At least 5-6 experiments are to be done in this semester. More experiments may be included to the following set of experiments. The following experiments may be replaced by equivalent/better experiments in a semester.

1. Determination of the strength of HCl and NaCl in their mixture by conductometric titration.
2. Determination of E^0 of Fe^{2+}/ Fe^{3+} and strength of a Mohr's salt solution against standard $K_2Cr_2O_7$/$KMnO_4$ solution.
3. Determination of K_{sp} of AgCl of and the strength of a silver nitrate solution by potentiometric titration of a $AgNO_3$ solution against a standard KCl solution.
4. Determination of the $K_a$of a weak mono-basic acid and the strength of its solution by pH-metric titration against a strong base.
5. Study of kinetics of decomposition of H_2O_2 catalysed by $FeCl_3$.
6. Determination of the solubility and solubility product of a sparingly soluble salt by conductometric method.
7. Kinetics of alkaline fading of crystal violet spectrophotometrically.

[**Reference books**: 1) to 8) in PhysicalChemistry (Practical) at page 44-48]

-X-

SEMESTER-5		**Course code: HCHE5CC011L**
Course name: Inorganic Chemistry-V, Physical Chemistry-V and Physical Chemistry Practical-IV		
Credits-6	Full Marks-100	Lectures-105
Theoretical (50 M) + Practical (30M) + Internal assessment (mid-semester) (15M) + Attendance (5M)		
Objectives: At the end of studying this course a student will acquire knowledge on (i) bioinorganic chemistry and organ metallic chemistry in organic chemistry and (ii) quantum mechanics – its applications to two-body systems, variation theorem, elementary discussions of atomic and molecular electronic structures, (iii) colligative properties and colloids and (iv) the physicochemical experiments in physical chemistry.		

Theoretical (50 M)
Inorganic Chemistry-V and Physical Chemistry-V

Group-A (Inorganic Chemistry-V)

Module-1: Bioinorganic chemistry **13M**

Elements of life: essential and beneficial elements, major, trace and ultra-trace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+}/^{2+}$, $Cu^{2+}/^{+}$, and Zn^{2+}). Metal ion transport across biological membrane: Na^+/K^+-ion pump. Dioxygen molecule in life. Dioxygen management proteins: Hemoglobin, Myoglobin, Hemocyanine and Hemerythrin. Blue copper protein. Hydrolytic enzymes: carbonate bicarbonate buffering system and carbonic anhydrase and carboxyanhydrase A. Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases (examples only).

Module-2: Organometallic chemistry I **12M**

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. 18-electron and 16-electron rules (p ictorial MO approach).Applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. General methods of preparation of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls. Electronic structures of NO complexes: brown ring and nitrosyls cyano complexes. pi-acceptor behaviour of CO, synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation, structure, evidences of synergic effect.

Group-B (Physical Chemistry-V)

Module-3: Quantum Mechanics II- Applications to Harmonic oscillator (1D), Two-Body Systems: Rigid Rotor and H-atom, Angular Momentum. 18M

The Harmonic Oscillator: Setting up of Schrödinger equation and characteristic features of the energy spectrum and the wave functions. The exact wave functions for the ground and the first excited states. Comparison with classical oscillator. Calculation of the average values of x, x^2, p_x, p_x^2 and the uncertainty product.

The Two-Body Systems: The statement of the problem and the concept of reduced mass and reduced coordinates. Setting up the Schrodinger equation for the two-body problems in the rectangular Cartesian coordinates and the separation of the centre-of-mass motion and the internal motion (outlines only). The Schrodinger equation for the internal motion in spherical polar coordinates (the final form only).

Two-Body Rigid Rotor and Angular momentum: Schrödinger equation for rigid rotor in spherical polar coordinates and the separation of variables (outlines only).Solution of the φ part. Rigid rotor wave functions -spherical harmonics, features of the wave functions, quantum numbers. The rigid rotor energy spectrum- characteristic features.

Angular momentum- Definitions, commutation relations and eigen spectrum (without derivation) significance of the results.

Hydrogen atom and hydrogen-like ions: Setting up of Schrödinger equation in spherical polar coordinates, Separation of variables, Solution of angular Part (φ part only), quantization of energy (only final energy expression); Real wave functions. Average and most probable distances of electron from nucleus.

Module-4: Colligative properties and colloids 7M

Colligative properties: Thermodynamic treatment of colligative properties viz. Elevation of boiling point, depression of freezing point and van't-Hoff osmotic pressure equation of solutions using the concept of chemical potential and their interrelationships. Abnormal colligative properties.

Lyophobic and lyophilic sols, Origin of charge of colloids, coagulation and Schultz-Hardy rule. Zeta potential and Stern double layer (qualitative idea). Electro kinetic phenomena (qualitative idea only). Stability of colloids and zeta potential, Tyndall effect.

Question Pattern for End Semester Examination (HCHE5CC011L)

	Module-1	Module-2	Modue-3	Module-4
Question to be set in total marks	20 to 23	18 to 21	27 to 30	10 to 12
Answer to be done in marks	13	12	18	7

[**Reference books** module 1 and 2: 1) to 8) in InorganicChemistry (Theory) at page 44-48]

[**Reference books** module 3 to 4: 1) to 6), 11) to 13), 26) to 30) and 38) to 42) in PhysicalChemistry (Theory) at page 44-48]

Practical: Physical Chemistry Practical-IV (30 M)
(Exp-20 M, LNB-05 M and Viva Voce 05 M)

At least 5-6 experiments are to be done in this semester for this paper. More experiments may be included to the following set of experiments. The following experiments may be replaced by equivalent/better experiments in a semester.

1. Determination of the ionisation constants of a poly-basic acid and the strength of its solution by pH-metric titration against a strong base.
2. Determination of the degree of dimerization and the dimerization constant of benzoic acid in an organic solvent by partition method.
3. Kinetics study of saponification reaction conductometrically.
4. Verification of Ostwald dilution law and determination of dissociation constant of a weak acid conductometrically.

5. Determination of the indicator constant of an acid-base indicator spectrophotometrically.
6. Studies on perdisulphate Potassium Iodide reaction kinetics (spectrophotometrically)
7. Studies on kinetics of auto-catalyzed reaction between potassium permanganate and oxalic acid.

[**Reference books**: 1) to 8) in Physical Chemistry (Practical) at page 44-48]

-X-

SEMESTER-5		**Course code: HCHE5CC012L**
Course name: Organic Chemistry-V and Organic Chemistry Practical-V		
Credits-6	Full Marks-100	Lectures-105
Theoretical (50 M) + Practical (30M) + Internal assessment (mid-semester) (15M) + Attendance (5M)		
Objectives: At the end of studying this course a student will acquire knowledge on (i) ^{1}H NMR and Mass spectroscopy in the structure determination of organic compounds, (ii) conformation and reactivity of cyclic molecules and preparation and reactions of polyaromatic hydrocarbons, (iii) pericyclic reactions, (iv) properties, synthesis and reactions of heterocyclic compounds and (v) TLC and column Chromatographic techniques in separation of organic amino acids and dyes.		

Theoretical (50 M)
Organic Chemistry-V

Module-1: Organic spectroscopy II **13M**

NMR Spectroscopy: Introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; choice of solvent and internal standard; equivalent and non-equivalent protons; chemical shift and factors influencing it; significance of the terms: up-/downfield, shielded and deshielded protons; anisotropic effects in alkene, alkyne, aldehydes and aromatics; ring current effect; rapid proton exchange; NMR peak area, integration; spin coupling and coupling constant (1st order spectra); relative intensities of *first-order* multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR. Relative peak positions with coupling patterns of common organic compounds (both aliphatic and benzenoid-aromatic); interpretation of NMR spectra of simple compounds.

Mass Spectroscopy: Basic principle, metastable peak, General fragmentation mode, Retro-Diels Alder reaction, McLafferty rearrangement, determination of presence and isotopic pattern for one halogen atom.

Applications: IR, UV, NMR and Mass spectroscopy for identification of organic molecules

Module-2: Carbohydrates **12M**

Monosaccharides: Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): Haworth representations and non-planar conformations; anomeric effect (including stereoelectronic explanation); mutarotation; epimerization; reactions (mechanisms in relevant cases): Fischer glycosidation, osazone formation, bromine-water oxidation, HNO_3 oxidation, selective oxidation of terminal –CH_2OH of aldoses, reduction to alditols, Lobry de Bruyn-van Ekenstein rearrangement; stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's &Wohl's methods) of aldoses; end-group-interchange of aldoses; acetonide (isopropylidene and benzylidene protections; ring size determination; Fischer's proof of configuration of (+)-glucose.

Disaccharides: Glycosidic linkages, concept of glycosidic bond formation by glycosyl donor-acceptor, structure of sucrose, inversion of cane sugar.

Module-3: Pericyclic reactions **13M**

Mechanism, stereochemistry, regioselectivity in case of
Electrocyclic reactions: FMO approach involving 4π- and 6π-electrons (thermal and photochemical) and corresponding cycloreversion reactions.
*Cycloaddition reactions:*FMOapproach, Diels-Alder reaction, photochemical [2+2] cycloadditions.

Sigmatropic reactions: FMO approach,sigmatropic shifts and their order; [1,3] and [1,5] H shifts and [3,3] shifts with reference to Claisen and Cope rearrangements.

Module-4: Heterocycles **12M**

Heterocyclic compounds: Biological importance of heterocycles referred in the syllabus; 5- and 6-membered rings with one heteroatom; reactivity, orientation and important reactions (with mechanism) of furan, pyrrole,thiophene and pyridine; synthesis (including retrosynthetic approach and mechanistic details): pyrrole: Knorr synthesis, Paal-Knorr synthesis, Hantzsch; furan: Paal-Knorr synthesis, Feist-Benary synthesis and its variation; thiophenes: Paal-Knorr synthesis, Hinsberg synthesis; pyridine: Hantzschsynthesis;benzo-fused 5-and 6-membered rings with one heteroatom: reactivity, orientation and important reactions (with mechanistic details) of indole, quinoline and isoquinoline; synthesis (including retrosynthetic approachand mechanistic details): indole: Fischer,quinoline: Skraup, isoquinoline: Bischler-Napieralski synthesis.

Question Pattern for End Semester Examination (HCHE5CC012L)

	Module-1	Module-2	Modue-3	Module-4
Question to be set in total marks	20 to 23	18 to 21	20 to 23	18 to 21
Answer to be done in marks	13	12	13	12

[**Reference books**for module 1 to 4: 1), 4) to 8), 10) to 15), 17) to 21) and 25) to 27) in OrganicChemistry (Theory) at page 44-48]

Practical: Organic Chemistry Practical-V (30 M)
(Exp-20 M, LNB-05 M and Viva Voce 05 M)

A. *Chromatographic Separations*

1. TLC separation of a mixture containing 2/3 amino acids.
2. TLC separation of a mixture of dyes (fluorescein and methylene blue).
3. Column chromatographic separation of mixture of dyes.
4. Paper chromatographic separation of a mixture containing 2/3 amino acids.
5. Paper chromatographic separation of a mixture containing 2/3 sugars.

B. *Spectroscopic Analysis of Organic Compounds:*

1. Assignment of labelled peaks in the ^{1}H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.
2. Assignment of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C≡C, C≡N stretching frequencies; **characteristic bending vibrations are included**).
3. The students must record full spectral analysis of **at least 15 (fifteen)** compounds from the following list: (i) 4-Bromoacetanilide (ii) 2-Bromo-4-methylacetophenone (iii) Vanillin (iv) 2- Methoxyacetophenone (v) 4-Aminobenzoic acid (vi) Salicylamide (vii) 2-Hydroxyacetophenone (viii) 1,3-Dinitrobenzene (ix) *trans*-Cinnamic acid (x) Diethyl fumarate (xi) 4-Nitrobenzaldehyde (xii) 4-Methylacetanilide (xiii) Mesityl oxide (xiv) 2-Hydroxybenzaldehyde (xv) 4-Nitroaniline (xvi) 2,3-Dimethylbenzonitrile (xvii) Pent-1-yn-3-ol (xviii) 3-Nitrobenzaldehyde (xix) 3-Aminobenzoic acid (xx) Ethyl-3-aminobenzoate (xxi) Ethyl-4-aminobenzoate (xxii) 3-Nitroanisole (xxiii) 4-Oxo-pentanoic acid (xxiv) Benzylacetate (xxv) Diethylmaleate.

[**Reference books**: 1) to 7) in Organic Chemistry (Practical) at page 44-48]

-X-

***DISCIPLINE SPECIFIC ELECTIVE COURSES**

1. **Any one from HCHE5DS11L and HCHE6DS12L**
2. **Any one from HCHE5DS21L and HCHE5DS22L**

SEMESTER-5		**Course code: HCHE5DS11L**
Course name: Polymer, Solid State, Nuclear Magnetic Resonance Spectroscopy and Supramolecular Chemistry and Polymer Chemistry Practical		
Credits-6	Full Marks-100	Lectures-105
Theoretical (50 M) + Practical (30M) + Internal assessment (mid-semester) (15M) + Attendance (5M)		
Objectives: At the end of studying this course a student will acquire knowledge on (i) introduction and Classification of polymer chemistry, (ii) solid state, (iii) nuclear magnetic resonance spectroscopy and (v) supramolecular chemistry.		

Theoretical (50 M)

Polymer, Solid State and Supramolecular Chemistry

Module-1: Polymer **20M**

Introduction: Definition, importance and application of polymers, Molecular forces and chemical bonding in polymers, classification of polymers : homopolymers, copolymers : statistical, block, graft and alternate, ter- polymers. Tacticity in polymers.

Types of polymerization: Criteria for synthetic polymer formation, classification of polymerization processes, chain growth (free radical, anionic and living), condensation and ring opening polymerization (ROP).

Glass transition temperature (Tg): Free volume theory, Factors affecting glass transition temperature (Tg).

Kinetics of Polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization. Mechanism of ring opening polymerization (introductory).

Determination of molecular weight of polymers (*Mn*, *Mw*, etc) by end group analysis, Colligative property measurement, light scattering, intrinsic viscosity measurement and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Module-2: Solid State **10M**

Types of solid, Bragg's law of diffraction. Laws of crystallography (Haüy's law and Steno's law). Permissible symmetry axes in crystals. Indexing of planes, Miller indices. Lattice, space lattice, Module-cell, crystal planes, Bravais lattice. Distance between consecutive planes [cubic, tetragonal and orthorhombic lattices]. Relation between molar mass and Module- cell dimension for cubic system. Applications of Bragg's law and powder method in determination of patterns of NaCl and KCl. Packing of uniform hard sphere close packed arrangements (fcc and hcp). Tetrahedral and octahedral voids. Void space in p-type, F-type and I-type cubic systems.

Heat capacity of solids: Dulong-Petit Law - justification from the Equipartition principle and Einstein's theory.. Einstein's theory of heat capacity of solids and its limitations, Justification of Dulong-Petit Law from Einstein's theory. Debye's T^3 Law- main propositions and difference with Einstein's theory of heat capacity.

Module-3: Molecular Spectroscopy II: Nuclear Magnetic Resonance Spectroscopy **10M**

Magnetic Resonance Spectroscopy: Introduction, basis of magnetic resonance spectroscopy, nmr active nuclei, the nmr spectrometer (Principle and schematic representation); chemical shift and δ scale, Shielding constant and its dependence on different contributions (elementary physical idea only). Qualitative discussion of spin-spin coupling and line structure splitting. Equivalent nuclei (in respect of two protons) and its simple consequences. Applications of magnetic resonance spectroscopy

Module-4: Supramolecular chemistry. **10M**

Various type of non-covalent interactions- electrostatic, H-bonding, π–π interaction, cation-π etc. Historical background and Elementary idea of supramolecular chemistry, molecular recognition, host/guest chemistry, self-assembly. Emil Fischer's lock and key theory and induced fit model. Definitions of crown ethers, lariat ethers, cryptands, cryptates, alkalides, electrides, catenanes, rotaxanes, pseudo rotaxanes. Synthesis, Properties and application crown ethers and cryptand. Kinetic and thermodynamic stability. Macrocyclic and chelate effect.

Question Pattern for End Semester Examination (HCHE5DS11L)

	Module-1	Module-2	Modue-3	Module-4
Question to be set in total marks	30 to 35	15 to 17	15 to 17	15 to 17
Answer to be done in marks	20	10	10	10

[**Reference books** for module 1: 1) to 14) in Polymer Chemistry (Theory) at page 44-48]
[**Reference books** for module 2 to 3: 1) to 6) in Physical Chemistry (Theory) at page 44-48]
[**Reference book** for module 4: 34) in Organic Chemistry (Theory) at page 44-48]

Practical: Polymer Chemistry Practical (30 M)
(Exp-20 M, LNB-05 M and Viva Voce 05)

Polymer synthesis

1. Preparation of urea-formaldehyde resin
2. Preparations of novalac resin/ resold resin.
3. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
   a. Polyacrylamide-aq.NaNO2 solution
   b. (Poly vinyl proplylidine (PVP) in water

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. IR studies of polymers

*at least 5 experiments to be carried out.

[**Reference books**: 1) to 14) in PolymerChemistry (Practical) at page 44-48]

-X-

SEMESTER-5		**Course code: HCHE6DS12L**
Course name: Green Chemistry and Green Chemistry Practical		
Credits-6	Full Marks-100	Lectures-105
Theoretical (50 M) + Practical (30M) + Internal assessment (mid-semester) (15M) + Attendance (5M)		
Objectives: At the end of studying this course a student will acquire knowledge on (i) principles and applications of green chemistry and (ii) preparation organic compounds by green methods.		

Theoretical (50 M)
Green Chemistry

Module-1: Introduction and principles of Green Chemistry. **20M**

Introduction to Green Chemistry: What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry; Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Principles of Green Chemistry and Designing a Chemical synthesis: Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following: Designing a Green Synthesis using these principles; Prevention of Waste/byproducts; maximum incorporation of the

materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
Prevention/ minimization of hazardous/toxic products reducingtoxicity; Green solvents–supercritical fluids, water as a solvent for organic reactions, ionic liquids, PEG, solventless processes.
Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.
Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry.

Module-2: Examples of Green Synthesis/ Reactions and some realworld cases **20M**
Examples of Green Synthesis/ Reactions and some real-world cases: Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis). Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic. solvents: Diels-Alder reaction and Decarboxylation reaction Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine). Green counterpart of common organic reactions: Aldol, Friedel-Crafts, Michael, Knoevenagel, Cannizzaro, benzoin condensation and Dieckmann condensation. Rearrangement reactions by green approach: Fries rearrangement, Claisen rearrangement, Beckmann rearrangement, Baeyer-Villiger oxidation.

Module-3: Future Trends in Green Chemistry **10M**
Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions. Green chemistry in sustainable development.

Question Pattern for End Semester Examination (HCHE5DS12L)

	Module-1	Module-2	Modue-3
Question to be set in total marks	30 to 35	30 to 35	15 to 17
Answer to be done in marks	20	20	10

[**Reference books** for module 1 to 3: 1) to 7) in Green Chemistry (Theory) at page 44-48]

Practical: Green Chemistry Practical (30 M)
(Exp-20 M, LNB-05 and Viva-05 M)

(Any SIX of the following list)

1. Acetylation of primary amine (preparation of acetanilide).
2. [4+2] Cycloaddition reaction (Diels-Alder reaction between furan and maleic anhydride).
3. Preparation of biodiesel from vegetable/waste cooking oil.
4. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
5. Pinacol-pinacolone rearrangement reaction (preparation of benzopinacolone).
6. Solid state synthesis of benzilic acid from benzil.
7. Benzoin condensation using thiamine hydrochloride as a catalyst instead of potassium cyanide.
8. Green multicomponent synthesis (three component coupling).
9. Base catalysed aldol condensation (synthesis of dibenzal propanone from benzaldehyde and acetone).
10. Bromination of *trans*-stilbene using bromide/bromate mixture.
11. Preparation and characterization of gold nanoparticles using tea leaves.
12. Extraction of D-limonene from orange peel using liquid carbon dioxide.
13. Electrophilic aromatic substitution reaction (nitration of salicylic acid).
14. Green radical coupling reaction.

[**Reference books**: 1) to 7) in Green Chemistry (Practical) at page 44-48]

-X-

SEMESTER-5		Course code: HCHE6DS21L
Course name: Analytical Chemistry and Analytical Chemistry Practical		
Credits-6	Full Marks-100	Lectures-105
Theoretical (50 M) + Practical (30M) + Internal assessment (mid-semester) (15M) + Attendance (5M)		
Objectives: At the end of studying this course a student will acquire knowledge on (i) extraction of various noble metals, (ii) the principles and applications of spectrophotometry, chromatography, (iii) complexometric, oxidemetric, reductimetric, gravimetric, colorimetric, flame photometric, fluorometric titration and (iv) TLC and column chromatographic techniques in purification of organic compounds.		

Theoretical (50 M)
Analytical Chemistry

Module-1: Extractions **12M**

Extraction of noble metals: rhenium (Re), ruthenium (Ru), rhodium (Rh), palladium (Pd), silver (Ag), osmium (Os), iridium (Ir), platinum (Pt), and gold (Au). Ellingham diagram and its applications.

Module-2: Spectrophotometry **12M**

Flame photometry and colorometry: Introduction to flame photometry and its application in detecting alkali metal ions; Introduction to colorometry and its application in estimating transition metal ions, e.g, iron (III), iron(II), manganese and also phosphate ion.Fluorometry: Introduction to fluorometry and its application in chemical analyses and medical diagnosis

Module-3: Estimation **13M**

Redox reactions and their importance, permanganometry and applications, dichromometry and applications, iodometry and applications, iodimetry and applications, complexometry and applications, gravimetry and applications.

Module-4: Chromatography **13M**

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Ion exchange resin and their exchange capacities, principle and simple applications of ion exchange separation. Chromatographic separations: TLC, paper column chromatographic techniques and their simple applications, R_f values and their significance, migration rate of solutes, band broadening and column efficiency, column resolution. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Question Pattern for End Semester Examination(HCHE5DS21L)

	Module-1	Module-2	Modue-3	Module-4
Question to be set in total marks	18 to 21	18 to 21	20 to 23	20 to 23
Answer to be done in marks	12	12	13	13

[**Reference books** for module 1 to 4: 1), 9) to 11) in Inorganic Chemistry (Theory) at page 44-48]

Practical: Analytical Chemistry Practical (30 M)
(Exp-20 M, LNB-05 and Viva-05 M)

1. Estimation of Fe(III) by complexometry.
2. Estimation of Mn(II) by permanganometry.
3. Estimation of Ni(II) by gravimetry.
4. Estimation of Fe(III) by colorometry.
5. Estimation of Mn(II) by colorometry.
6. Detection by flame photometry.
7. Detection by fluorometry.

8. Separation and identification of monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.
9. Separation and identification of aromatic amine and nitro compounds present in the given mixture by thin layer chromatography. Reporting the R_f values.
10. Separation by column chromatography.

[**Reference books**: 1) and3) in Inorganic Cchemistry (Practical) at page 44-48]

-X-

SEMESTER-5		**Course code: HCHE6DS22L**
Course name: Inorganic Materials of Industrial Importance and Inorganic Materials of Industrial Importance Practical		
Credits-6	Full Marks-100	Lectures-105
Theoretical (50 M) + Practical (30M) + Internal assessment (mid-semester) (15M) + Attendance (5M)		
Objectives: At the end of studying this course a student will acquire knowledge on (i) inorganic materials of industrial importance including glass, ceramics, cements, fertilizers, explosives, surface coating agents, batteries and alloys etc., (ii) principle of catalysis, properties and application of catalysts and (iii) analysis of inorganic materials of industrial importance.		

Theoretical (50 M)

Inorganic Materials of Industrial Importance

Module-1: Silicate Industries **10M**

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, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Module-2: Fertilizers and Chemical explosives. **10M**

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.

Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX).Introduction to rocket propellants.

Module-3: Surface Coatings. **10M**

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings.Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

Module-4: Batteries and Alloys **10M**

Batteries: Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

Alloys: Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (Arand heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

Module-5: Catalysis. **10M**

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.

Question Pattern for End Semester Examination (HCHE5DS22L)

	Module-1	Module-2	Modue-3	Module-4	Module-5
Question to be set in total marks	15 to 17	15 to 17	15 to 17	15 to 17	15 to 17
Answer to be done in marks	10	10	10	10	10

[**Reference books** for module 1-5: 1) to 7) in Industrial and Environmental Chemistry (Theory) at page 44-48]

Practical: Inorganic Materials of Industrial Importance Practical (30 M)
(Exp-20 M, LNB-05 and Viva-05 M)

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).

[**Reference books**: 1) to 6) in Industrial and Environmental Chemistry (Practical) at page 44-48]

-X-

SEMESTER-6		**Course code: HCHE6CC13L**
Course name: Inorganic Chemistry-VI, Catalysis and Inorganic Chemistry Practical-IV		
Credits-6	Full Marks-100	Lectures-105
Theoretical (50 M) + Practical (30M) + Internal assessment (mid-semester) (15M) + Attendance (5M)		
Objectives: At the end of studying this course a student will acquire knowledge on (i) preparation and reaction of organometallic complexes including metallocene, (ii) reaction kinetics and mechanism of coordination complexes, (iii) basic principles of catalysis and its applications and (iv) physiochemical experiments.		

Theoretical (50 M)
Inorganic Chemistry-VI and Catalysis

Group-A (Inorganic Chemistry-VI)

Module-1: Organometallic Chemistry II **10M**

Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination and insertion reactions. *Metallocenes*: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Fluxional molecules, quadruple and quintuple bonds.