

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	<p>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.</p> <p>Substitution reactions in octahedral complexes, factors affecting the substitution reaction, effect of acid and bases on substitution reaction of octahedral complexes.</p> <p>Substitution reaction of square planar complexes, trans-effect, theories of trans effect, trans effect in synthesis of square planar complexes.</p> <p>Electron transfer reactions (elementary ideas only)</p>	15
Unit II Organometallics II	<p>Metal alkenes, alkynes and allyls: synthesis, structure, bonding and reactivity.</p> <p>Metal carbene: synthesis, structure, bonding and reactivity</p> <p>Ferrocene: preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene</p> <p>Fundamentals of organometallic reactions: oxidative addition, reductive elimination, insertion and β-hydride elimination reaction.</p> <p>Transition metals in catalysis.</p> <p>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.</p>	15
Unit III Bioinorganic Chemistry	<p>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)</p> <p>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}</p>	15

Laboratory: Inorganic Preparation	<p>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.</p> <ul style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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. Crabtree, 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 alkenes 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 [4 π +2] and [4 π] 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 from 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

<p>Recommended books</p>	<ol style="list-style-type: none"> 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.
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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

	<p>electrode potential, Electrochemical series; Concentration cells with and without transference; Applications of EMF measurements including potentiometric titrations.</p> <p>Electrochemistry behind standard Pb Batteries and rechargeable Li-ion batteries.</p>	
Laboratory experiments (a minimum of seven experiments to be performed)	<ol style="list-style-type: none"> 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. <p>** Other experiments may also be introduced.</p>	30
<p>Textbooks:</p> <ol style="list-style-type: none"> 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. <p>Reference Books:</p> <ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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. 	