DEPARTMENT OF CHEMISTRY

FACULTY OF NATURAL SCIENCES

JAMIA MILLIA ISLAMIA

(A Central University)

B.Sc. with CHEMISTRY

Effective from Academic Year 2017-2018

Syllabus of Courses Offered

Core courses, Elective Courses and Ability Enhancement courses

COURSE OUTLINE					
Semester	**Paper/ Practical**	**Paper No**	**Paper Code**	**Paper Title**	**Total Credits**
Semester-I	**Theory (Core)**	**I-G**	**CHG-101**	**Inorganic Chemistry-I**	**03**
	Practical (Core)		**CHG-101L**	**Inorganic Chemistry Practical-I**	**01**
Semester-II	**Theory (Core)**	**II-G**	**CHG-202**	**Organic Chemistry-I**	**03**
	Practical(Core)		**CHG-202L**	**Organic Chemistry Practical-I**	**01**
	Theory (Ability Enhancement)	**III-G**	**CHG-205**	**Basic Analytical Chemistry**	**04**
Semester-III	**Theory (Core)**	**IV-G**	**CHG-301**	**Inorganic Chemistry-II**	**03**
	Practical (Core)		**CHG-301L**	**Inorganic Chemistry Practical-II**	**01**
	Theory (Core)	**V-G**	**CHG-303**	**Physical Chemistry-I**	**03**
	Practical (Core)		**CHG-303L**	**Organic Chemistry Practical-II**	**01**
	Theory (Elective)	**VI-G**	**CHG-304**	**General Chemistry**	**03**
	Practical (Elective)		**CHG-304-L**	**General Chemistry Practical**	**01**
Semester-IV	**Theory (Core)**	**VII-G**	**CHG-402**	**Organic chemistry-II**	**03**
	Practical (Core)		**CHG-402L**	**Organic Chemistry Practical-II**	**01**
	Theory (Core)	**VIII-G**	**CHG-403**	**Physical Chemistry-II**	**03**
	Practical (Core)		**CHG-403L**	**Physical Chemistry Practical-II**	**01**
	Theory (Elective)	**IX-G**	**CHG-404**	**Novel Inorganic Solids**	**03**
	Practical		**CHG-404L**	**Novel Inorganic Solids Practical**	**01**
Semester-V	**Theory (Core)**	**X-G**	**CHG-501**	**Inorganic Chemistry-III**	**03**
	Practical (Core)		**CHG-501L**	**Inorganic Chemistry Practical-III**	**01**
	Theory (Core)	**XI-G**	**CHG-502**	**Organic Chemistry-III**	**03**
	Practical (Core)		**CHG-502L**	**Organic Chemistry Practical-III**	**01**
	Theory (Elective)	**XII-G**	**CHG-504**	**Polymer Chemistry**	**03**
	Practical (Elective)		**CHG-504L**	**Polymer Chemistry Practical**	**01**
Semester-VI	**Theory (Core)**	**XIII-G**	**CHG-603**	**Physical Chemistry-IV**	**03**
	Practical (Core)		**CHG-603L**	**Physical Chemistry Practical-IV**	**01**
	Theory (Core)	**XIV-G**	**CHG-604**	**Green Chemistry**	**03**
	Practical (Core)		**CHG-604L**	**Green Chemistry Practical**	**01**
	Total Credits				**56**

Paper code – 1st letter for semester, 2nd and 3rd for subject as mentioned below:-

01- Inorganic Chemistry,02-Organic Chemistry,03-Physical Chemistry,04- Elective, 05-Ability Enhancement

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Semester-I **UE = 75 marks**
Paper No: I-G **IA = 25 marks**
Paper Code: CHG-101

Inorganic Chemistry-I

Unit I: Atomic Structure

Bohrôs theory and its limitations; Atomic spectrum of hydrogen atom; Wave mechanics: de Broglie equation; Heisenbergôs Uncertainty Principle and its significance; Schrödingerôs wave equation; significance of ψ and ψ^2;Quantum numbers and their significance; Sign of wave functions; Radial and angular wave functions for hydrogen atom; Radial and angular distribution curves;Shapes of *s*, *p*, *d* and *f* orbitals; Contour boundary and probability diagrams;Rules for filling electrons in various orbitals; Electronic configurations of the atoms; Stability of half-filled and completely filled orbitals; Concept of exchange energy;Pauliôs Exclusion Principle; Hundôs rule of maximum multiplicity;Aufbauôs principle and its limitations ;Variation of orbital energy with atomic number.

Unit II: Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding; Energy considerations in ionic bonding; lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds;Statement of Born-Landé equation for calculation of lattice energy; Born-Haber cycle and its applications; polarizing power and polarizability;Fajanôs rules; ionic character in covalent compounds; bond moment; dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonalbipyramidal and octahedral arrangements;Concept of resonance and resonating structures in various inorganic and organic compounds; MO Approach: Rules for the LCAO method, bonding and anti-bonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals; nonbonding combination of orbitals;MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+;Comparison of VB and MO approaches.

Unit III: Elements of Group I

Alkali Metals: Chemical properties of the metals: reaction with water, air, nitrogen; Compounds of alkali metals: oxides, hydroxides, peroxides, superoxides- preparation and properties; oxo salts: carbonates; bicarbonates; nitrates; halides; anomalous behaviour of Li.

Unit IV: Elements of Group II

Alkaline Earth metals: Comparative study of these elements with special reference to their hydrides, oxides, hydroxide and halides; Diagonal relationship; Complexes of s-block metals; complexes with crown ethers, biological significance.

Books Suggested:

1. Basic Inorganic Chemistry by F.A. Cotton, G. Wilkinson & P.L. Gauss.
2. Concise Inorganic Chemistry by J.D. Lee.
3. Inorganic Chemistry by W.W. Portfield.
4. Inorganic Chemistry by D.E. Shriver, P.W. Atkins and C.H. Longford.
5. Inorganic Chemistry by A.G. Sharpe.

Practical Code: CHG-101L **UE = 25 marks**
IA = 25 marks

Inorganic Chemistry Practical-I

A. Titrimetric Analysis

i. Calibration and use of apparatus
ii. Preparation of solutions of different Molarity/Normality of titrants.

B. Volumetric Analysis

i. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
ii. Estimation of oxalic acid by titrating it with $KMnO_4$.
iii. Estimation of water of crystallization in Mohrôs salt by titrating with $KMnO_4$.
iv. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
v. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.

Any other experiment introduced during the year

Books Suggested:

1. Mendham, J., A. I., Vogelôs *Quantitative Chemical Analysis, 6th Ed.,* Pearson, 2009.
2. Svehla, G.,*Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.

Semester-II **UE = 75 marks**
Paper No: II-G **IA = 25 marks**
Paper Code: CHG-202

Organic Chemistry-I

Unit I: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, ElectromericEffect,Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles.Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückelôs rule.

Unit II: Stereochemistry

Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations.Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L;
cis- trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

Unit III: Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbeôs synthesis,nfrom Grignard reagent. Reactions: Free radical Substitution: Halogenation. Alkenes: Preparation: Elimination reactions: Dehydration of alkenes andDehydro-halogenation of alkyl halides (Saytzeffôs rule); cis alkenes (Partial catalyticnhydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk.KMnO4) and trans-addition (bromine), Addition of HX (Markownikoffôs and anti-nMarkownikoffôs addition), Hydration, Ozonolysis, oxymecuration-demercuration,nHydroboration-oxidation. Alkynes: Preparation: Acetylene from CaC_2 and conversion into higher alkynes; byndehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4,ozonolysis and oxidation with hot alk. KMnO4.

Unit IV: Aromatic hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.Preparation(Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel- Craftôs reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Books Suggested:

1. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. &Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
7. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998)

Practical Code: CHG-202L **UE = 25 marks**
IA = 25 marks

Organic Chemistry Practical-I

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing uptotwo extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case:
   (a) Identify and separate the components of a given mixture of 2 amino acids (glycine,aspartic acid, glutamic acid, tyrosine or any other amino acid) by paperchromatography
   (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Books Suggested:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.
3. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

Semester-II **UE = 75 marks**
Paper No: III-G **IA = 25 marks**
Paper Code: CHG-205

Basic Analytical Chemistry

Unit I: Introduction

Analytical Chemistry and its interdisciplinary nature; Conceptof sampling; Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results from the point of view of significant figures; Analysis of soil: Composition of soil; Concept of pH and pH measurement;Complexometrictitrations; Chelation, Chelating agents, use of indicators; Determination of pH of soil samples; Estimation of Calcium and Magnesium ions as carbonate by complexometric titration.

Unit II: Analysis of Water

Definition of pure water, sources responsible for contaminating water,water sampling methods, water purification methods; Determination of pH, acidity and alkalinity of a water sample; Determination of dissolved oxygen (DO), free chlorine and chloride ion of a water sample.

Unit III: Analysis of Food Products

Nutritional value of foods; idea about food processing and food preservations and adulteration;Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.; Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc. Paper chromatographic; Separation of mixture of metal ions (Fe^{3+} and Al^{3+}) and (Zn^{2+} and Cd^{2+}); Ion-exchange: Column, ion-exchange chromatography etc.

Unit IV: Analysis of Cosmetics

Major and minor constituents and their function; Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration. Applications (Any one):To study the uses of phenolphthalein in trap cases: (i)To analyze arson accelerants;(ii) To carry out analysis of gasoline.

Instrumental demonstrations:Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry(i) Spectrophotometric determination of Iron in Vitamin / Dietary Tablets; (ii)Spectrophotometric Identification and Determination of Caffeine and Benzoic acid in Soft Drink.

Books Suggested:

1. Skoog, D.A.; West, D.M. & Holler, F.J., *Fundamentals of Analytical Chemistry, 6th Ed.,* Saunders College Publishing, Fort Worth (1992).
2. Harris, D. C., *Quantitative Chemical Analysis*, W. H. Freeman. Dean, J. A., *Analytical Chemistry, Notebook*, McGraw Hill.
3. Cooper, T.G., *The Tools of Biochemistry,* John Wiley and Sons, N.Y., USA. (1977)
4. Vogel, A. I., *Vogel's Qualitative Inorganic Analysis, 7thEd.,* Prentice Hall.
5. Vogel, A. I., Vogelôs *Quantitative Chemical Analysis, 6thEd.,* Prentice Hall.
6. Robinson, J.W., *Undergraduate Instrumental Analysis, 5thEd.,* Marcel Dekker, Inc., New York (1995).

Semester-III **UE = 75 marks**
Paper No: IV-G **IA = 25 marks**
Paper Code: CHG-301

Inorganic Chemistry-II

Unit I: Elements of Group III

Comparative study of physical and chemical properties of these elements with special reference to their oxides, hydrides, halides and nitrides.Preparation and properties of boric acids and borax, borax bead test. Structure and bonding in diborane, an idea of three center-two electron bond in the light of molecular orbital theory, borazine, borohydrides.

Unit II: Elements of Group IV

Comparative study of physical and chemicals properties of these elements with special references to their oxides, hydrides, sulphides and carbides, fluorocarbons, study of silicates (structural aspects only) and silicones. Allotropy, inert pair effect, metallic and non-metallic character, and catenation.

Unit III: Elements of Group V

Comparative study of the physical and chemical properties of these elements with special reference to their hydrides, oxides, halides, oxyhalides and sulphides, Oxoacids of nitrogen: nitrous acid, nitric acid, hyponitrous acid, hydrazoic acid, pernitric acid; oxoacids of phosphorus- orthophosphorous acid, metaphosphorous acid, hypophosphorous acid; orthophosphoric acid, di-, tri-, and tetrapolyphosphoric acids.

Unit IV: Elements of Group VI

Comparative study of physical and chemical properties of these elements with special reference to their hydrides, oxides, halides and oxyhalides.Detailed study of oxyacids, peroxyacids and thio-oxyacids of sulphur (with special emphasis on their structure).oxoacids of sulphur - thionic acid series, peroxoacid series, (with special emphasis on their structure and methods of preparation), allotropy.

Books Suggested:

1. Basic Inorganic Chemistry by F.A. Cotton, G. Wilkinson & P.L. Gauss.
2. Concise Inorganic Chemistry by J.D. Lee.
3. Inorganic Chemistry by W.W. Portfield.
4. Inorganic Chemistry by D.E. Shriver, P.W. Atkins and C.H. Longford.
5. Inorganic Chemistry by A.G. Sharpe.

Practical Code: CHG-301L

UE = 25marks
IA = 25marks

Inorganic Chemistry Practical -II

(A) Inorganic synthesis

i. Potash alum and chrome alum
ii. Tetraamminecopper(II) sulphate monohydrate, $[Cu(NH_3)_4]SO_4.H_2O$
iii. Potassium tris oxalate ferrete(III).

(B) Qualitative analysis

i. Qualitative analysis of inorganic mixtures containing three anions and three cations including interfering radicals.

Books Suggested:

1. Mendham, J., A. I. Vogelôs *Quantitative Chemical Analysis 6thEd.,* Pearson, 2009.
2. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.

Semester-III **UE = 75 marks**
Paper No: V-G **IA = 25 marks**
Paper Code: CHG-303

Physical Chemistry-I

Unit I: Solutions

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoults law, relative lowering of vapour pressure, molecular weight determination. Osmosis, Law of osmotic pressure determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Abnormal molar mass, degree of dissociation and association of solutes.

Unit II: Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution.Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperatureï Kirchhoffôs equation.

Statement of Third Law of thermodynamics and calculation of absolute entropies ofsubstances.

Unit III: Chemical Equillibrium

Reversible and irreversible reactions, Characteristics of chemical equilibrium, Formulation of equilibrium law, equilibrium law for ideal gases, relation between Kp and Kc and Kx. Reaction quotient, factors affecting the equilibrium constant. Equilibrium between gases and solids, equilibrium constant for a system of real gases, equilibrium constant of reactions in solution. Thermodynamic treatment of equilibrium constant. Variation of equilibrium constant with temperature, pressure and concentration, effect of inert gas on reaction equilibrium, Le ï Chatelierôs principle.

Unit IV: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization. Acid-baseconcept. Dissociation constants of weak acids and weak bases. Ionization constant and Ionic product of water. The pH scale, Buffer solutions, Calculations of pH values of buffer mixtures, Derivation of Henderson equation and its applications, buffer capacity and buffer action. Salt hydrolysis, Determination of hydrolysis constant, degree of hydrolysis and pH for different salts. Relation between K_h, K_a and K_b. Solubility and solubility product of sparingly soluble salts ï Applications of solubility product principle and Common ion effect.

Books Suggested:

1. Essentials of Physical Chemistry, B.S. Bahl, G.D.Tuli and ArunBahl, S. Chand & Company Ltd.
2. A Text Book of Physical Chemistry, A.S. Negi and S.C. Anand, New Age International Publishers.
3. Physical Chemistry, G. M. Barrow, International Student Edition, McGraw Hill.
4. Physical Chemistry, P. W. Atkins, & J. de Paula, 10th Ed., Oxford University Press (2014).

Practical Code: CHG-303L

UE = 25marks
IA = 25marks

Physical Chemistry Practical -II

1. Determination of the heat capacity of a calorimeter.
2. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic andexothermic) of solution of salts.
3. To determine the enthalpy of neutralization of a weak acid / weal base versus strong base/ strong acid and determine the enthalpy of ionisation of the weak acid / weak base.
4. To determine the enthalpy of hydration of $CuSO_4$.
5. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
6. Determination of dissociation constant of a weak acid.
7. To verify Beer-Lambert law for $KMnO_4$ / $K_2Cr_2O_7$ and determine the concentration of the given substance.
8. **Any other experiment carried out in the class.**

Books Suggested:

1. O.P. Pandey, D.N. Bajpai& S. Giri, Practical Chemistry, S. Chand & Company Ltd.
2. B. D. Khosla, V. C. Garg& A. Gulati, *Senior Practical Physical Chemistry,* S. Chand & Co.: New Delhi (2011).
3. C. W. Garland, J.W. Nibler, & D.P. Shoemaker, *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
4. A.M. Halpern & G.C. McBane, *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Semester-III
Paper No: VI-G
Paper Code: CHG-304

UE = 75 marks
IA = 25 marks

General Chemistry

Unit I: Some Basic Concept in Chemistry

Matter and its nature, Daltonôs atomic theory; Concept of atom, molecule, element and compound; Physical quantities and their measurements in Chemistry, precision and accuracy, significant figures, S.I. Units, dimensional analysis; Laws of chemical combination; Atomic and molecular masses, mole concept, molar mass, percentage composition, empirical and molecular formulae; Chemical equations and stoichiometry.

Unit II: Oxidation reduction

Redox reactions, Standard Electrode Potential and its application to inorganic reactions, Oxidation state, rules for the determination of oxidation states, electrochemical series, applications of electrochemical series.

Unit III: Acids and bases

Theories of acids and bases- Arrhenius, Bronsted-Lowry, Lewis, solvent and Lux-Flood, Relative strengths of acids and bases-effect of solvent, polarity and dielectric constants, effect of substituents and steric effects of substituents.

Unit IV: Reaction Mechanism of Organic Molecules

Localised and delocalised bonds, Vander Walls interactions , Inductive & field effects, Charge transfer complexes, Resonance, Hyper-conjugation, Hydrogen bonding Aromaticity.Curved arrow notation, drawing electron movements with arrows, half headed and double headed arrows, homolytic and heterolytic bond breaking.Types of reagents (electrophiles and nucleophiles).Types of organic reactions, energy considerations. Reactive intermediated (carbocations, carbanions, free radicals, carbenes with example). Methods of determination of reaction mechanism (product analysis, intermediates).

Books Suggested:

1. Concise Inorganic Chemistry by J. D. Lee.
2. Inorganic Chemistry by Puri and Sharma
3. Principle of Physical Chemistry by Puri, Sharma and Pathania.

Practical Code: CHG-304L

UE = 25 marks
IA = 25 marks

General Chemistry Practical

1. To prepare standard solution of sodium carbonate and determine the percentage of given NaOH and KOH mixture solution (2.5 g/liter) by using HCl solution.
2. To prepare standard solution of potassium dichromate and find out the strength of given potassium dichromate solution using sodium thiosulphate (hypo solution) as an intermediate.
3. To prepare standard solution of potassium permanganate and find out the strength of given potassium permanganate solution using sodium thiosulphate (hypo solution) as an intermediate.
4. To prepare standard solution of copper(II) sulphate and find out the strength of given copper(II) sulphate solution using sodium thiosulphate (hypo solution) as an intermediate.
5. To determine the viscosity of pure liquids and binary mixtures by Ostwald viscometer.
6. Determination of the surface tension of pure liquids and binary mixtures.
7. Determination of partition coefficient of iodine jbetween water and carbon tetrachloride or toluene or chloroform.
8. Determination of partition coefficient of Benzoic acid between water and toluene.

Books Suggested:

1. Practical Chemistry, OP Pandey, DN Bajpai, S. Giri, S. Chand & Company Ltd., 2008.
2. Senior Practical Physical Chemistry by B.D. Khosla, V.C. Garg and AdarshKhosla ï R. Chand & Co. Delhi.

Semester-IV
Paper No: VII-G
Paper Code: CHG-402

UE = 75 marks
IA = 25 marks

Organic Chemistry-II

Unit I: Alkyl and Aryl Halides

Alkyl Halides Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions.Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile &isonitrile formation. Williamsonôs ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer&Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by ï OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit II: Alcohols

Alcohols: Preparation: Preparation of 1ts, 2ts and 3ts alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO4, acidic dichromate, conc. HNO3).Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Unit III: Phenols and Ethers

(Phenol case) Preparation:Cumenehydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-TiemannReaction,Gattermann-Koch Reaction, Houbenï Hoesch Condensation, Schotten ï Baumann Reaction. Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4.Cleavage of ethers with HI.

Unit IV: Aldehydes and ketones (aliphatic and aromatic)

Formaldehye, acetaldehyde, acetone and benzaldehyde)Preparation: from acid chlorides and from nitriles. Reactions ï Reaction with HCN, ROH, NaHSO3, NH2 -G derivatives. Iodoform test.Aldol Condensation, Cannizzaroôs reaction, Wittig reaction, Benzoin condensation.Clemensen reduction and Wolff Kishner reduction.Meerwein-PondorffVerley reduction.

Books Suggested:

1. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
   Bahl, A. &Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
6. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).

CHG-402L

UE = 25 marks
IA = 25 marks

Organic Chemistry Practical -II

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed.Recrystallisation, determination of melting point and calculation of quantitativeyields to be done.
    (a) Bromination of Phenol/Aniline
    (b)Benzoylation of amines/phenols
    (c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Books Suggested:

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry.
2. Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

Semester-IV
Paper No: VIII-G
Paper Code: CHG-403

UE = 75 marks
IA = 25 marks

Physical Chemistry-II

Unit I: Kinetic Theory of Gases

Brief descriptions of Gas laws, Ideal gas equation, Daltonôs law of partial pressure and Grahamôs law of diffusion. Postulates of kinetic theory of gases, Kinetic gas equation. Deviation from ideal behavior: Effect of temperature and pressure. Maxwell's distribution of molecular velocities: Root mean square, Average and Most probable velocities. Collision properties: Collision number, Mean free path, Collision diameter and Collision frequency. Liquefaction of gases. Critical Phenomena: PV isotherms of real gases, van der Walls equation, Isotherms of van der Waals equation, Relationship between critical constants and van der Waals constants, Law of corresponding states, Reduced equation of state.

Unit II: Liquids

Surface tension and its determination using stalagmometer.Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid.

Unit III: Solids

Crystalline and Amorphous solid, Symmetry of crystal systems, Space lattice and Unit cell, Summary of crystal systems, Applications of crystallographic studies; Packing fraction, Density, Coordination number and Number of atoms in unit cell. Law of rational of indices, Inter-planer spacing.X-ray diffraction, Powder method and Bragg's equation.Determination of crystal structure of NaCl using powder method.Defects in crystals.

Unit IV: Chemical Kinetics

Chemical Kinetics and its Scope, Rate of a Reaction, Rate Laws, Rate Constant, Elementary and Complex Reactions, Molecularity, Order of Reactions. Factors Influencing the Rate of Reaction: Concentration, Temperature, Pressure, Catalyst. Mathematical Characteristics of Simple Chemical Reactions - Zero Order, First Order, Second Order, Pseudo Order, and their Half-life Expressions.Determination of Order of Reaction - Differential Method, Method of Integration, Half-life Method and Isolation Method. Activation Energy, Theories of Reaction Rates: Collision Theory of bimolecular reactions, Arrhenius Equation, Absolute Reaction Rate Theory.

Books Suggested:

1. Essentials of Physical Chemistry, B.S. Bahl, G.D.Tuli and ArunBahl, S. Chand & Company Ltd.
2. A Text Book of Physical Chemistry, A.S. Negi and S.C. Anand, New Age International Publishers.
3. Physical Chemistry, G. M. Barrow, International Student Edition, McGraw Hill.
4. Physical Chemistry, P. W. Atkins, & J. de Paula, 10th Ed., Oxford University Press (2014).

CHG-403L

UE = 25 marks
IA = 25 marks

Physical Chemistry Practical -II

1. **Surface tension measurements.**
   b) Determine the surface tension of given solution using drop number method.
   c) Study the variation of surface tension of detergent solutions with concentration.

2. **Viscosity measurement using Ostwald's viscometer**.
   a) Determination of viscosity of (i) ethanol (ii) amyl alcohol and (iii) aqueous solution of sugar at room temperature.
   b) Study the variation of viscosity of sucrose solution with the concentration of solute.

3. **Indexing of a given powder diffraction pattern of a cubic crystalline system.**
4. **Chemical Kinetics**
   a) To determine the order of the reaction betweenthiosulphate and HCl.
   b) To determine the order of reaction for acid hydrolysis of methyl acetate at room temperature.
   c) To study the effect of acid strength on the hydrolysis of an ester.
   d) To study the kinetics of the saponification of ethyl acetate by integrated rate method.

5. **Any other experiment carried out in the class.**

Books Suggested:

1. O.P. Pandey, D.N. Bajpai& S. Giri, Practical Chemistry, S. Chand & Company Ltd.
2. B. D. Khosla, V. C. Garg& A. Gulati, *Senior Practical Physical Chemistry,* S. Chand & Co.: New Delhi (2011).
3. C. W. Garland, J.W. Nibler, & D.P. Shoemaker, *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
4. R.C. Das and B. Behra, *Experiments in Physical Chemistry*,; Tata McGraw Hill.

Semester-IV
Paper No: IX-G
Paper Code: CHG-404

UE = 75 marks
IA = 25 marks

Novel Inorganic Solids

Unit I: Inorganic solids of technological importance:
Solid electrolytes ï Cationic, anionic, mixed Inorganic pigments ï coloured solids, white and black pigments. Molecular material and fullerides, molecular materials & chemistry ï one-dimensional metals, molecular magnets, inorganic liquid crystals.

Unit II: Nanomaterials:
Overview of nanostructures and nanomaterials: classification.
Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisical nanomaterials, bionano composites.

Unit III: Introduction to engineering materials for mechanical construction:
Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminium and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

Unit IV: Composite materials:
Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

Books Suggested:

Fahlman, B.D. *Materials Chemistry,* Springer, 2004.

Practical Code: CHG-404L

UE = 25 marks
IA = 25 marks

Novel Inorganic Solids Practical

1. Determination of cation exchange method
2. Determination of total difference of solids.
3. Synthesis of hydrogel by co-precipitation method.

Books Suggested:

Fahlman, B.D. *Materials Chemistry,* Springer, 2004.

Semester-V
Paper No: X-G
Paper Code: CHG-501

UE = 75 marks
IA = 25 marks

Inorganic Chemistry-III

Unit I: Transition Elements (*d*-block elements)

Introduction; elements of first transition series; their general properties: electronic configuration, density, melting and boiling point/s, reactivity, ionization energies, variable oxidation states and their stabilities; Colour and magnetic properties, magnetic susceptibility and its measurement.

Unit II: Inner Transition Elements (*f* block elements)

Introduction; Lanthanides series: electronic configuration, their oxidation states, extraction of lanthanides, colour & electronic spectra, magnetic properties, lanthanide contraction.

Unit III: Coordination Chemistry

Double salts and coordination compounds; structures of coordination compounds; Wernerôs work; ligands and their classification; IUPAC nomenclature; isomerism: structural and stereo (with special reference to coordination number 4 & 6),

Unit IV: Theories of Metal-Ligand bonding (M-L Bonding)

Shapes and energies of *d*-orbitals, Valence bond theory (inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu) and drawbacks of VBT; Crystal field theory and Molecular orbital theory for Oh complexes; CFSE and calculation of CFSE, strength of ligands, spectro-chemical series; factors affecting the magnitude of CFSE; Complexes of coordination numbers 4 & 6 (inner & outer orbital complexes), octahedral effects of Crystal field splitting, comparison of CFSE for *Oh* and *Td* complexes, tetragonal distortion (Jahn ï Teller distortion).

Books Suggested:

1. Concise Inorganic Chemistry by J.D. Lee.
2. Inorganic Chemistry by W.W. Portfield.
3. Inorganic Chemistry by D.E. Shriver, P.W. Atkins and C.H. Longford.
4. Inorganic Chemistry by A.G. Sharpe.
5. Basic Inorganic Chemistry by F.A. Cotton, G. Wilkinson & P.L. Gauss.

Practical Code: CHG-501L

UE = 25 marks
IA = 25 marks

Inorganic Chemistry Practical-III

A. **Synthesis and calculation of percentage yield of the following**:
   i. Ni-DMG Complex $[Ni(DMG)_2]$.
   ii. Cis and Trans potassiumbisoxalatodiaquachromate(III).
   iii. Tetraamminecopper(II)sulphate, $[Cu(NH_3)_4]SO_4$.
   iv. Potassium tris(oxalato)ferrate(III).
   v. Acetylacetanato complexes of Cu^{2+}/Fe^{3+} and find the λ_{max} of these complexes.

B. Gravimetric Analysis:
   i. Determination of Al as Aluminium 8ï dehydroxyquinolate
   ii. Determination of SO_4^{2-} ion as barium sulphate.
   iii. Determination of aluminium as aluminum oxide.

Books Suggested:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Marr &Rockett*Practical Inorganic Chemistry.* John Wiley & Sons 1972.

Semester-V
Paper No: XI-G
Paper Code: CHG-502

UE = 75 marks
IA = 25 marks

Organic Chemistry –III

Unit I: Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters.Reactions: Hell ï Vohlard - Zelinsky Reaction. Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study ofnucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Unit II: Amino Acids, Peptides and Proteins

Preparation of Amino Acids: Strecker synthesis using Gabrielôs phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.Reactions of Amino acids: ester of ï COOH group, acetylation of ï NH2 group, complexation with Cu2+ ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and Cï terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (tbutyloxycarbonyl andphthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

Unit III: Carbohydrates

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Unit IV: Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabrielôs Phthalimide synthesis, Hofmann Bromamide reaction.Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten ï Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination,sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions:conversion to benzene, phenol, dyes.

Books Sduggested:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Nelson, D. L. & Cox, M. M. Lehningerôs Principles of Biochemistry 7th Ed., W. H. Freeman.
5. Berg, J.M., Tymoczko, J.L. &Stryer, L. Biochemistry, W.H. Freeman, 2002

Practical Code: CHG-502L

UE = 25 marks
IA = 25 marks

Organic Chemistry Practical –III

Section I

1. Systematic Qualitative Organic Analysis of Organic Compounds possessingmonofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines)and preparation of one derivative.

Section II.

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. Titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing and a nonreducing sugar

Books Suggested:

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press

Semester-V
Paper No: XII-G
Paper Code: CHG-504

UE = 75 marks
IA = 25 marks

Polymer Chemistry

Unit I: Introduction and History of Polymeric Materials

Brief history of polymers, different scheme of classification of polymers, polymer nomenclature, molecular forces and chemical bonding in polymers.

Unit II: Kinetics of Polymerization

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations (Ziegler-Natta polymerization of alkenes).Mechanism and kinetics of copolymerization.

Unit III: Characterization of Polymers

Determination ofmolecular weight of polymers (*Mn*, *Mw*, etc) by end group analysis, Glass transition temperature (Tg), determination of Tgand factors affecting Tg, *Crystallinity in polymers*: crystalline melting point, degree of crystallinity.

Unit IV: Preparation and applications of Polymers

Plastics ï thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);Fabrics ï natural and synthetic (acrylic, polyamido, polyester);Rubbers ï natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization;Polymer additives; Introduction to liquid crystal polymers;Biodegradable and conducting polymers with examples

Books Suggested:

1. R. B. Seymour & C.E. Carraher, *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc.New York, 1981.
2. G. Odian, *Principles of Polymerization*, 4th Ed. Wiley, 2004.
3. F. W. Billmeyer, *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
4. P. Ghosh, *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
5. R. W. Lenz, *Organic Chemistry of Synthetic High Polymers*. Interscience Publishers, NewYork, 1967.

Practical Code: CHG-504L

UE = 25 marks
IA = 25 marks

Polymer Chemistry Practical

1. To synthesize polystyrene from styrene monomer by bulk polymerization method.
2. To determine the glass transition temperature (T_g) of the synthesized polystyrene.
3. To determine the glass transition temperature (T_g) of the commercial polystyrene and compare it with the synthesized one.
4. To find out the molecular weight of synthesized polystyrene.
5. To find out the molecular weight of commercial polystyrene.
6. To synthesize the copolymer from styrene (monomer) and methymethacrylate (monomer) bysolution polymerization method.
7. To synthesize ónovalacôresin from formaldehyde and phenol.
8. To synthesize polymethylmethacrylate (PMMA) from methymethacrylate (monomer) by suspension polymerization method.
9. To determine the glass transition temperature (T_g) of the synthesized polymethylmethacryate (PMMA).
10. To find out the molecular weight of synthesized polymethylmethacrylate (PMMA).

Books Suggested:

1. M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press,1999.
2. S.M.Ashraf, Sharif Ahmad and UfanaRiaz, A laboratory Manual of Polymers, IK International, 2010.
3. F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, *Polymer Science and Technology*, 2nd ed. Prentice-Hall (2003)

Semester-VI **UE = 75 marks**
Paper No: XIII-G **IA = 25 marks**
Paper Code: CHG-603

Physical Chemistry –III

Unit I: Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium.Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius ï Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

Unit II: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Kohlrausch law of independent migration of ions.Transference number and its experimental determination using Hittorf and Moving boundary methods.Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).

Unit III: Electrochemistry

Electrolytic and Galvanic cells, reversible and irreversible cells, conventional representation of electrochemical cells, electromotive force and its measurement, electrical and electrochemical potentials, Nernst equation, types of half-cells and their reactions (gas-ion half cells, metal-metal ion half cells, metal- insoluble salt ï anion half-cell, oxidation reduction half-cell, electrochemical series, calculation of cell e.m.f., thermodynamic quatities of cell reactions (qG, qH, and qS), reference electrodes, glass electrode, calomel electrode, determination of equilibrium constant, determination of pH of a solution, potentiometric titration. Concentration cells with transference and without transference.

Unit IV: Colloidal State

Introduction and Definition of Colloids, Classification of Colloids ï Lyophilic and lyophobic colloids. Solids in Liquids (Sols): Preparation of Sols, Optical and Electrical Properties of Sols; electro-kinetic potential, electrophoresis, electro osmosis, Stability of Colloids, Protective Action, Hardy-Schulze Rule, Flocculation value, Gold Number. Liquids in Liquids (Emulsions): Types of Emulsions, Preparation and Properties of Emulsions, Emulsifier. General Applications of Colloids.

Books Suggested:

1. Essentials of Physical Chemistry, B.S. Bahl, G.D.Tuli and ArunBahl, S. Chand & Company Ltd.
2. A Text Book of Physical Chemistry, A.S. Negi and S.C. Anand, New Age International Publishers.
3. Physical Chemistry, G. M. Barrow, International Student Edition, McGraw Hill.
4. Physical Chemistry through Problems, S. K. Dogra and S. Dogra Wiley Eastern Ltd.
5. Physical Chemistry, P. W. Atkins, &J. de Paula, 10th Ed., Oxford UniversityPress (2014).

Practical Code: CHG-603L **UE = 25 marks**

IA = 25 marks

Physical Chemistry Practical-III

1. **Phase Equilibrium**
   d) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
   e) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

2. **Conductance**.
   c) To study changes in the conductance during titration with strong alkali in the following systems:
   (i) Strong acid; (ii) Weak acid, and (iii) Mixture of strong acid and weak acid.
   d) To determine the ionization constant of a weak acid conductometrically.

3. Distribution.
   a) Determination of partition coefficient of iodine between water and carbon tetrachloride or toluene or chloroform.

4. Potentiometry
   a) Perform the following potentiometric titrations:
   (i). Strong acid vs. strong base
   (ii). Weak acid vs. strong base
   (iii). Potassium dichromate vs. Mohr's salt

5. Any other experiment carried out in the class.

Books Suggested:

1. O.P. Pandey, D.N. Bajpai & S. Giri, Practical Chemistry, S. Chand & Company Ltd.
2. B. D. Khosla, V. C. Garg &A. Gulati, *Senior Practical Physical Chemistry,* S.Chand & Co.: New Delhi (2011).
3. C. W. Garland, J.W. Nibler, &D.P. Shoemaker, *Experiments in Physical Chemistry8th Ed.*; McGraw-Hill: New York (2003).
4. A.M. Halpern&G.C. McBane, *Experimental Physical Chemistry 3rd Ed.;* W.H.Freeman & Co.: New York (2003).

Semester-VI **UE = 75 marks**
Paper No: XIV-G **IA = 25 marks**
Paper Code: CHG-604

Green Chemistry

Unit I: 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.

Unit II: Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples, Green solventsï supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.Energy requirements for reactions ï alternative sources of energy: use of microwaves and ultrasonic energy.Selection of starting materials; avoidance of unnecessary derivatization ï careful use of blocking/protecting groups.catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD ñWhat you donôt have cannot harm youò, greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) andFlixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Unit III: 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).Surfactants for carbon dioxide ï replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.Designing of Environmentally safe marine antifoulant.Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils.Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting.

Unit IV: Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C^2S^3); Green chemistry in sustainable development.

Books Suggested:

1. Ahluwalia, V.K. &Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C. &Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
5. Ryan, M.A. &Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.

Practical Code: CHG-604L

UE = 25 marks
IA = 25 marks

Green Chemistry Practical

1. Using renewable resources
   Preparation of biodiesel from vegetable/ waste cooking oil.

2. Use of enzymes as catalysts
   Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

3. Alternative Green solvents
   - Extraction of D-limonene from orange peel using liquid CO2 prepared form dry ice.
   - Mechanochemical solvent free synthesis of azomethines

4. Alternative sources of energy
   Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

5. Avoiding waste
   Synthesis of Tris(acetylacetonato)manganese(III) without the use of any buffer.

Books Suggested:

1. Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistryexperiment. American Chemical Society, Washington DC (2002).
3. Sharma, R.K.; Sidhwani, I.T. &Chaudhari, M.K. I.K. Green Chemistry Experiment:A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN978-93-81141-55-7 (2013).
4. Cann, M.C. & Connelly, M. E., Real world cases in Green Chemistry, American Chemical Society (2008).