalysts), Wacker Process, synthetic gasoline (Fischer Tropsch reaction), Monsanto acetic acid process.	15
Unit III Bioinorganic Chemistry	Essential and trace metals in biology. Effect of deficiency of essential metal ions. Toxic effect of metal ions (Fe, Cu, Hg, Pb, Cd and As), chelate therapy, cisplatin as anticancer drug. Storage and transport of iron, active transport of ions (sodium -potassium pump) Active site structure and function of haemoglobin (cooperativity and Bohr effect), myoglobin, hemocyanin, hemerythrin, rubredoxin, ferredoxin (Fe_2S_2, Fe_4S_4), cytochrome P450, superoxide dismutase, carbonic anhydrase and carboxypeptidase, nitrogenase enzyme, vitamin B_{12}	15

Laboratory: Inorganic Preparation	Following compounds should be prepared and tested for the presence of ions qualitatively. IR and UV-Visible spectra of these complexes should be recorded, interpreted and discussed. i) Preparation of Mohr's Salt, chrome alum and potash alum ii) Cis and trans $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III) iii) Potassium tris(oxalato)ferrate(III) iv) Vanadyl bis(acetylacetonate) v) Cu-thiourea complex vi) Acetylation of ferrocene and purification of mono and bis derivatives by column chromatography.	30
Text/ Reference Books	1. Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education. 2. Principles of Inorganic Chemistry, 7th edition, Puri, Sharma, Kalia, Vishal Publishing Co. 3. Bioinorganic Chemistry, Bertini, Gray, Lippard and Valentine, University Science Books. 4. The Organometallic Chemistry of the transition Metals, Robert H. Cratbtree, 4th edition, Wiley 5. Inorganic syntheses, series, Wiley.	

Semester-VI: Organic Chemistry III (3 L- 0 T- 1 P)

Graduate Attributes

i. ***Course Objective:***

This course aims at introducing the students to photo-chemical and pericyclic organic reactions. The learners shall be able to understand the chemistry of polynuclear aromatic hydrocarbons, organometallic compounds and their reactions.

Experiments are aimed at introducing the students to natural product extraction, photochemical organic transformations and estimation of organic compounds.

ii. ***Learning outcome:***

Students will be able to recognize and explain the mechanisms of photochemical and pericyclic reactions and apply mechanistic concepts to predict the outcome of synthetic reactions. Students will be introduced to the preparation, structure and reactivity of polyaromatic hydrocarbons and organometallic compounds.

Students will develop the skill set to extract important organic components from natural samples, estimate organic compounds and perform photochemical conversion.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. ***Particulars of Course Designer*** (Name, Institution, email id):

1) Prof. Rupam Jyoti Sarma, Gauhati University, rjs@gauhati.ac.in

2) Dr. Ranjit Thakuria, Gauhati University, ranjit.thakuria@gauhati.ac.in

Semester-VI: Organic Chemistry III (3 L- 0 T- 1 P)

Unit	Content	Contact Hours
Unit I: Photochemistry	Electron excitation in organic molecules (alkenes and carbonyl compounds); fate of electronically excited molecules; singlet and triplet states; photoreduction of carbonyl compounds; photoaddition of alkenes to carbonyl compounds (Paterno-Buchi reaction); photoaddition of alkeñes to aromatic compounds; photorearrangement (cis-trans isomerization, intramolecular cyclization of dienes); photochemical fragmentation (photolysis of carbonyl compounds: Norrish type I and type II reactions).	10
Unit II: Pericyclic reactions	Cycloadditions: general description of the Diels-Alder reaction; frontier orbital description of [4+2] cycloadditions; regioselectivity in Diels-Alder reactions; Woodward-Hoffmann description of the Diels-Alder reaction; photochemical [2+2] cycloadditions; thermal [2+2] cycloadditions. Sigmatropic reactions: conditions for sigmatropic reactions, orbital descriptions of [3,3]-sigmatropic rearrangements; Cope rearrangement Electrocyclic reactions: conditions for [4π+2] and [4π] electrocyclic reactions; conrotatory and disrotatory reactions.	15
Unit III: Polynuclear hydrocarbons	Preparation, structure and reactions of naphthalene, phenanthrene and anthracene.	5
Unit IV: Organometallic chemistry	General introduction to preparation, structure and reactivity of organolithium, organomagnesium (Schlenk equilibrium), organocopper, organozinc, organoaluminum, and organoboron reagents; general methods of preparation: deprotonation, metal-halogen exchange, transmetallation; directed metallation.	15
Laboratory Course	1. Extraction of D-limonene from orange peel by the conventional method/ using liquid CO_2 prepared form dry ice. 2. Extraction of caffeine from commercially available tea leaves. 3. Photoreduction of benzophenone to benzopinacol in the presence of sunlight/UV irradiation. 4. Organic estimations (any three): (i) Estimation of glycine by Sorenson's formalin method. (ii) Study of the titration curve of glycine (by pH metric methods). (iii) Determination of Iodine number of vegetable oil or a fat. (iv) Saponification value of vegetable oil or a fat. (v) Estimation of glucose by titrimetric methods.	30

Recommended books	1. Foundations of Photochemistry, K. K. Rohatgi-Mukherjee, 3rd Edition. 2. Principles of Organic Synthesis, R. O. C. Norman, J. M. Coxon, 3rd Edition. 3. Mechanism and Theory in Organic Chemistry, T. H. Lowry, K. S. Richardson. 4. Pericyclic Reactions, Vinod Kumar, S. P. Singh. 5. Organic Chemistry, Volume 1, I. L. Finar, 5th Edition. 6. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, 2nd Edition. 7. Modern Methods of Organic Synthesis, W. Carruthers, I. Coldham, 4th Edition. 8. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012. 9. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press. 10. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.

Semester-VI: Equilibria and Electrochemistry (3L-0T-1P)

Graduate Attributes

i. ***Course Objective:***

The aim of this course is to introduce students to primarily two areas of physical chemistry- equilibria and electrochemistry. Discussion of equilibria encompasses- chemical, ionic and phase equilibria. The learners are expected to learn various laws of electrochemistry, measurements of conductance, applications of electrolysis in industry, electrochemical cells etc. The accompanying laboratory course is designed to introduce students to various experiments using pHmetry, conductometry, calorimetry etc.

ii. ***Learning outcome:***

Students shall understand how dynamic equilibrium works in chemical reactions. They shall be introduced to ionics, phases and electrochemical systems.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. ***Particulars of Course Designer*** (Name, Institution, email id):

1) Dr. Debajyoti Mahanta, Gauhati University, debam@gauhati.ac.in

2) Dr. Sanjib Deuri, M C College, Barpeta, s_deuri@yahoo.com

Semester VI – Equilibria and Electrochemistry (3L-0T-1P)

Unit	**Content**	**Contact Hrs**
Unit I: Chemical Equilibria	Equilibrium of homogeneous and heterogeneous systems. Law of mass action, derivation of expression of equilibrium constants; temperature, pressure and concentration dependence of equilibrium constants (K_P, K_C, K_X), their applications. Le Chatelier's principle of dynamic equilibrium and its applications.	**5**
Unit II: Ionic Equilibria	Introduction to ionic equilibrium. Ionic product. Common ion effect: its application. Acid-base equilibria. Dissociation constants of mono and dibasic acids. pH scale, pH of very dilute and very concentrated solutions. Concept of strengths of solutions (molarity, normality and molality, difference between mass of a substance and amount of a substance). Calculation of strengths of acid and basic mixtures. pH titration curves of acid mixtures, salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions and derivation of Henderson-Hasselbalch equation (for mono and dibasic acids). Solubility and solubility product of sparingly soluble salts – applications of solubility product principle with special reference to inorganic group separation. Explanation of inorganic group separation table using Le Chatelier's principle, solubility product and common ion effect.	**10**
Unit III: Phase Equilibria	Definitions of phase, component and degrees of freedom. Gibb's phase rule and its derivations. Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law. Solvent extraction.	**15**
Unit IV: Electrochemistry	Conductivity, equivalent and molar conductivity and their properties; Kohlrausch law; Debye-Huckel Theory, Debye-Huckel Limiting Law , Debye Hückel Onsager equation (no derivation required); Ionic velocities, mobilities, transference numbers and its experimental determination using Hittorf and moving boundary methods; Applications of conductance measurement; Quantitative aspects of Faraday's laws of electrolysis, applications of electrolysis in metallurgy and industry; Electrolytic and galvanic cells, Electromotive force of a cell, Nernst equation; Standard	**15**

	electrode potential, Electrochemical series; Concentration cells with and without transference; Applications of EMF measurements including potentiometric titrations. Electrochemistry behind standard Pb Batteries and rechargeable Li-ion batteries.	
Laboratory experiments (a minimum of seven experiments to be performed)	1. pH metric titration of strong acid vs. strong base, 2. pH metric titration of weak acid vs. strong base. 3. Determination of dissociation constant of a weak acid. 4. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it. 5. Determine the transition temperature of a salt hydrate. 6. Construction of phase diagram (freezing point curve) using ignition tube method for two- component simple eutectic system. 7. Construction of phase diagram (freezing point curve) using ignition tube method for two- component congruently melting compound forming system. 8. Study the distribution of iodine between water and kerosene/carbon tetrachloride. 9. Determine the association factor of benzoic acid in benzene by distribution of benzoic acid between water and benzene. 10. Determine the vapour pressure of water at different temperatures and hence evaluate the enthalpy of vaporization of water. 11. Determine the partition coefficient of ammonia between water and chloroform and also determine the formula of copper-ammonia complex. 12. Study of the solubility of benzoic acid in water and determination of ΔH. ** Other experiments may also be introduced.	**30**

Textbooks:

1. Atkins Physical Chemistry, P Atkins, J de Paula and J Keeler, 11th Edition, Oxford University Press.
2. Principles of Physical Chemistry, Puri, Sharma, Pathania, 48th Edition, Vishal Publishing Com.

Reference Books:

1. Physical Chemistry: RS Berry, SA Rice and J Ross, 2nd Edition, Oxford University Press.
2. Physical Chemistry, P C Rakshit, Enlarged Seventh Edition, Sarat Book House.
3. Modern Electrochemistry, J O'M Bockris and AKN Reddy, Volume I: Ionics, Second Edition, Springer

Semester-VI: Industrial Chemistry (3L-0T-1P)

Graduate Attributes

i. ***Course Objective:***

This course provides an introduction to the various industrial gases and inorganic chemicals, their manufacturing processes, applications, storage and the hazards of handling them. The students are also expected to learn the synthetic processes, properties and the utility of the industrially important inorganic materials.

ii. ***Learning outcome:***

Students shall acquire knowledge of industrially important chemical processes. They shall know the extraction processes and the chemistry of firecrackers, ceramics, glass and cements.

No. of Required Classes: 45 (Theory) + 30 (Practical)

No. of Contact Classes: 45 (Theory) + 30 (Practical)

No. of Non-Contact Classes:

iii. ***Particulars of Course Designer*** (Name, Institution, email id):

1) Dr. Akhtar Hussain, Handique Girls College, akhtariisc@gmail.com

2) Dr. Sonit Kumar Gogoi, Gauhati University, skgogoi@gauhati.ac.in

Semester VI: Industrial Chemistry (3L-0T-1P)

Units	Content	Contact Hrs
Unit I: Industrial Gases and Common Inorganic Chemicals	**Industrial Gases:** large scale production, uses, storage and hazards in handling of the following gases: hydrogen, oxygen, nitrogen, chlorine, argon, helium, acetylene, phosgene. **Inorganic Chemicals:** manufacture, application and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, bleaching powder, hydrogen peroxide, potash alum, and potassium permanganate.	**9**
Unit II: Silicate Industries	**Glass**: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, borosilicate glass, armoured glass, coloured glass, photosensitive glass. **Ceramics:** important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, semiconducting oxides. **Cements:** classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.	**8**
Unit III: Fertilizers	Different types of fertilizers. Manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate. Compound and mixed fertilizers, potassium chloride, potassium sulphate.	**6**
Unit IV: Surface Coatings	Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Pigments, toners and lake pigments, fillers, thinners, enamels, emulsifying agents. Special paints (heat retardant, fire retardant, eco-friendly and plastic paint), dyes, wax polishing, water and oil paints, additives, metallic coatings (electrolytic and electroless), metal spraying and anodizing.	**8**
Unit V: Alloys	Classification of alloys, ferrous and non-ferrous alloys, specific properties of elements in alloys. Manufacture composition and properties of different types of steels (stainless steel, Ni-steel, Cr-steel). Brass, bronze and Cu-Ni alloy.	**6**

Unit VI: Catalysis	Catalysts and their industrial applications, deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.	**4**
Unit VII: Pyrotechnics and Propellants	Firecrackers- composition and effect. Fire extinguishers-types and use. Car airbag chemistry. Introduction to rocket propellants.	**4**
Laboratory	1. Determination of free acidity in ammonium sulphate fertilizer. 2. Estimation of calcium in calcium ammonium nitrate fertilizer. 3. Estimation of phosphoric acid in superphosphate fertilizer. 4. Electroless metallic coatings on ceramic and plastic material. 5. Determination of composition of dolomite (by complexometric titration). 6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples. 7. Analysis of Cement. 8. Preparation of pigment (zinc oxide).	**30**
Text Books and Reference Books	1. Industrial Chemistry, Vol-I, E. Stocchi, Ellis Horwood Ltd. UK. 2. Industrial Chemistry-I & Industrial Chemistry-II, B. K. Sharma, Krishna's Educational Publishers. 3. Riegel's Handbook of Industrial Chemistry, J. A. Kent, CBS Publishers. 4. R. Gopalan, D. Venkappayya, S. Nagarajan, Engineering Chemistry, Vikas Publications. 5. Engineering Chemistry, B. K. Sharma, Goel Publishing House.	