

Syllabus for B Sc (Honors) Semester 1-6**Chemistry****2016****Semester I (Theory Courses)****CHE--1101C01/ CHE1104S01 Chemistry I (3 Credits)****Chemistry-1****Unit I (15 h)**

Metallic and electrolytic conductors: Conduction of electricity by metals and solutions. Classification of substances- electrolytes and nonelectrolytes. Arrhenius theory of electrolytic dissociation. Specific, equivalent and molar conductance - measurement of conductance - variation of conductance with dilution for strong and weak electrolytes, Debye-Huckel- Onsager (D-H-O) theory of electrolytic conductance. Transport number and its determination by Hittorff's and moving boundary method. Effect of temperature and concentration: ionic mobility and ionic conductance - Kohlrausch's law and its applications.

Unit II (15 h)

Alkanes: Introduction, Preparation of alkanes, hydrogenation of alkenes and alkynes, Reduction of alkyl halide (Metal & mineral acid, Grignard reagent) and Corey House synthesis. Reactions: combustion and halogenation, free radical mechanism (orientation, reactivity, transition state and reaction intermediates, stability and relative energy of free radicals).

Alkyl halides: Introduction, synthesis of alkyl halides from alcohols, hydrocarbons, alkenes, alkynes. Reactions: S_N^1 and S_N^2 reactions (concept of substrate, nucleophile, leaving group, kinetics and solvent effect). Reaction of alkyl halides with OH^- , H_2O , $RC \equiv C^-$, CN^- , NH_3 , $R-M$, I^- , $RCOO^-$.

E_1 and E_2 mechanism of dehydrohalogenation, orientation and reactivity: Generation of carbocation, structure, stability, energy diagram, rearrangement and reactions of carbocation.

Unit III (15 h)**Principles of Chemical Analysis:**

Principles of qualitative analysis.

Methodologies used in quantitative analysis.

Significant figures, Types of Errors involved during analysis- determinate and indeterminate, detection of errors and correction, rejection of data (based on standard deviation, coefficient of variation and Q- test)

Titrimetric Analysis- Neutralization, redox, complexometric and precipitation titrations

Principles of gravimetric analysis.

Applications of metal complexes in quantitative and qualitative analysis.

Flame Emission Spectroscopy- Principle, Instrumentation and Applications

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books (Unit I):

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2005), 41st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
3. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.

Reference Books (Unit II):

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.

Reference Books (Unit III):

1. Christian Gary, (2004) Analytical Chemistry, 6th Edition, John Wiley and Sons, Inc. New York.
2. Khopkar, S.M.(2009) Basic Concepts of Analytical Chemistry New Age, International Publisher,
3. John Bassett (Editor) Vogel's Textbook of Quantitative Inorganic Analysis, Including Elementary Instrumental Analysis, 4th edition, Longman Science and Tech
4. Sharma B.K.(2006) Industrial Chemistry, Goel Publishing House,

CHE-1102C02/ CHE1105S02 Chemistry-II (2 Credits)
Industrial Chemistry, Alkenes & Alkynes

Unit I (15 h)

Heavy chemicals in industries, Special methodology used in the manufacture (including the physicochemical principles involved), properties and uses of sulphuric acid, nitric acid and ammonia.

Types of cement and their manufacturing processes, reactions involved in the setting of cement. Role of lime and gypsum.

Fertilizers: Definition, types, properties and classification. Nitrogenous fertilizers, phosphate fertilizers, potassium fertilizers, NPK fertilizers, micronutrients, biodegradable fertilizers.

Marine chemicals: nodules, recovery of Br₂, I₂ and Mg.

Unit II (15 h)

Alkenes: Introduction, geometric isomerism and nomenclature, preparation of alkenes, from halides, dehydration of alcohols and dehalogenation of vicinal dihalides, Saytzeff's rule.

Electrophilic addition reactions and orientation; mechanism of addition of H₂, X₂, HX, H₂SO₄, H₂O and X₂/H₂O, addition of alkene, oxymercuration-demercuration, hydroboration, hydroxylation (syn. and anti), Structure, reactivity and stability of allyl and vinyl radicals, ozonolysis and its use in structure determination.

Alkynes: Introduction, acidity of alkynes and formation of acetylides with Na, Ag, Cu and Grignard reagents. Preparation and reaction of alkynes with H₂, X₂, HX and H₂O. Resonance and tautomerism.

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books (Unit I):

1. Thompson D. (Editor) Insights into Specialty Inorganic Chemicals, (Royal Society of Chemistry special Publication), Springer Verlag (1995).
2. Sharma B. K. Industrial Chemistry including Chemical Engineering, 9th revised edition, Goel Publishing House, Merrut (1997-98).

Reference Books (Unit II):

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.

Elective courses in Chemistry
B.Sc. Semester I
CHE1107E01 Basic Chemistry-I
(Elective) (Theory Course) (2 Credits)

Unit I (15 h)

Nuclear Chemistry: Fundamental particles of nucleus, isotopes, natural abundance, stability of nucleus, n/p ratio, mass defect and nuclear binding energy, Einstein's mass energy relationship. Natural radioactivity and disintegration rate, half life, average life, artificial transmutation and radioactivity. Radioactive series. Nuclear reactions, nuclear fission, principle and types of nuclear reactors (thermonuclear and fast breeder), nuclear fusion, thermonuclear radiations, Mechanism of solar energy (proton-proton chain and Carbon/ nitrogen cycle). Applications of radioactivity in chemistry and industry.

Unit II (15 h)

Electronic configuration and chemical properties: Origin of quantum numbers and their relation to the symbols and energy of atomic orbitals, radial and angular probabilities.

Electronic configuration and Periodic properties – atomic size, ionization energy, electron affinity, electronegativity. Trends in the metallic character. Ionization of elements and stabilization of various oxidation states.

Characteristic and distinctive properties of elements.

Chemistry of s Block elements:

Hydrogen. Hydrides - Classification and Chemistry.

Heavy Water: Manufacture, properties and uses.

Alkali Metals: Li, Na, K, Rb and Cs – occurrence, comparative study of elements, oxides, halides, hydroxides and carbonates. Exceptional property of Lithium.

Alkaline Earth Metals: Be, Mg, Ca, Sr and Ba - occurrence, and comparative study of the elements, oxides, hydroxides, halides, sulphates and carbonates. Exceptional property of Beryllium.

Reference Books:

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2005), 41st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
3. Arnikar. H. J., (1995), Essential of Nuclear Chemistry, 4th Edition, New Age International Publishers, New Delhi.
4. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
5. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi
- 6 Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
7. Mahan B.H., (2009) University Chemistry, 3rd Edition, Narosa Publ House, New Delhi.
8. Gilreath E. S., (1985) Fundamental Concepts of Inorganic Chemistry, 2nd Edition, McGraw Hill Int,
9. Sharma B.K.(2006) Industrial Chemistry, Goel Publishing House,

**Semester I: CHE1108E02 Basic Analytical and Organic Chemistry
(Elective) (Theory Course) (2 Credits)**

Unit I (15 h)

Concept of functional groups and their nomenclature, Homologous series.

Alkanes: Introduction, Preparation of alkanes, hydrogenation of alkenes and alkynes, Reduction of alkyl halide (Metal & mineral acid, Grignard reagent) and Corey House synthesis. Reactions: combustion and halogenation, free radical mechanism.

Alkyl halides: Introduction, synthesis of alkyl halides from alcohols, hydrocarbons, alkenes, alkynes. Reactions: S_N^1 and S_N^2 reactions (concept of substrate, nucleophile, leaving group, kinetics and solvent effect). Reaction of alkyl halides with OH^- , H_2O , $RC \equiv C^-$, CN^- , NH_3 , $R-M$, I , $RCOO^-$. E_1 and E_2 mechanism of dehydrohalogenation.

Benzene : Preparation, Electrophilic substitution reactions with mechanism (Nitration, sulphonation, Halogenation, Friedel Crafts alkylation acylation)

Unit II (15 h)

Principles of qualitative analysis: Methodologies used in quantitative analysis.

Titrimetric Analysis- Neutralization, redox, complexometric and precipitation titrations, Principles of gravimetric analysis.

Applications of metal complexes in quantitative and qualitative analysis.

Flame Emission Spectroscopy: Principle, Instrumentation and Applications.

Precision and accuracy in quantitative analysis.

Reference Books:

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Christian Gary, (2004) Analytical Chemistry, 6th Edition, John Wiley and Sons, Inc. New York.
9. De A.K. (2008) Environmental Chemistry, 6th Edition New Age International Pvt. Limited, New Delhi.
10. John Bassett (Editor) Vogel's Textbook of Quantitative Inorganic Analysis, Including Elementary Instrumental Analysis, 4th edition, Longman Science and Tech

Semester II (Theory Courses)
CHE-1201C04/ CHE1204S04 Chemistry-III (3 Credits)
Atomic Structure and bonding Nuclear Chemistry, Aromatic Compounds

Unit I (15 h)

Atomic Structure : Dual nature of radiation and matter, de Broglie's principle, Heisenberg's Uncertainty principle, Schrödinger wave equation and its interpretation, origin of quantum numbers and symbols for orbitals, shapes of orbitals - s, p, d. Radial and angular probabilities. Electronic configuration and Periodic properties – atomic size, ionization energy, electron affinity, electronegativity. Trends in the metallic character.

Chemical Bonding: Introduction to types of bonds.

Ionic compounds: Lattice energy and factors affecting it, Madelung constants, Born-Haber Cycle. Applications of lattice energetics. Solvation energy. Effect of lattice energy and solvation on the solubility of ionic compounds.

Covalent bonding: Valence Shell Electron Pair Repulsion (VSEPR) theory and shapes of simple covalent molecules like H₂O, NH₃, BF₃, CH₄, PCl₅, SF₆, IF₇.

Valence Bond Theory (VBT) - assumptions, linear combination of atomic orbitals and properties of hybrid orbitals. hybridization involving s, p and d orbitals (dsp², sp³d, dsp³, d²sp³, sp³d², sp³d³) and shapes of simple molecules like SF₆, IF₅, PCl₅, IF₇. Concept of resonance (including examples of various oxyanions).

Unit II (15 h)

Nuclear Chemistry: Fundamental particles of nucleus, isotopes, natural abundance, stability of nucleus, n/p ratio, mass defect and nuclear binding energy, Einstein's mass energy relationship. Natural radioactivity and disintegration rate, half life, average life, artificial transmutation and radioactivity. Radioactive series. Nuclear reactions, nuclear fission, principle and types of nuclear reactors (thermonuclear and fast breeder), nuclear fusion, thermonuclear radiations, Mechanism of solar energy (proton-proton chain and Carbon/ nitrogen cycle). Applications of radioactivity in chemistry and industry.

Unit III (15 h)

Benzene: Structure, Huckel rule. Electrophilic substitution reactions with mechanism: Nitration, Sulphonation, Halogenation, Friedel-Craft's alkylation and acylation, Reactivity and orientation, *Arenes*: Synthesis, substitution reactions, side chain and ring halogenation and side chain oxidation. Structure and stability of benzyl cation, Alkenyl and alkynylbenzenes: Nomenclature, synthesis and reactions.

Polynuclear Aromatic Hydrocarbons: Preparation and reactions of naphthalene, anthracene, phenanthrene, naphthol and naphthyl amine.

Mode of transaction: Through Classroom lectures with models, charts, OHP, power point presentation and multimedia.

Reference Books (Unit I):

1. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
2. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi
- 3 Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
4. Mahan B.H., (2009) University Chemistry, 3rd Edition, Narosa Publ House, New Delhi.
5. Gilreath E. S., (1985) Fundamental Concepts of Inorganic Chemistry, 2nd Edition, McGraw Hill Int,

Reference Books (Unit II):

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
5. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.
6. Arnikar. H. J., (1995), Essential of Nuclear Chemistry, 4th Edition, New Age International Publishers, New Delhi.

Reference Books (Unit III):

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Finar I L Organic Chemistry Vol 1 & 2 ELBS/ Pearson 1982

CHE-1202C05 /CHE1205S05 Chemistry- IV (2 Credits)
Main group Chemistry, alcohols, ethers & stereo Chemistry

Unit I(15 h)

Characteristic and distinctive properties of s, p, d and f block elements.

Chemistry of s Block elements:

Hydrogen. Hydrides - Classification and Chemistry. Heavy water – manufacture and properties.

Alkali Metals: Li, Na, K, Rb and Cs – occurrence, comparative study of elements, oxides, halides, hydroxides and carbonates. Exceptional property of Lithium.

Alkaline Earth Metals: Be, Mg, Ca, Sr and Ba - occurrence and comparative study of the elements, oxides, hydroxides, halides, sulphates and carbonates. Exceptional property of Beryllium.

p-Block elements: Comparative study of the p-Block elements- Groups 13-18 with special reference to electronic configuration, structure of elements and trends in atomic and ionic radii, ionization potential, electron affinity, electronegativity and oxidation states. Inert pair effect.

Occurrence, extraction and important uses of p-Block elements.

Unit II(15 h)

Alcohols: Introduction. Preparation: oxymercuration-demercuration, hydroboration-oxidation, hydroxylation of alkenes, Grignard reaction, hydrolysis of alkyl halides. Reactions with HX, PX₃, dehydration and oxidation. Esterification. 1,2-Glycols, glycerol, preparations and reactions, periodic acid oxidation, pinacol – pinacolone rearrangement.

Ethers: Nomenclature, preparations, reactions, cleavage, auto oxidation, Ziesel's method.

Cyclic ethers: epoxides, synthesis, acid and base catalysed opening. Orientation, reaction with Grignard and organolithium reagents. Crown ethers.

Stereochemistry: Isomerism, conformation of butane, optical activity, specific rotation, Newman and Fischer Projection, chirality, enantiomers, diastereoisomers, meso compounds .

Mode of transaction: Through Classroom lectures with models, charts, OHP, power point presentation and multimedia.

Reference Books (Unit I):

1. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
2. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi
- 3 Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
4. Mahan B.H., (2009) University Chemistry, 3rd Edition, Narosa Publ House, New Delhi.
5. Gilreath E. S., (1985) Fundamental Concepts of Inorganic Chemistry, 2nd Edition, McGraw Hill Int,

Reference Books (Unit II):

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Finar I L Organic Chemistry Vol 1 & 2 ELBS/ Pearson 1982

Semester I & II (Practical Courses)
CHE-1103C03/CHE1106S03 (3 Credits)
Chemistry Practicals-1 CHE1103C03(3 Credits)

&
CHE-1203C06/ CHE1206S06 (3 Credits)
Chemistry Practicals-II

The course content of the two semesters put together should cover the following aspects:

1. Volumetric analysis:
Acidimetry – Alkalimetry
Oxidation – Reduction
Iodometry – Iodimetry
Complexometry
2. Qualitative analysis of Inorganic Salts (single salts with one cation and one anion)
3. Spotting of mono-functional Organic Compounds via elemental analysis and functional group analysis.

Reference Books :

1. Shah R C, (2005) Inorganic Analysis Part I Qualitative, Baroda Book Depot, Vadodara
2. Shah R C, (2005) Inorganic Analysis Part II Quantitative, Baroda Book Depot, Vadodara
3. Shah R C, (2001) Organic Analysis Part I Qualitative Analysis Baroda Book Depot, Vadodara

Semester II Elective course
CHE1207E03 Fundamental Organic Chemistry(2 Credits)

Unit I (15 h)

Alkenes: Introduction, geometric isomerism and nomenclature, preparation of alkenes, from halides, dehydration of alcohols and dehalogenation of vicinal dihalides, Saytzeff's rule. Electrophilic addition reactions: Markownikov's rule and peroxide effect, mechanism of addition of H₂, X₂, HX, H₂SO₄, H₂O and X₂/H₂O, oxymercuration-demercuration, hydroboration-oxidation, hydroxylation (syn. and anti.), ozonolysis and its use in structure determination.

Alkynes: Introduction, acidity of alkynes and formation of acetylides with Na, Ag, Cu and Grignard reagents. Preparation and reaction of alkynes with H₂, X₂, HX and H₂O. Tautomerism.

Unit II (15 h)

Alcohols: Introduction. Preparation: oxymercuration-demercuration, hydroboration-oxidation, hydroxylation of alkenes, Grignard reaction, hydrolysis of alkyl halides. Reactions with HX, PX₃, dehydration and oxidation. Esterification.

Ethers: Nomenclature, preparations, reactions.

Stereochemistry: Isomerism, conformation of butane, optical activity, specific rotation, Newman and Fischer Projection, chirality, enantiomers, diastereoisomers, meso compounds .

Mode of transaction: Through Classroom lectures with models, charts, OHP, power point presentation and multimedia.

Reference Books :

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Finar I L Organic Chemistry Vol 1 & 2 ELBS/ Pearson 1982

**Semester II: CHE1208E04 Non Metal Chemistry and Separation Techniques
(Elective) (Theory Course) (2 Credits)**

Unit I (15 h)*Non-metal Chemistry :*

p-Block elements: Comparative study of the elements of Groups 13-18 with special reference to electronic configuration, structure of elements and trends in atomic and ionic radii, ionization potential, electron affinity, electronegativity, metallic character and oxidation states. Inert pair effect.

Oxides and Oxyacids of nitrogen, phosphorus and halogens

Interhalogen compounds

Unit I (15 h):*Separation Techniques:*

Chromatography : Principle, Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: Paper

Chromatography, Thin Layer Chromatography and Column chromatography.

Solvent extraction: Principle, extraction of organic species from aqueous and non aqueous media.

Reference Books :

1. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
2. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi
- 3 Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
4. Mahan B.H., (2009) University Chemistry, 3rd Edition, Narosa Publ House, New Delhi.
5. Gilreath E. S., (1985) Fundamental Concepts of Inorganic Chemistry, 2nd Edition, McGraw Hill Int,
6. Willard, Hobert H. *et. al: Instrumental Methods of Analysis*, 7th Ed. Wordsworth Publishing Company, Belmont, California, USA, 1988.
7. Christian, Gary D; *Analytical Chemistry*, 6th Ed. New York- John Willy, 2004.
8. Khopkar, S.M. *Basic Concepts of Analytical Chemistry* New Age, International Publisher, 2009.
9. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Thomson Asia Pvt. Ltd. Singapore.
10. Mikes, O. & Chalmes, R.A. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Ltd. London

Semester II:
CHE1209E05 Basic Chemistry Practicals
(Elective) (Practical Course) (2 Credits)

1. Organic Spotting (Minimum 5)
Simple chemical reactions, elemental analysis and functional group analysis of mono-functional organic compounds.
2. Qualitative analysis of Inorganic Salts : (Minimum 5)
Analysis of single salts with one cation and one anion from the following list:
Cations : Hg^{2+} , Pb^{2+} , Cu^{2+} , Cd^{2+} , $\text{Sn}^{2+/4+}$, Bi^{3+} , $\text{Fe}^{2+/3+}$, Al^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Co^{2+} , Ni^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+} , Mg^{2+} , K^{+} , NH_4^{+}
Anions : Cl^{-} , SO_4^{2-} , NO_3^{-} , CO_3^{2-} , S^{2-} , PO_4^{3-}
3. Volumetric analysis
Acidimetry-Alkalimetry
Oxidatio-Reduction
Use of various pH and Redox indicator

Reference Books:

1. Shah R.C. (2005) Inorganic Analysis Part I Qualitative, Baroda Book Dept, Vadodara
2. Shah R.C. (2005) Inorganic Analysis Part II Qualitative, Baroda Book Dept, Vadodara
3. Shah R.C, (2001) Organic Analysis Part I Qualitative Analysis Baroda Book Depot, Vadodara.

Semester III (Theory Courses)**CHE-1311C07/ CHE1314S07- Chemistry-V (3 Credits)****MOT, CFT, carbonyl compounds thermodynamics, thermo chemistry****Unit I (15 h)**

Molecular Orbital Theory (MOT) - Formation of bonding and antibonding molecular orbitals and bond order. Graphical representation of orbital energies (MO diagram). Bonding in homonuclear diatomic molecules/ions like N_2 , F_2 , B_2 , C_2 , O_2 , O_2^- , O_2^+ with MO diagrams, relation between bond order and bond lengths, magnetic properties. Bonding in heteronuclear diatomic molecules/ions like CO, NO, NO^+ and HX. The concept of polarization of a bond.

Partial ionic character and Fajan's rules, Van der Waals forces, other weak electrostatic forces and H-bonding (intra and inter).

Coordination compounds: Introduction to basic terminologies (primary and secondary coordination spheres, ligands and their types, Coordination number and coordination geometry, chelation, sequestering agents), Effective Atomic Number (EAN) and 18 electron rules. Bonding in complexes with coordination number 4 & 6 in terms of VBT, high and low spin complexes. Capability and limitations of VBT.

Unit II (15 h)

Aldehydes and Ketones: Introduction, preparation: oxidation, reduction, Reimer-Tiemann reaction, Friedel-Crafts acylation, use of lithium dialkylcuprites. Reactivity, nucleophilic addition reactions, oxidation, reduction, Cannizzaro reaction, haloform reaction, Beckmann Rearrangement.

Carboxylic acids: Introduction, acidity, Preparation: oxidation of primary alcohols, alkylbenzenes, carbonation of Grignard reagents, hydrolysis of nitriles. Reactions of carboxylic acids: Hell-Volhard-Zelinsky reaction, reduction, conversion into acid chlorides, anhydrides, esters and amides, mechanism of esterification and decarboxylation. Preparation and reactions of dicarboxylic acids, conversion to anhydrides and imides.

Unit III (15 h)

Thermodynamics: Definition and explanation of terms - types of systems, intensive and extensive properties, thermodynamic process - cyclic, reversible, irreversible, isothermal and adiabatic processes.

Zeroth law of thermodynamics: concept of heat and work. Internal energy and enthalpy.

First law of thermodynamics: Statement and equation, C_p and C_v relationship - calculation of W, E and H for the expansion of ideal gases and real gas under reversible, isothermal and adiabatic conditions. Joule - Thomson effect, inversion temperature and its significance.

Thermochemistry: Standard states, standard enthalpy of formation-Hess's law of heat summation and its application. Kirchoff's equation.

Mode of transaction: Through Classroom lectures with models, charts, OHP, power point presentation and multimedia.

Reference Books (Unit I):

1. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
2. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi
3. Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
4. Mahan B.H., (2009) University Chemistry, 3rd Edition, Narosa Publ House, New Delhi.

5. Gilreath E. S., (1985) Fundamental Concepts of Inorganic Chemistry, 2nd Edition, McGraw Hill Int,

Reference Books (Unit II):

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Finar I L Organic Chemistry Vol 1 & 2 ELBS/ Pearson 1982

Reference Books (Unit III):

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.

CHE-1312C08/ CHE1315S08- Physical Chemistry-I (2 Credits)
States of Matter-Gaseous, Liq. Solid, colloidal and mesomorphic states

Unit I (15 h)

Gaseous State: Recapitulations of Ideal gas/Real gas, Heat capacity (molecular basis), Heat capacity ratio. Deviation from ideal gas Behavior - Boyle temperature, Compressibility Factor. Derivation of van der Waals gas equation. Liquefaction of gases, Critical phenomenon and critical constants, Law of corresponding states, Reduced equation of state, Joule-Thomson effect and Inversion temperature (definition). Methods of liquefaction of gases: Faraday's, Linde's method and Claude's method.

Liquid State: Intermolecular forces and structure of liquids (qualitative description)

Definition and determination of Vapour Pressure, Surface tension, Viscosity and their variation with temperature. Parachor and its importance.

Unit II (15 h)

Solid State: Recapitulations, Symmetry elements in crystals. Laws of crystallography: Law of constancy of interfacial angles, Law of rationality of indices, Law of symmetry. X-ray diffraction by crystals. Derivation of Bragg's law, Structure of few metallic elements, ionic solids (NaCl and KCl) radius ratios, defects in solids.

Colloidal State: Classification of colloids, Preparation and purification of sols, Stability of sols, Schulze-Hardy rule, Gold Number. Emulsions, gel and foam. Association colloids, Surfactants, Micelle formation and critical micelle concentration, Action of soap.

Applications.

Mesomorphic state: Difference between liquid crystal, liquid and solid. Classification and structure of nematic, smectic and cholesteric phases. Non-conventional liquid crystals. Applications.

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books (Unit I and II):

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44th Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.
7. West A. R. (Reprinted 2008), Solid State Chemistry and its Applications, John Wiley and Sons (Asia) Pvt. Ltd, Singapore.
8. Keer, H.V. (1993), Principles of Solid State, Wiley Eastern Ltd., New Delhi

B.Sc. Semester III
CHE-1317E05
Coordination and & Electro Chemistry
Chemistry (Elective Course) (2 credits)

Unit I (15 h)

Electrochemistry:

Metallic and electrolytic conductors: Conduction of electricity by metals and solutions. Classification of substances- electrolytes and nonelectrolytes. Arrhenius theory of electrolytic dissociation. Specific, equivalent and molar conductance - measurement of conductance - variation of conductance with dilution for strong and weak electrolytes,

Ionic Equilibria: Arrhenius theory of electrolytic dissociation, ionic product of water, pH scale, measurement of pH, common ion effect, Henderson's equation, buffer solutions, buffer capacity. Hydrolysis of salts.

Electrolytic and galvanic cells, reversible and irreversible cells. EMF of a Cell and its measurement. Nernst's equation. Determination of E^0 and equilibrium constant of cell reaction. Standard electrodes (including reference electrodes). Electrochemical series of electrode potentials. Convention for half cell potential. Applications of EMF measurements.

Unit II (15 hr)

Coordination compounds: Introduction to basic terminologies (primary and secondary coordination spheres, ligands and their types, CN, chelation), Effective Atomic Number(EAN) and 18 electron rule. Bonding in complexes with coordination number 4 & 6 in terms of VBT, high and low spin complexes. Capability and limitations of VBT.

Electrostatic concept of complex formation : Crystal field theory, (CFT), energy of d orbitals in spherical, octahedral, tetrahedral and square planar fields. Weak field and strong field complexes. Colour and magnetism of complexes on the basis of CFT.

Complexes of biomolecules and their importance.

Reference Books :

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.
7. Day M. C. and Selbin J., (1985) Theoretical Inorganic Chemistry, East-West Press
8. Cartmell E. and Fowles G.W.A., (1977) Valency and Molecular Structure, 4th Edition. ELBS, Butterworths,
9. Kettle S. F. A., Murrell J. N. and Teddler S., (1985) The Chemical Bond, ELBS, Butterworths
10. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
11. Emeleus H.J. and Sharpe A.G., (1994) Modern Aspects of Inorganic Chemistry, 4th Ed., UBS,
12. Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
13. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi

B.Sc. Semester III**CHE-1318E06****States of matter, Chemistry of transition & inner transition elements****Chemistry (Elective Course) (2 credits)****Unit I (15 h)****States of matter:**

Gaseous State: Ideal and Real gases, Postulates of kinetic theory of gases, derivation of Kinetic gas equation, Derivation of gas laws from kinetic gas equation, Deviation from ideal gas Behavior - Derivation of van der Waals gas equation. Liquefaction of gases, Critical phenomena.

Liquid State: Intermolecular forces and structure of liquids (qualitative description) Definition and determination of Vapour Pressure, Surface tension, Viscosity and their variation with temperature.

Colloidal State: Classification of colloids, Preparation and purification of sols, Stability of sols, Schulze-Hardy rule, Gold Number. Emulsions, gels and foams. Association colloids, Surfactants, Micelle formation and critical micelle concentration.

Mesomorphic state: Difference between liquid crystal, liquid and solid. Classification and structure of nematic, smectic and cholesteric phases.

Unit II (15 h)

Chemistry of Transition elements:

Characteristic properties of d-block elements. Electronic configuration. Comparative account of atomic and ionic radii, density, M.P., B.P., metallic character, reactivity of metals, ionization energies.

Difference between the properties of the elements of first and the other two transition Series.

Application of coordination compounds in analysis and industry.

Lanthanides and Actinides : Abundance, occurrence and extraction of lanthanides and actinides.

Separation of lanthanides. Metallurgy of thorium and uranium. Preparation of transuranium elements. Electronic configuration, oxidation states, atomic & ionic radii.

Lanthanide contraction and its consequences.

Reference Books :

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.
7. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi
8. Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
9. Mahan B.H., (2009) University Chemistry, 3rd Edition, Narosa Publ House, New Delhi.
10. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,.
11. Emeleus H.J. and Sharpe A.G., (1994) Modern Aspects of Inorganic Chemistry, 4th Edition, UBS.

Semester IV (Theory Courses)**CHE1411C10/ CHE1414S10 (3 Credits) Chemistry – VI**
Chemistry tr. & inner tr. elements aryl halides & phenols Ionic equilibrium**Unit I (15 h)**

Chemistry of Transition elements:

Characteristic properties of d-block elements. Electronic configuration. Comparative account of atomic and ionic radii, density, M.P., B.P., metallic character, reactivity of metals, ionization energies.

Difference between the properties of the elements of first and the other two transition Series.

Application of coordination compounds in analysis and industry.

Lanthanides and Actinides : Abundance, occurrence and extraction of lanthanides and actinides. Separation of lanthanides. Metallurgy of thorium and uranium. Preparation of transuranium elements. Electronic configuration, oxidation states, atomic & ionic radii.

Lanthanide contraction and its consequences.

Unit II (15 h)

Aryl halides: Introduction, preparation, electrophilic aromatic substitution, nucleophilic aromatic substitution, bimolecular displacement, elimination-addition (benzyne) mechanism, evidence for benzyne mechanism.

Phenols: Introduction, acidity, preparation, Reactions, ether and ester formation, nitration, nitrosation, sulphonation, halogenation, coupling with diazonium salt, Fries rearrangement, Reimer-Tiemann Reaction, Lederer-Manasse and Kolbe reactions with mechanism. Dihydric and trihydric phenols.

Unit III (15 h)

Ionic Equilibria: Arrhenius theory of electrolytic dissociation, ionic product of water, pH scale, measurement of pH, common ion effect, Henderson's equation, buffer solutions, buffer capacity. Multistage equilibria. Hydrolysis of salts, hydrolysis constant, degree of hydrolysis, Methods of determination of degree of hydrolysis. Relationship between K_b , K_a , K_b and K_w , Theory of Acid-Base indicators. Theory of strong electrolytes, Debye-Huckel limiting law.

Mode of transaction: Through classroom lectures with models, charts, power point presentation and multimedia.

Reference Books (Unit I):

1. Cotton F. A. and Wilkinson G., (1988), Basic Inorganic Chemistry, Wiley Eastern.
2. Emeleus H. J. and Sharpe A.G., (1994) Modern Aspects of Inorganic Chemistry, 4th Edition, UBS,
3. Sanderson R. T., (1971) Inorganic Chemistry, East-West Press
4. Huheey J. E., Keiter E. A. and Keiter R. L., (1993) Inorganic Chemistry: Principles of Inorganic Chemistry, 4th Edition, Addison-Wesley International,

Reference Books (Unit II):

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..

7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Finar I L Organic Chemistry Vol 1 & 2 ELBS/ Pearson 1982

Reference Books (Unit III):

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.

Books Recommended for Further Reading:

1. Purcell K. F. & Kotz J. C., Inorganic Chemistry, Holt-Saunders (1980).
2. Cotton F. A. & Wilkinson G., Advanced Inorganic Chemistry, 1-6th Editions, Wiley Inter Science (1962, 1966, 1972, 1980, 1988, 1999).
3. Housecroft C. E. & Sharpe A. G., Inorganic Chemistry, Prentice Hall (2004, 2005).
4. Rodgers Glen E., Introduction to Coordination, Solid State and Descriptive Inorganic Chemistry, McGraw Hill Inc. (1994).
5. Shriver D.F., Atkins P. W & Langford C. H., Inorganic Chemistry, Oxford University Press, Oxford (1990).
6. Atkins P., Overton T., Rourke J., Weller M. & Armstrong F., "Shriver and Atkins-Inorganic Chemistry" 4th Edition. Oxford University Press, Oxford (2006).
7. Thompson D. (Editor), Insights into Specialty Inorganic Chemicals, (Royal Society of Chemistry - Special Publication), Springer Verlag (1995).
8. Sharma B. K., Industrial Chemistry Including Chemical Engineering, 9th Revised Edition, Goel Publishing House, Meerut (1997-98).

Organic Chemistry – II CHE1412C11/CHE1415S11 (2 Credits)
Nitro compounds amines, Amino acids peptides & proteins

Unit 1 (15 h)

Nitro compounds: Preparation of nitroalkanes and nitroarenes. Reactions: Alkylation at α -carbon, nucleophilic substitution reactions in nitroarenes, reduction of nitro compounds. Picric acid.

Amines: Structure, classification, nomenclature and physical properties of amines, preparation of alkyl and aryl amines, reduction of nitro and nitrile compounds, reductive amination of aldehydes and ketones. Hofmann rearrangement, basicity of amines, effect of substituent on basicity of aromatic amines, Hinsberg's test, quaternary ammonium salts, Hofmann exhaustive methylation, Hofmann elimination and orientation. Diazonium salts: diazotization and its mechanism, synthetic applications of aromatic diazonium salts.

Unit 2 (15 h)

Amino Acids: Introduction, Classification, Isoelectric point, Preparation: α amino acid synthesis, Gabriel phthalimide synthesis, Reactions.

Peptides and proteins: Structure of peptides and proteins, nomenclature of peptides classification of proteins, peptide structure determination, end group analysis, selective hydrolysis of peptides, classical peptide synthesis, solid phase peptide synthesis, protein denaturation. *Nucleic acids:* Introduction, nucleoproteins, structure of nucleic acids, ribonucleosides and ribonucleotides, the double helical structure of DNA, genetic code.

Mode of transaction: Through classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Finar I L Organic Chemistry Vol 1 & 2 ELBS/ Pearson 1982

Semester III & IV (Practical Courses)
CHE-1313C09/ CHE1316S09 (3 Credits)
Chemistry Practicals-III
&
CHE1413C12/ CHE1416S12 (3 Credits)
Chemistry Practicals-IV

The two semesters put together should cover the following aspects:

1. Volumetric analysis :
 - i. Oxidation - reduction
 - ii Iodometry
 - ii. Complexometry
 - iv. Mohr's Method
2. Qualitative analysis of Inorganic Mixtures containing 4 (four) radicals.
3. Systematic analysis of Organic compounds with more than one functional groups.
4. Organic Estimations:
 - i. Phenol/ Aniline
 - ii. Amide
 - iii. Nitro group
5. Physical Experiments:
 - i. Hydrolysis of methyl acetate
 - ii. Partition coefficient of Benzoic acid
 - iii. Surface tension by Stalagmometer
 - iv. Viscosity.

Reference Books :

1. Shah R C, (2005) Inorganic Analysis Part I Qualitative, Baroda Book Depot, Vadodara
2. Shah R C, (2005) Inorganic Analysis Part II Quantitative, Baroda Book Depot, Vadodara
3. Shah R C, (2001) Organic Analysis Part I Qualitative Analysis Baroda Book Depot, Vadodara

**Semester IV : CHE1407E07 Basic Organic Chemistry
(Elective) (Theory Course) (2 Credits)**

Unit I*Chemistry of Carbonyl Group*

Aldehydes and Ketones: Introduction, preparation: oxidation, reduction, Reimer–Tiemann reaction, Friedel–Crafts acylation. Reactions: nucleophilic addition reactions, oxidation, reduction, haloform reaction, aldol condensation.

Carboxylic acids and their derivatives: Introduction, acidity, Preparation: oxidation of primary alcohols, alkylbenzenes, carbonation of Grignard reagents, hydrolysis of nitriles. Reactions of carboxylic acids: Hell-Volhard-Zelinsky reaction, reduction, conversion into acid chlorides, anhydrides, esters and amides, mechanism of esterification and decarboxylation.

Unit II*Amines and Amino acids*

Amines: Structure, Introduction, preparation of alkyl and aryl amines, reduction of nitro and nitrile compounds, reductive amination of aldehydes and ketones. Hofmann rearrangement, basicity of amines, effect of substituent on basicity, diazotization and its mechanism, synthetic applications of aromatic diazonium salts.

Amino Acids: Introduction, Classification, Isoelectric point, Preparation: malonic acid synthesis, Gabriel phthalimide synthesis, Reactions. Synthesis of Peptides: Classical peptide synthesis, solid phase peptide synthesis.

Reference Books :

1. Morrison R.T. and Boyd R.N; (1994) Organic Chemistry, Prentice Hall of India, New Delhi
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley, New York.
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India..
7. Mehta B. and Mehta M; (2005) Organic Chemistry, Prentice Hall India New Delhi.
8. Finar I L Organic Chemistry Vol 1 & 2 ELBS/ Pearson 1982

**Semester IV : CHE1408E08 Thermodynamics and Speciality Chemicals
(Elective) (Theory Course) (2 Credits)**

Unit I (15 h)

Thermodynamics: Definition and explanation of terms - types of systems, intensive and extensive properties, thermodynamic process - cyclic, reversible, irreversible, isothermal and adiabatic.

Zeroth law of thermodynamics: concept of heat and work. Internal energy and enthalpy.

First law of thermodynamics: Statement and equation, C_p and C_v relationship - calculation of W , E and H for the expansion of ideal gases and real gas under reversible, isothermal and adiabatic conditions. Joule - Thomson effect, inversion temperature and its significance.

Thermochemistry: Standard states, standard enthalpy of formation-Hess's law of heat summation and its application.

Second law of thermodynamics and its significance, Gibbs free energy.

Unit II (15 h)

Preparation of high purity silicon, silicon based semiconductors and devices.

Silicones. Synthesis and structure of silicone fluids, greases, resins and rubbers. Thermal stability, water and chemical resistance. Applications in various fields like medicine to electronics and construction.

Glassy state. Manufacturing of glass, structure of glass, colouring and decolorization in glass making, change in physical properties of glass with variation in additives. Various types of glass and their use.

Ceramics: General properties, classifications, raw materials and formation of clay, types and typical properties of clays, manufacturing process of potteries, application of colours to pottery, use of ceramics in resistors and capacitors.

Refractories: Properties, classification, manufacture of fire clay bricks, silica bricks, pure oxides, super refractories and insulating refractories.

Reference Books :

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.
7. Puri B.R., Sharma L.R. and Kalia K.C., (2006). Principles of Inorganic Chemistry, 29th Edition, Milestone Publ., Delhi
8. Cotton F.A. and Wilkinson G., (2009) Basic Principles of Inorganic Chemistry, 3rd Edition, Wiley Eastern,
9. Mahan B.H., (2009) University Chemistry, 3rd Edition, Narosa Publ House, New Delhi.
10. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
11. Sharma B. K. Industrial Chemistry including Chemical Engineering, 9th revised edition, Goel Publishing House, Merrut (1997-98).

Semester V (Theory Courses)
Chemistry – V CHE-1501C13 (3 Credits)
At. St., Intro to spectroscopy & phase equilibria

Unit I (15 h)

Schrodinger wave equation, Laplacian operator, Energy associated with particle in one dimensional box (qualitative treatment).

Polar coordinates r , θ and ϕ . Separation of the wave equation in translational and rotational parts, Φ , Θ and R equations and the $\Phi(\phi)$, $\Theta(\theta)$ and $R(r)$ functions. Quantum numbers derived from the wave equation, relation between quantum numbers and radial and angular nodes, spherical harmonics and shapes of orbitals.

Radial probability, Screening effect and order of suborbital energies in multielectronic atoms, Ground spectral states of atoms and ions (up to $Z=30$).

Elementary concept of symmetry elements and symmetry operations, Point symmetries, C_{nv} , D_{4h} , D_{6h} , T_d and O_h .

Unit II (15 h)

Introduction to Spectroscopy: Electromagnetic spectrum, interaction of electromagnetic radiation with matter, atomic and molecular spectroscopy, absorption and emission spectroscopy.

Ultraviolet-Visible (UV-Vis) Spectroscopy: Absorption laws, instrumentation, UV-Vis spectrum, types of electronic transitions, concept of chromophore and auxochrome, UV spectra of alkenes, conjugated enes, enones and aromatic compounds.

Infrared (IR) Spectroscopy: Molecular vibrations, Hooke's law, selection rules, instrumentation and measurement of IR spectrum, Fundamental, overtone, combination and coupled bands, fingerprint region, characteristic absorptions of various functional groups.

Unit III (15 h)

Phase equilibria I: Phases, components, degrees of freedom, equilibrium between phases, phase boundaries, phase stability and phase transitions, Ehrenfest classification of phase transitions, phase diagrams. Derivation of phase rule and Experimental procedures for phase studies. One component systems (Water, sulphur, carbon dioxide, carbon, helium), supercritical fluid. Two component systems involving eutectics, congruent and incongruent melting points. Solid solutions, partial miscibility in solid and liquid states. Fractional crystallization, Ultrapurity and controlled impurity, zone refining.

Mode of transaction: Through classroom lectures with models, charts, power point presentation and multimedia.

Reference Books (Unit I):

1. Day M. C. and Selbin J., (1985) Theoretical Inorganic Chemistry, East-West Press
2. Cartmell E. and Fowles G.W.A., (1977) Valency and Molecular Structure, 4th Edition. ELBS, Butterworths,
3. Kettle S. F. A., Murrell J. N. and Teddler S., (1985) The Chemical Bond, ELBS. Butterworths
4. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
5. Emeleus H.J. and Sharpe A.G., (1994) Modern Aspects of Inorganic Chemistry, 4th Edition, UBS,

Books Recommended for Further Reading:

1. Banerjea D., Coordination Chemistry, Tata McGraw Hill (1993).
2. Cotton. F.A. & Wilkinson G., Basic Inorganic Chemistry, Wiley Eastern (1988).

3. Huheey J.E. & Harper-Collins, *Inorganic Chemistry: Principles of Inorganic Chemistry*, 4th Edition (1983).
4. Cotton F.A. & Wilkinson G., *Advanced Inorganic Chemistry*, 1-6th Editions, Wiley Interscience, (1962, 1966, 1972, 1980, 1988, 1999).
5. Purcell K.F. & Kotz J.C., *Inorganic Chemistry*, Holt-Saunders (1980).
6. Atkins P., Overton T., Rourke J., Weller M. & Armstrong F., "Shriver and Atkins – *Inorganic Chemistry*" 4th edition. Oxford University Press, Oxford (2006).

Reference Books (Unit II):

1. Dyer J.R; *Applications of Spectroscopy of Organic Compounds*, Prentice Hall of India Ltd. New Delhi, Reprint (2005).
2. Silverstein R M, Webster F X, Kiemle D; *Spectrometric Identification of Organic Compounds*, John Wiley & Sons, New York, 2005.
3. Kalsi P.S; *Spectroscopy of Organic Compounds*, New Age International Ltd. New Delhi (2004).
4. Jag Mohan *Organic Spectroscopy: Principles and Applications*, Narosa Publishing House, New Delhi. (2004)
5. Sharma Y R; *Elementary Organic Spectroscopy-Principles and Chemical Applications*, S Chand and Co, New Delhi, (2007)
6. Morrison R.T. and Boyd R.N; *Organic Chemistry*, Prentice Hall, New Delhi. Loudon G M; *Organic Chemistry*, Oxford, New York (2002)

Reference Books (Unit III):

1. Atkins P. and Paula J. D. (2006), *Physical Chemistry*, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), *Text Book of Physical Chemistry*, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, *Principles of Physical Chemistry*, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), *Essentials of Physical Chemistry*, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), *Physical Chemistry*, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), *University Chemistry*, 3rd Edition, Narosa Publishing House, New Delhi.

Inorganic Chemistry -II CHE-1502C14 (3 Credits)
Chemistry of main group elements & speciality chemicals.

Unit I (15 h)

Chemistry of Boron family : Electron deficiency and acceptor behavior, Oxides, hydroxides and halides, boronitride and borazole. Structure, bonding and important applications.

Boranes, borohydrides and carboranes.

Chemistry of Carbon family: Allotropy, trends in metallic properties and conduction, structure, bonding and properties of oxides. Carbides, graphitic compounds, silicates, zeolites, feldspars, ultramarines and clay minerals. Synthetic zeolites and clays.

Unit II (15 h)

Nitrogen family: hydrazine, hydroxylamine and hydrazoic acid, hydrides of other elements, Oxides and halides, Oxyacids of nitrogen and phosphorous.

Chemistry of Oxygen family : Ozone, oxides, peroxides and superoxides. Oxyacids and halides of sulphur, peracids and persalts of sulphur, Chemistry and applications of lead compounds, toxicity and biological role of selenium and tellurium.

Chemistry of Halogens: Oxides and oxyacids of halogens, peracids and persalts, interhalogen compounds, pseudohalogens and polyhalides, basic properties of Iodine, Chemistry of Astatine.

Chemistry of Noble Gases: Oxides, fluorides and oxyfluorides of xenon.

Unit III: (15 h)

Preparation of high purity silicon, silicon based semiconductors and devices.

Silicones. Synthesis and structure of silicone fluids, greases, resins and rubbers. Thermal stability, water and chemical resistance. Applications in various fields like medicine to electronics and construction.

Glassy state. Manufacturing of glass, structure of glass, network formers and network modifiers, colouring and decolorization in glass making, change in physical properties of glass with variation in additives. Various types of glass and their use.

Ceramics: General properties, classifications, raw materials and formation of clay, types and typical properties of clays, manufacturing process of potteries, application of colours to pottery, use of ceramics in resistors and capacitors.

Refractories: Properties, classification, manufacture of fire clay bricks, silica bricks, pure oxides, super refractories and insulating refractories.

Mode of transaction: Through classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
2. Cotton F.A. and Wilkinson G., (1988) Basic Inorganic Chemistry, Wiley Eastern.
3. Huheey J.E., (1983), Inorganic Chemistry: Principles of Inorganic Chemistry, 4th Edition, Harper-Collins
4. Housecroft C. E. and Sharpe A. G., (2004, 2005), Inorganic Chemistry, Prentice Hall.

Books Recommended for Further Reading:

1. Cotton F.A. & Wilkinson G., Advanced Inorganic Chemistry, 1-6th Editions, Wiley Interscience (1962, 1966, 1972, 1980, 1988, 1999).
2. Sanderson R.T., Inorganic Chemistry, East-West Press (1971).
3. Purcell K.F. & Kotz J.C., Inorganic Chemistry, Holt-Saunders (1980).
4. Rodgers Glen E., Introduction to Coordination, Solid State & Descriptive Inorg. Chemistry, McGraw Hill Inc. (1994).

Organic Chemistry -III CHE-1503C15 (3 Credits)
Conformation & chirality carbohydrates, hetrocyclic compounds

Unit I (15 h)

Conformation and Chirality: Conformation, stability of conformers, conformation of cyclohexane, mono- and di-substituted cyclohexanes, conformation of glucose.

Chiral molecules: generation of chiral centre, reactions remote from chiral centre, application in correlation of chiral compounds, generation of another chiral centre, reaction with chiral compounds, resolution, stereochemistry of addition of halogens to alkenes. Chirality in biphenyls, allenes and spiro compounds.

Unit II(15 h)

Carbohydrates: Classification and nomenclature, open chain and cyclic structure of glucose, determination of ring size, mutarotation and its mechanism, epimers, chain shortening and chain lengthening of aldose, conversion of glucose to fructose and Mannose, conversion of fructose to glucose, formation of glycosides, ethers and esters, erythro and threo diastereoisomers. Disaccharides and polysaccharides: Introduction to maltose, sucrose and lactose, starch and cellulose.

Energy production in biological systems, biological oxidation of alcohols and carbohydrates.

Unit III (15 h)

Heterocyclic compounds: Introduction, structure, molecular orbitals and aromaticity in pyrrole, furan and thiophene, mechanism of electrophilic and nucleophilic substitution reactions; basicity of pyridine, piperidine and pyrrole.

Condensed five and six member heterocycles: preparation and reactions of indole, quinoline and isoquinoline, Fischer indole synthesis, Skraup synthesis, Bischler-Napieralski synthesis, electrophilic and nucleophilic substitution reactions of indole, quinoline and isoquinoline.

Mode of transaction: Through classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Morrison R.T., Boyd R.N.; Organic Chemistry, Prentice Hall of India, NewDelhi (VI Ed).
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California, USA.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India.
12. Finar I.L; (1982) Organic Chemistry, Vol 1 & 2, ELBS & Longman group
13. Arora M. G.; (1997) Stereochemistry in Organic Compounds, Anmol Publ. New Delhi
14. Chatwal G; (1985) Synthetic Dyes, Himalaya Publication Home

Physical Chemistry-II CHE-1504C16 (3 Credits)
Electrochemistry, thermodynamics & chemistry equilibria

Unit I (15 h)

Electrochemistry I: Electrolytic and galvanic cells, reversible and irreversible cells. EMF of a Cell and its measurement. Nernst's equation. Determination of E_0 and equilibrium constant of cell reaction. Standard electrodes (including reference electrodes). Electrochemical series of electrode potentials. Convention for half cell potential. Applications of EMF measurements: Determination of solubility product, pH, mean activity coefficient, transport number. Potentiometric titrations : Acid-base, Precipitation and Redox. Weston-Cadmium cell

Unit II (15 h)

Second law of thermodynamics: Need for the II law, statements of the second law. Spontaneous process, Carnot's cycle and efficiency of heat engine. Concept of entropy, definition, entropy of an ideal gas, entropy changes in cyclic, reversible and irreversible processes and physical transformations. Calculation of entropy changes with changes in T, V and P, entropy of mixing. Gibbs free energy, Helmholtz work functions, their variations with temperature, pressure and volume. Criteria for spontaneity, Gibbs-Helmholtz equations- derivation and its applications. *Third law of Thermodynamics:* Nernst heat theorem statement of Third law of thermodynamics. Evaluation and absolute entropy from heat capacity measurements. Exception to Third law.

Unit III (15 h)

Chemical Equilibrium: Equilibrium constant and free energy, Thermodynamic derivation of law of mass action, Le Chatelier's principle. Reaction isotherm and isochore-Clapeyron equation and Clausius-Clapeyron equation, applications. *Partial Molar Properties:* Chemical potential, Gibbs Duhem equation- effect of temperature and pressure on chemical potential, chemical potential in system of ideal gases, Duhem-Margules equation. Concept of Fugacity, activity and activity coefficient, Methods for determination of fugacity of gas.

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.

Inorganic Chemistry-III CHE-1505C17 (2 Credits)
Met. Properties, Coord. Compounds, CFT theory

Unit I (15 h)

Metallic Properties: Properties of metals, crystal structure of metals, electron gas theory and Pauling's theory of metals, Band theory, Alloys, Hume-Rothery rules.

Simple idea of conduction, Semiconductors and insulators. Magnetic and electrical properties of solids. Introduction to superconductivity.

Molecular orbital (MO) theory of multiatomic molecules and ions : linear triatomic molecules like BeCl_2 and CO_2 , planar AB_3 type molecules like BCl_3 and CO_3^{2-} , tetrahedral molecules like CH_4 , NH_4^+ , and SO_4^{2-} . Comparison with valence bond theory.

Unit II (15 h)

Coordination compounds : Covalent interaction in metal complexes and hybridization involving d-orbitals, high and low spin complexes. Limitations of VBT.

Electrostatic concept of complex formation : Crystal field theory, (CFT), energy of d orbitals in spherical, octahedral, tetrahedral, tetragonal and square planar fields. Extrinsic and intrinsic distortion in octahedral geometry, Weak field and strong field complexes.

Spectrochemical series, colour, magnetism and geometry of complexes on the basis of CFT.

Factors affecting the crystal field splitting. Geometry preferred by various transition metal ions in strong and weak fields. Limitations of crystal field theory (qualitative approach).

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Day M. C. and Selbin J., (1985) Theoretical Inorganic Chemistry, East-West Press
2. Cartmell E. and Fowles G.W.A., (1977) Valency and Molecular Structure, 4th Edition. ELBS, Butterworths,
3. Kettle S. F. A., Murrell J. N. and Teddler S., (1985) The Chemical Bond, ELBS. Butterworths
4. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,.
5. Emeleus H.J. and Sharpe A.G., (1994) Modern Aspects of Inorganic Chemistry, 4th Edition, UBS,

Books Recommended for Further Reading:

1. Banerjee D., Coordination Chemistry, Tata McGraw Hill (1993).
2. Cotton. F.A. & Wilkinson G., Basic Inorganic Chemistry, Wiley Eastern (1988).
3. Huheey J.E. & Harper-Collins, Inorganic Chemistry: Principles of Inorganic Chemistry, 4th Edition (1983).
4. Cotton F.A. & Wilkinson G., Advanced Inorganic Chemistry, 1-6th Editions, Wiley Interscience, (1962, 1966, 1972, 1980, 1988, 1999).
5. Purcell K.F. & Kotz J.C., Inorganic Chemistry, Holt-Saunders (1980).
6. Atkins P., Overton T., Rourke J., Weller M. & Armstrong F., "Shriver and Atkins – Inorganic Chemistry" 4th edition. Oxford University Press, Oxford (2006).

Foundation course in Chemistry (T Y B Sc) B Sc Semester V
Selected topics in Organic Chemistry CHE1510F02(2 credits)

Unit-1**Medicinal Chemistry:**

Anti-malarial agents: Malaria cycle. Structure and synthesis of chloroquine and primaquine. **Analgesic and antipyretics:** Synthesis and action of ibuprofen and paracetamol.

Anticancer agents: Nitrogen mustards and 5-fluorouracil and tamoxifen.

Antibiotics: Introduction. broad spectrum antibiotics- Penicillin and amoxicillin.

Antitubercular agents: M tuberculosis. Chemistry and synthesis of isoniazide and ethambutol

Unit -2

Vitamins: Structure and synthesis of Vitamin A1 (retinol) and Vitamin K1 (phylloquinone). Structure and synthesis (Gorlich and Bakke) of Vitamin C (ascorbic acid).

Natural pigments: Pigments in apple, rose, carrot and tomato. Structure elucidation and synthesis of flavone. Anthocyanins: Cyanin and Cyanidin chloride. Structure elucidation and synthesis of cyanidin chloride and quercetin (a flavanol). Carotenes: Structure elucidation and synthesis (one) of β -carotene. Structure relation between α - β , γ -carotenes and the tomato pigment. Structure of porphyrin pigments- haemin and chlorophyll.

Reference books:

1. Kar A. : Medicinal Chemistry. New Age International Publishers.
2. Chatwal G. R., Synthetic Drugs.-Himalaya Publication Home
3. Finar I.L: Organic Chemistry. Vol I & 2. ELBS / Pearson.
4. Chatwal G R: Organic Chemistry of Natural Products Vol.I& 2. Himalaya Publication Home

Green Chemistry and Industrial Processes CHE1511F03 [2 credits]**Unit 1: Green chemistry and Sustainability**

Definitions, Basic principles of Green Chemistry .

Green solvents -Aqueous medium: Enhancement of selectivity, efficiency, and industrial applicability, Ionic liquids, Supercritical fluids Solvent free reactions in liquid phase and reaction conditions.

Non-conventional energy sources- Microwave assisted reaction, Ultrasound assisted reactions and photochemical reactions using sunlight.

Green catalysis- Heterogeneous catalysis, biocatalysis and phase transfer catalysis

Unit 2- Green starting materials, Green reagents and Green synthesis

Real industrial examples- (Traditional processes and green ones)-Synthesis of Ibuprofen, Adipic acid etc.

Some Representative Green reactions: Addition Reactions (Michael, Diels-Alder), Oxidation reduction reactions (Baeyer-Villiger, Barbier, Cannizzaro, Dakin), Acid catalysed(solid acid catalysts), Rearrangement reactions (Claisen, Pinacol), Transesterification reactions (biodiesel synthesis), halogenation reaction using vanadium catalyst

Books Recommended:

1. Green Chemistry, Theory and Practice, P.T. Anastas and J.C. Warner, Oxford University Press, 2000.
2. V. K. Ahluwalia, M. Kidwai, New trends in Green Chemistry, New Age Publications, 2005.
3. Real World Cases in Green Chemistry, Cann, M. C.; Connelly, M. E. American Chemical Society: Washington, DC, 2000.
4. Introduction to Green Chemistry, M.A. Ryan & M. Tinnesand, American Chemical Society, Washington, 2002.
5. Green Chemistry: Introductory Text. M. Lancaster Royal Society of Chemistry (London)2002.
6. Green Chemistry, 2nd Ed: Environmentally Benign Reactions. V.K Ahluwalia. Ane Books Pvt Ltd.,2012.

Semester VI (Theory Courses)**Chemistry – VI CHE- 1601C20 (3 Credits)
Isomerism, react. Chem.. Mass, NMR macro mol.****Unit I (15 h)**

Isomerism in complexes.

Stability of complexes formed by transition metal ions and the factors influencing it.

$M \rightarrow L$ and $L \rightarrow M$ π interaction in metal complexes.

Introduction to organometallic compounds, Metal carbon σ -bonds, σ -bonding in metal carbonyls and nitrosyls.

Mechanism of inorganic reactions: Hard and soft acids and bases, classification of acceptors and donors, the concept of acceptor A and B. Metal and ligand substitution reactions.

Complementary and non-complementary redox processes, atom transfer and electron transfer mechanisms.

Metal complexes in biology and medicine.

Unit II (15 h)

Mass Spectrometry: Principle, Instrumentation, types of fragmentation, nitrogen rule, isotope peaks, Mcclafferty rearrangement fragmentation of simple organic molecules such as halides, ethers, carbonyl compounds.

Nuclear Magnetic Resonance (NMR) Spectroscopy: Nuclear magnetic resonance, instrumentation, proton NMR, nuclear shielding and deshielding, chemical shift, spin-spin splitting, interpretation of NMR spectra of simple organic molecules.

Interpretation of UV, IR and NMR spectra, problems based on combined use of spectral data.

Unit III (15 h)

Macromolecules: Importance of polymers. Basic concepts: Monomers, repeat units, degree of polymerization. Linear, branched and network polymers, classification of polymers. Chain growth (free radical, ionic and coordination) and step growth polymerization and copolymerization. Polydispersion-average molecular weight concept, Number, weight and viscosity average molecular weights, The practical significance of molecular weight, Molecular weight determination using viscosity method, Osmometry, Cryoscopy, Ebullioscopy (qualitative description) Polymer degradation and environmental concerns.

Mode of transaction: Classroom teaching, PPT and multimedia presentation.

Reference Books (Unit I):

1. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
2. Emeleus H.J. and Sharpe A.G., (1994) Modern Aspects of Inorganic Chemistry, 4th Edition UBS
3. Banerjea D., (1993) Coordination Chemistry, Tata McGraw Hill
4. Cotton F.A. and Wilkinson G., (1988) Basic Inorganic Chemistry, Wiley Eastern.
5. Huheey J.E. (1983) Inorganic Chemistry: Principles of Inorganic Chemistry, 4th Edition, Harper-Collins

Reference Books (Unit II):

7. Dyer J.R; *Applications of Spectroscopy of Organic Compounds*, Prentice Hall of India Ltd. New Delhi, Reprint (2005).
8. Silverstein R M, Webster F X, Kiemle D; *Spectrometric Identification of Organic Compounds*, John Wiley & Sons, New York, 2005.
9. Kalsi P.S; *Spectroscopy of Organic Compounds*, New Age International

Ltd.New Delhi (2004).

10. Jag Mohan *Organic Spectroscopy: Principles and Applications*, Narosa Publishing House, New Delhi. (2004)
11. Sharma Y R; *Elementary Organic Spectroscopy-Principles and Chemical Applications*, S Chand and Co, New Delhi, (2007)
12. Morrison R.T. and Boyd R.N; *Organic Chemistry*, Prentice Hall, New Delhi.
13. Loudon G M; *Organic Chemistry*, Oxford, New York (2002)
14. Graham Solomons T.W., Fryhle C., *Organic Chemistry*, John Wiley, (2002).

Reference Books (Unit III):

1. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2005), 41st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Polymer Science , V.R.GowarikarN.V. Viswanathan & J. Sreedhar, New Age (1986)

Inorganic Chemistry-IV CHE-1602C21 (3 Credits)
Comparative study Gr. 3 to 13 Redox Chemistry chem.. of lanthanides, Nucl. Chem.

Unit I (15 h)

Comparative studies of Group 3 to 12, occurrence and extraction of elements, Ionic salts, Stoichiometric and non-stoichiometric oxides, trends in the acidic/ basic characteristic of oxides and hydroxides. Horizontal comparison in iron, cobalt and nickel groups.

Iso and heteropolyacids and their salts.

Tungsten bronzes.

Complex formation by transition metal ions in different oxidation states, colour, magnetic properties and catalytic properties.

Structure and uses of representative compounds of various transition elements.

Chemistry of platinum group elements, application of platinum group metals and their compounds in catalysis.

Unit II (15 h)

Redox potentials and electrochemical series, analysis of redox cycle, redox stability in water, Disproportionation, oxidation by atmospheric oxygen, presentation and use of redox potential data- Frost, Latimer and Pourbaix diagrams, pH dependence of redox and conditional Latimer diagrams, trends in stabilities of the oxidation states of metals.

Effect of complex formation on redox potentials and stabilization of oxidation states of transition metal ions in various complexes.

Inorganic complexes and compounds in catalysis: Ziegler-Natta catalyst, Hydrogenation of alkenes, Wacker process, Water gas shift reaction (oxo process).

Unit III (15 h)

Chemistry of lanthanide and actinide compounds, higher coordination number and complex formation, colour and absorption spectra, magnetic properties and their important applications.

Genesis of elements and extension of periodic table.

Szilard-Chalmers' separation process, separation of Neptunium and Plutonium from ${}_{92}\text{U}^{238}$, processing of spent fuel, extraction of U^{233} and Pu^{239} .

Application of radioactive elements and radioisotopes in agriculture, industries and clinical diagnosis. Preliminary concept of damage to DNA from nuclear radiations.

Metallurgy of Titanium, Zirconium, silver and gold. Powder metallurgy of Platinum.

Inorganic colours: pigment types, physical and chemical properties, choice of pigment, synthetic iron oxide, titania, colloidal gold, zircon, glaze stains.

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Lee J.D., (1991) Concise Inorganic Chemistry, 4th Edition, Chapman and Hall,
2. Emeleus H.J. and Sharpe A.G., (1994) Modern Aspects of Inorganic Chemistry, 4th Edition UBS
3. Banerjee D., (1993) Coordination Chemistry, Tata McGraw Hill
4. Cotton F.A. and Wilkinson G., (1988) Basic Inorganic Chemistry, Wiley Eastern.
5. Huheey J.E., (1983) Inorganic Chemistry: Principles of Inorganic Chemistry, 4th Edition, Harper-Collins

Books Recommended for Further Reading :

1. Cotton F.A. and Wilkinson G., Advanced Inorganic Chemistry, 1-6th Editions, Wiley Interscience (1962, 1966, 1972, 1980, 1988, 1999).
2. Housecroft C. E. & Sharpe A. G., Inorganic Chemistry, Prentice Hall (2004, 2005).
3. Purcell K.F. & Kotz J.C., Inorganic Chemistry, Holt-Saunders (1980).
4. Rodgers Glen E., Introduction to Coordination, Solid State and Descriptive Inorganic Chemistry, McGraw Hill Inc. (1994).
5. Atkins P., Overton T., Rourke J., Weller M. & Armstrong F., "Shriver and Atkins – Inorganic Chemistry" 4th Edition. Oxford University Press, Oxford (2006).

Organic Chemistry-IV CHE-1603C22 (3 Credits)
Natural products, drugs, dyes, pericyclic reactions, enolates

Unit I (15 h)

Chemistry of Natural Products: Terpenes: Classification and isolation, structure and synthesis of citral, geraniol and α -terpeniol, essential oils.

Alkaloids: Classification, isolation, physiological activity, and general characteristics, structure elucidation and synthesis of nicotine, coniine and papaverine.

Fats: Occurrence and composition of fats, saponification, general chemical properties of fats, hydrolysis, hardening of oil, rancidity, phosphoglycerides.

Unit II (15 h)

Drugs: Classification, methods of preparation and uses of Aspirin, mode of action, salol principle, true and partial salol, sulphanilamide, sulphathiazole, succinoyl sulphathiazole, mechanism of action of sulpha drugs.

Synthetic Dyes: Introduction, classification of dyes, colour and constitution, methods of preparation and uses of methyl orange, congo red, malachite green, crystal violet, phenolphthalein and fluorescein.

Unit III (15 h)

Pericyclic Reactions: Molecular orbitals of ethylene and 1,3-butadiene, and 1,3,5-hexatriene, Photochemical and thermal reactions, [2+2] and [4+2] cycloaddition reactions, the Diels-Alder reaction, electrocyclic reactions, Claisen rearrangement as a sigmatropic reaction, Photochemical reactions: Norrish type-I and type II reactions of carbonyl compounds.

Enolates in organic synthesis: Acidity of α -hydrogen, halogenation of ketones, aldol condensation, Claisen condensation, Wittig reaction, alkylation of diethyl malonate and ethyl acetoacetate and its application in organic synthesis.

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Morrison R.T., Boyd R.N.; Organic Chemistry, Prentice Hall of India, New Delhi (VI Ed).
2. Pine S.H; (1993) Organic Chemistry, McGraw Hill, New Delhi.
3. Loudon G M; (2002) Organic Chemistry, Oxford, New York.
4. Roberts J.D. and Caserio M.C., (1992) Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., California, USA.
5. Graham Solomons T.W. and Fryhle C., (2002) Organic Chemistry, John Wiley
6. Singh S.P. and Mukherjee S.M; (1984) Organic Chemistry, McMillan India.
7. Dyer J.R; (2005) Applications of Spectroscopy of Organic Compounds, Prentice Hall -India. New Delhi.
8. Silverstein R M, Webster F X and Kiemle D; 2005 Spectrometric Identification of Organic Compounds, John Wiley, New York.
9. Kalsi P.S; (2004) Spectroscopy of Organic Compounds, New Age International Ltd. New Delhi.
10. Jag Mohan, (2004) Organic Spectroscopy: Principles and Applications, Narosa Publishing House, New Delhi.
11. Sharma Y. R.; (2007) Elementary Organic Spectroscopy-Principles and Chemical Applications, S Chand and Co, New Delhi,
12. Finar I.L; (1982) Organic Chemistry, Vol 1 & 2, ELBS & Longman group
13. Arora M. G.; (1997) Stereochemistry in Organic Compounds, Anmol Publ. New Delhi
14. Chatwal G; (1985) Synthetic Dyes, Himalaya Publication Home

Physical Chemistry-III CHE-1604C23 (3 Credits)
Electrochem II, phase equilibrium –II, Photochemistry II

Unit I (15 h)

Electrochemistry II: Chemical and concentration cells with and without transference. Effect of temperature on cell voltage. Electrode polarization and overvoltage. Polarography and its applications. Amperometry and coulometry. Cyclic voltametry.

Corrosion: Definition, types, theories and mechanism for dry and wet corrosion, special types of corrosion. Chemical passivators and passivations. corrosion inhibitors.

Fuel cells: Principle, types and their functioning.

Unit II (15 h)

Phase equilibria II: Liquid - gas and liquid - liquid systems, Ideal/non-ideal liquids, Raoult's Law, Henry's Law, Fractional distillation of binary miscible liquids. Column efficiency, Azeotropes, Breaking of azeotropism, Lever rule, partial miscibility of liquids, lower and upper critical solution temperature, Immiscible liquid pairs, steam distillation.

Three component systems, triangular plots: Partially miscible three liquid systems.

(Formation of one, two and three immiscible pairs).

Colligative properties of dilute solution: Definition, types and importance of colligative property, van't Hoff factor.

Unit III (15 h)

Photochemistry: Photophysical and photochemical processes, Grothus-Draper law, Stark-Einstein's law of photochemical equivalence and quantum yield. Electronic excitation of molecules, Frank-Condon principle. Examples of low and high quantum yields.

Photostationary equilibrium. Photosensitization, Photochemical formation of HCl, HBr and HI and rate of photochemical reactions. Actinometry. Luminescence phenomenon: Timescales of photophysical processes, phosphorescence, fluorescence, chemluminescence. Quenching of fluorescence, Stern-Volmer equation. Photochemistry of stratospheric ozone, harvesting of light during plant photosynthesis, photochemistry of vision. Solar energy conversion.

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.

CHE-1605C24 Physical Chemistry-IV (2 Credits)
Chemical kinetics & catalysis

Unit I (15 h)

Chemical Kinetics I : Rates of chemical reactions, Rate laws, Order of reaction and Molecularity, factors affecting rate of reaction. Derivation of rate constants for zero, first and second order reactions. Methods of determination of order of chemical reactions. Arrhenius equation.

Catalysis I : Catalyst, inhibitor, autocatalysis. Catalytic activity, selectivity and stability.

Homogeneous and heterogeneous catalysis, General characteristics of catalytic reactions.

Theories of catalysis (Chemical theory and adsorption theory). Active sites. Applications of catalysts in industries.

Adsorption: Physisorption and Chemisorption and factors affecting adsorption, Freundlich and Langmuir Adsorption Isotherms. BET isotherm (No derivation). Applications.

Unit II (15 h)

Chemical Kinetics II: Elementary and complex reactions, Examples of parallel, opposing and consecutive reactions, rate determining step, steady state approximation. Derivation of rate laws of complex reactions (only first order). Arrhenius equation and concept of energy of activation. Collision theory and transition state theory (elementary treatment of reaction rates). Mechanism of unimolecular reactions. Fast reactions.

Catalysis II: Role of active sites in catalysis. Turn over number. Characterization of catalysts, Acid - base catalysis. Solid acid catalysts, Importance of selectivity, Enzyme catalysis. Catalysis in atmospheric pollution control. Applications of catalysts in industries.

Mode of transaction: Through Classroom lectures with models, charts, power point presentation and multimedia.

Reference Books:

1. Atkins P. and Paula J. D. (2006), Physical Chemistry, 8th Edition (International Student Edition) Oxford Univ. Press, New Delhi.
2. Glasstone, S. (1990), Text Book of Physical Chemistry, 2nd Edition Reprint, Macmillan and Co. Ltd., New York
3. Puri, B. R., Sharma, L.R. and Pathania, M. S. (2009), 44st Edition, Principles of Physical Chemistry, Vishal Publ. Co., Jalandhar
4. Bahl, B.S., Bahl A. and Tuli, G.D. (2007), Essentials of Physical Chemistry, 25th Edition, S. Chand, New Delhi.
5. Engel T. and Reid P. (2007), Physical Chemistry, Pearson Prentice Hall, Noida.
6. Mahan B. H. (2009), University Chemistry, 3rd Edition, Narosa Publishing House, New Delhi.

CHE-1606C25 Analytical Chemistry (2 Credits)
Separation methods & environmental chem.

Unit-I**Separation Methods and their importance in chemistry:**

Solvent Extraction: batch, continuous and counter current methods of solvent extraction, Solvent Extraction systems for inorganic species, effect of pH on such systems, important analytical and industrial applications.

Chromatography: Introduction, classification, principle of separation, terminology (stationary and mobile phases, retention time, retention volume, resolution, number of theoretical plates (N) and HETP).

Paper and thin layer chromatography- choice of adsorbent and solvent, factors affecting R_f values, development techniques, important applications.

Ion Exchange Chromatography- Principle, Choice of Resins and Applications

Liquid Chromatography and HPLC-Principle, Instrumentation and Applications

GC: Principle, instrumentation and applications.

Unit-II**Environmental Chemistry:**

Segments of the atmosphere, Air Pollutants and their effects- Green House Effect Ozone Depletion, Photochemical smog, Acid Rain and other effects, Air Sampling and Analysis of Sulphur dioxide, oxides of nitrogen, Suspended particulate matter, Respirable particulate matter, ozone, carbon monoxide, hydrocarbons and volatile organic compounds(BTX)

Water pollutants and their general effects. General methods of treatment of waste water, Techniques for measuring water pollution, Analysis of water pollutants

Reference Books

1. Willard, Hobert H. *et. al: Instrumental Methods of Analysis*, 7th Ed. Wordsworth Publishing Company, Belmont, California, USA, 1988.
2. Christian, Gary D; *Analytical Chemistry*, 6th Ed. New York- John Willy, 2004.
3. Khopkar, S.M. *Basic Concepts of Analytical Chemistry* New Age, International Publisher, 2009.
4. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Thomson Asia Pvt. Ltd. Singapore.
5. Mikes, O. & Chalmes, R.A. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Ltd. London.
6. Manahan S.E. (2005) *Environmental Chemistry*, CRC Press
7. De A.K., *Environmental Chemistry*, Wiley Eastern Ltd.

Semester V & VI (Practical Courses)

Courses CHE- Chemistry Practicals-V, VI, VII, VIII, IX and X CHE- CHE-1506C18, CHE-1507C19, CHE-1508E09, 1607C26, CHE-1608C27 and CHE-1609E10 **(with a total credit of 16) should cover the following course content:**

Physical Chemistry :

(15 experiments with at least 4 experiments of chemical kinetics from the list given below)

1. Potentiometric titration : strong acid – strong base
weak acid -- strong base
2. Conductometric titration: strong acid – strong base
weak acid -- strong base
weak acid -- weak base
3. Determination of Surface tension and Parachor of liquid.
4. Determination of composition of mixture of liquids by Viscometry.
5. Determination of composition of mixture of liquids by Refractometry.
6. Molecular weight by Victor Meyer's method.
7. Adsorption of oxalic acid on charcoal.
8. Determination of percentage of glucose/sucrose by polarimetry.
9. Dissociation constant of weak acid/base by pH metry.
10. Dissociation constant of weak acid/base by Conductometry.
11. Phase diagram of a two component solid-liquid system.
12. Kinetics of inversion of cane sugar by Polarimetry.
13. Kinetics of catalytic decomposition of H₂O₂.
14. Verification of Onsager equation for strong electrolyte by conductometry.
15. Kinetics of reaction between K₂S₂O₈ and KI
16. Kinetics of reaction between KBrO₃ and KI.
17. Kinetics of hydrolysis of methyl acetate by NaOH.
18. Kinetics of reaction between KMnO₄ and Oxalic acid.
19. Paper / Thin Layer Chromatography

Reference Books:

1. Shoemaker, D. P., Garland, C.W. and Nibler, J.W. (1996), Experiments in Physical Chemistry, McGraw Hill International Edition.
2. Findlay, A. (1972), Practical Physical Chemistry, 9th Edition, B.P. Levitt, Longman, London.
5. Athawale, V. D. and Mathur, P. (2001), Experimental Physical Chemistry, 1st Edition, New Age International Publication, New Delhi.
4. Yadav, J.B. (2003), Advanced Practical Physical Chemistry, Goel Pub., Meerut.

Inorganic Chemistry :**1. Quantitative analysis:**

- (1) Introduction to Gravimetric method of analysis and estimation of iron/ aluminium as oxide.
- (2) Separation of Binary mixtures of metal ions and their estimation by suitable combination of the following methods:
 - a. Gravimetric analysis
 - b. Alkalimetry
 - c. Redox titrations
 - d. Complexometric titrations
 - e. Argentimetry

The following ions will be quantitatively analysed:

Cations of : Ag(e), Al(a), Ba(a), Ca(a,b), Cr(c), Cu(c,d), Fe(a,c), Mg(a,d), Mn(c,d), Ni(a,d), Zn(a,d).
 Anions : Cl⁻(e), C₂O₄²⁻(a,b), NO₂⁻(c), SO₄²⁻(a) and S₂O₃²⁻(c).

Note: The letters in parenthesis indicate the method of analysis.

2. Qualitative analysis:

Introduction to and practice of semi- micro qualitative analysis and spot reactions with simple mixtures of ions.

Qualitative analysis of mixtures containing maximum six radicals including an ion of a rare element:

- (a) Cations of: Ag, Pb, Hg, Cu, Cd, Sn, Bi, As, Sb, Fe, Al, Cr, Co, Ni, Mn, Zn, Ca, Sr, Ba, Mg, Na and K. NH₄⁺.
- (b) Cations of rare elements: W, Mo, Ce, Ti, Th, Zr, U, V and Li.
- (c) Anions : Cl⁻, Br⁻, I⁻, NO₂⁻, NO₃⁻, S²⁻, SO₃²⁻, SO₄²⁻, CrO₄²⁻, Cr₂O₇²⁻, CO₃²⁻, PO₄³⁻.

3. Inorganic Preparations:

Synthesis and estimation of purity of fine chemicals (Any five).

4. Analysis of alloys:

Analysis of brass and stainless steel.

Reference Books :

1. Mendham J., Denney R C, Barnes J B, MJK Thomas, (2003) Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson Education, New Delhi.
2. Suehla G, (!989)Vogel's Qualitative Inorganic Analysis, 6th Edition, Orient Longman,
3. Shah R C, (1996)Inorganic Analysis Part-I, 5th Edition Baroda Book Depot, Vadodara
4. Shah R C, (1996)Inorganic Analysis Part-II R C Shah, 5th Edition, Baroda Book Depot, Vadodara
5. John Bassett (Editor) Vogel's Textbook of Quantitative Inorganic Analysis, Including Elementary Instrumental Analysis, 4th edition, Longman Science and Tech

Organic Chemistry :

1. Organic separation and identification of binary mixtures.: (acid/phenol/base/neutral)
 - i) Solid + Solid (6-7 mixtures).
 - ii) Liquid + Liquid (6-7 mixtures).
 - iii) Solid + Liquid (2-3 mixtures).
2. Organic Estimation:
 - i) Estimation of Aniline/ Phenol
 - ii) Estimation of Amide
 - iii) Estimation of Glucose
 - iv) Estimation of Ester
3. Organic Preparation (One stage preparation): (atleast five)
 - i) 7-Hydroxy-4-methyl coumarin from resorcinol
 - ii) p-Bromo acetanilide from acetanilide
 - iii) Acetyl salicylic acid from salicylic acid (Aspirin)
 - iv) Cinnamic acid from benzaldehyde
 - v) 1,4-Diacetoxy benzene from hydroquinone
 - vi) m-Nitroaniline from m-dinitrobenzene
 - vii) 1-Phenylazonaphthol from β -naphthol

Reference Books:

1. Shah R.C., Organic Analysis (Qualitative) – (Part I & Part II), Baroda Book Depot, Vadodara.
2. Shah R.C., Organic Analysis (Quantitative) – (Part III), Baroda Book Depot, Vadodara
3. Jag Mohan, (1992) Advanced Practical Organic Chemistry (Qualitative Analysis), Vol. I & II, 1st Edition, Himalaya Publishing House.
4. Laboratory Manual of Organic Chemistry – R.K. Bansal, New Age International Publishers. New Delhi.
5. Ahluwalia V.K. and Dhingra S. (2000), Comprehensive Practical Organic Chemistry- Qualitative Analysis, Univerities Press, Hyderabad.
6. Ahluwalia V.K. and Aggrawal R. (2000) Comprehensive Practical Organic Chemistry-Preparation and Quantitative Analysis, Univerities Press, Hyderabad.
7. Furniss B.S., Hannaford A. J., Smith P.W.G. and Tatchell A.R., (2006) Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Pearson Education, New Delhi
8. Mann F.G. and Saunders B.C. (2006), Practical Organic Chemistry, 4th Edition, Pearson Education, New Delhi.