

**SYLLABUS OF  
MASTER IN SCIENCE (CHEMISTRY)**

**w.e.f. the  
Academic Session  
2023-24.(CBCS)**

**D.D University**

**P.G. DEPARTMENT OF CHEMISTRY**

**D.D. UNIVERSITY, KEONJHAR**

**PGDEPARTMENT OF CHEMISTRY****[Structural Organisation of CBCS syllabus]****FIRST SEMESTER**

Course code	Title of the paper	Credits	Max. Marks		Total
			End-Sem.	Mid-Sem.	
CHEM-C-101	Physical Chemistry-I	04	80	20	100
CHEM-C-102	Inorganic Chemistry-I	04	80	20	100
CHEM-C-103	Organic Chemistry-I	04	80	20	100
CHEM-C-104	Analytical Chemistry-I	04	80	20	100
CHEM-P-105	Inorganic Practical-I	03	50	-	50
CHEM-P-106	Organic Practical-I	03	50	-	50
	<b>Total</b>	<b>22</b>	<b>420</b>	<b>80</b>	<b>500</b>

**SECOND SEMESTER**

Course code	Title of the paper	Credits	Max. Marks		Total
			End-Sem.	Mid-Sem.	
CHEM-C-201	Organic Chemistry-II	04	80	20	100
CHEM-C-202	Inorganic Chemistry-II	04	80	20	100
CHEM-C-203	Physical Chemistry-II	04	80	20	100
CHEM-C-204	Analytical Chemistry-II	04	80	20	100
CHEM-P-205	Inorganic Practical-II	03	50	-	50
CHEM-P-206	Organic Practical-II	03	50	-	50
CHEM VAC 1					
	<b>Total</b>	<b>22</b>	<b>420</b>	<b>80</b>	<b>500</b>

**THIRD SEMESTER**

Course code	Title of the paper	Credits	Max. Marks		Total
			End-Sem.	Mid-Sem.	
CHEM-C-301	Inorganic Chemistry-III	04	80	20	100
CHEM-C-302	Organic Chemistry-III	04	80	20	100
CHEM-C-303	Research Methodology	04	80	20	100
CHEM-E-304	Elective-I	04	80	20	100
CHEM-P-305	Physical Practical-I	03	50	-	50
CHEM-P-306	Polymer Practical-I	03	50	-	50
CHEM VAC 2					
	<b>Total</b>	<b>22</b>	<b>420</b>	<b>80</b>	<b>500</b>

**FOURTH SEMESTER**

Course code	Title of the paper	Credits	Max. Marks		Total
			End-Sem.	Mid-Sem.	
CHEM-C-401	Organic Chemistry-IV	04	80	20	100
CHEM-C-402	Inorganic Chemistry-IV	04	80	20	100
CHEM-E-403	Elective-II	04	80	20	100
CHEM-D-404	Dissertation Course/Project	04	100	-	100
CHEM-P-405	Physical Practical-II	03	50	-	50
CHEM-P-406	Analytical Practical	03	50	-	50
	<b>Total</b>	<b>22</b>	<b>440</b>	<b>60</b>	<b>500</b>

**Grand Total:****88 Credits****2000 Marks****Note: i. CHEM-C- Compulsory Core Course for all students of the subject concern.****ii. CHEM-E- Elective Course (Students have to opt any one paper in semester-III & IV).**

iii. CHEM-D- Dissertation Course/Project

iv. CHEM VAC- Value Added Course

**FIRST SEMESTER**  
**CC-101, PHYSICAL CHEMISTRY-I**

**Unit-I, Quantum Mechanics and its Applications:-**

Operators, addition, subtraction and multiplication of operators, linear operators, commutator vector operator, Laplacian operator, Eigen functions and Eigen values, Hermitian and unitary operators, step up step down operators, angular momentum in many electron atoms, MO-VB Theory, Born-Oppenheimer approximation, hydrogen molecule ion, LCAO-MO and VB treatments of hydrogen molecule, electron density, foreses and their role in chemical bonding, hybridisation and valency MOs of  $H_2O$ ,  $NH_3$  and  $CH_4$ , Huckel pi-electron theory and its application to ethylene, butadiene and benzene.

**Unit-II, Classical Thermodynamics**

Brief resume of concepts of law of thermodynamics, free energy, chemical potential and entropies, Partial molar properties, partial molar free energy, partial molar volume and partial molar heat content and their significances, Determination of these quantities, Concept of fugacity and determination of these quantities, Concept of fugacity and determination of fugacity Non-ideal system Excess functions for non-ideal solutions, Activity, Activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic coefficient, Debye – Huckel theory for activity coefficient of electrolytic solutions, Determination of activity and activity coefficients, ionic strength Application of phase rule to three components systems, Second order phase transitions

**Unit III, Statistical Thermodynamics**

Thermodynamic probability and entropy, Maxwell-Boltzmann, Einstein and Fermi-Dirac statistics, Energy and pressure of a Fermi gas, partition functions, rotational, translational, vibrational and electronic partition functions for diatomic molecules, calculation of thermodynamic functions and equilibrium constants, theories of specific heat of solids.

**Unit-IV Chemical Kinetics**

Complex reactions, consecutive and parallel first order reaction, opposing reactions, General treatment of chain reactions, activation energy, Chain length, Chain transfer, inhibition, Rice-Herzfeld mechanism for organic molecule decomposition, Preliminary idea of study of fast reactions by flow and relaxation methods. Flash photolysis. General acid - base

CBCS Syllabus of PG-Department of Chemistry, DD University  
catalysis. Homogeneous catalysis, Salteffects. Theories of reaction rates, Collision and  
absolute rate theory, unimolecularreaction-Llndermantheory.

**BooksRecommended:**

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1. Physical Chemistry, P.W. Atkins, ELBS
2. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
3. Quantum Chemistry, Ira N. Levine, ELBS
4. Coulson's Valence, R. McWeeny, ELBS
5. Chemical Kinetics, K.J. Laidler, McGraw Hill.
6. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman and J. Kuriacose, McMillan.
7. Micelles, Theoretical and Applied Aspects, V. Mori, Plenum
8. Modern Electrochemistry, Vol. I and II, J.O.M. Bockris and A.K.N. Reddy, Plenum.

### **C.C-102, INORGANIC CHEMISTRY-I**

#### **Unit-I, Symmetry and Group Theory;**

Symmetry elements and operations, definition of group, subgroup, relation between orders of a finite group and its sub group, conjugacy relation and classes of point group, Schoenflies symbols, representations of groups by matrices (representation for  $C_n, C_{nv}, C_{nh}, D_{nh}$  etc groups worked out explicitly), character table of a representation, the great orthogonality theorem (proof not necessary) and its importance, use of character table.

#### **Unit-II, Chemical Bonding and Reagents;**

LCAO method, chemical bonding in poly atomic molecules, directed valence, hybridization and geometry, simple Huckel theory of linear conjugated systems (ethylene, allyl and butadiene), cyclic conjugated systems; aromaticity, self-consistent field method, valence state ionisation potentials, metallic bonding, band theory, semiconductors and insulators.

#### **Unit-III, Bioinorganic Chemistry;**

Molecular mechanism of ion-transport across membranes, ionophores, photosynthesis, nitrogen fixation, oxygen uptake proteins, cytochromes and Ferredoxins,

#### **General treatment of metal clusters;**

Electron count and structure, Wade's rule, Isolobality, Synthesis, Reactions

#### **Unit-IV, Reaction of Metal Complexes;**



Energy of a reaction, thermodynamic and kinetic stability of metal complexes, kinetic application of valence bond and crystal field theories.

**Metal-ligand equilibrium in solution;**

Stepwise and overall formation constants and their interrelation, trends in stepwise constants, factors affecting the stability of metal complexed with reference to nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by  $p^H$ -metry, spectrophotometry, Job's method of continuous variation

**Books Recommended.**

1. Advanced inorganic Chemistry- Cotton and Wilkinson,; John Wiley
2. Inorganic Chemistry- J.E. Huhey; Harper & Row
3. Mechanism of Inorganic Reactions- F. Basolo and R.G. Person
4. Reaction Mechanism of Inorganic & Organic System – R.B. Jordan; Oxford Univ. Press
5. Concept & Model of Inorganic Chemistry – Douglas, Mc. Daniel and Alexander John Wiley & Sons.
6. Inorganic Chemistry- K.F. Purcel & J.C. Kotz.
7. Advanced Inorganic Chemistry- Satya Prakash.

**C.C-103. ORGANIC CHEMISTRY-I**

**Unit-I, Nucleophilic substitution Reaction:**

The  $SN^2$ ,  $SN^1$  and mixed mechanisms  $S_Ni$  mechanism, the neighbouring group mechanism, neighbouring group participation by pi and sigma bonds, classical and non – classical carbonations, phenonium ions, norbornyl system; substitution at allylic, aliphatic trigonal, vinylic carbon and aromatic substrates; Nucleophilicity, ambident nucleophiles and ambident substrates, Regiospecificity. Effect of substrate structure, attacking nucleophile, levelling group and reaction medium upon reactivity and mechanism.

**Unit-II, Electrophilic substitution Reaction;**

Electrophilic substitution reactions, the  $S_E1$ ,  $S_E2$  and  $S_Ei$  mechanism, electrophilic substitution accompanied by double bond shift; effect of substrates, leaving group and the solvent polarity on the reactivity; substitution on aromatic substrates, the arenium ion mechanism, orientation and reactivity, quantitative treatment of reactivity in substrate and electrophiles, diazonium coupling.

**Unit-III, Pericyclic Reaction**

CBCS Syllabus of PG-Department of Chemistry, DD University  
Molecularorbital symmetry; frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene, classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams, FMO approach, electrocyclic reactions, conrotatory-antarafacial and suprafacial additions,  $4n$  and  $4n+2$  systems,  $2+2$  addition of ketenes, 1,3-dipolar cycloadditions, sigmatropic rearrangements, suprafacial and antarafacial shifts of H, Sigmatropic shifts involving carbon molecules- 3, 3- and 5,5-sigmatropic rearrangements, Claisen & Cope reaction.

#### **Unit-IV, Photochemistry;**

Principles, Thermal and photochemical reactions, Law of photochemistry-grothus-Draper Law, Stark-Einstein law, Quantum yield, singlet and triplet state, Jablonsky diagram, fluorescence, phosphorescence, flash photolysis. Photochemical reactions and mechanism of carbonyl compounds, Norrish type-I and type-II reactions, Paterno-Buchi reactions, photoreduction, photodimerization, photorearrangement of cyclohexadienones, photochemistry of olefins and conjugated olefins.

#### **Books Recommended**

1. Pericyclic Reactions-Ian Fleming; Oxford University Press.
2. Conservation of Orbit Symmetry-A.J. Bellamy, Longman.
3. Pericyclic Reactions-S.M. Mukharjee, Macmillan.
4. Advanced Organic Chemistry-Jerry March, John Wiley.
5. Advanced Organic Chemistry-F.A. Carey and R.J. Sundberg, Plenum
6. A Guide Book to Mechanism in Organic Chemistry-Petersykes, Longman
7. Reaction Mechanism in Organic Chemistry-S.M. Mukharjee & S.P. Singh & S.K. Bhattacharjee Macmillan.
8. Organic Chemistry-R.T. Morrison, R.N. Boyd, Macmillan-prentice-Hall
9. Mechanism & Theory in Organic Chemistry-Theomas H. Lawer and K.S. Richardson-Addison Wesley.
10. Reactions, Rearrangements and Reagents-S.N. Sanyal, Bharati Bhawan.
11. Photochemistry and pericyclic Reaction-Jagadama Singh & Jaya Singh & Jaya Singh-New Age International.



**C.C-104 ANALYTICAL CHEMISTRY-I**

**Unit-I, UV-Visible Spectroscopy:-**

- A. Electromagnetic radiations, features of spectra of spectrum, spectral range and characteristic of different radiations.
- B. Beer-Lambert's law, molar extinction coefficient, Instrumentation, Analysis UV spectra, types of electronic transitions, Concept of chromophores and auxochromes; bathochromic; hypsochromic; hyperchromic and hypochromic shifts. Effect of conjugation and effect of solvent. UV spectra of conjugated enes and enones, determination of  $\lambda_{\max}$  by the application of Woodward-Fieser rule.

**Unit-II, IR Spectroscopy:-**

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, variation of vibrational frequency with force constant and relative masses of the bonded atoms, vibration poly atomic molecule, degree of freedom, selection rules, normal modes of vibration of polyatomic molecule, degree of freedom, selection rule, normal modes of vibrations, overtones and combination of bands. Instrumentation (double-beam spectrophotometer). Frequency shifts by change of phase and solvents. Finger print region, Spectral features of major functional groups and interpretation of IR spectra. Applications of IR spectroscopy.

**Unit-III, Mass Spectroscopy:-**

Basic principles, theory, instrumentation, limitation and modification, the molecular ion or parent ion, determination of molecular formula, McLafferty's rearrangement, Metastable ions or peaks, the nitrogen rule, important features of the mass spectra of hydrocarbon, olefins, cycloalkanes, cycloalkenes, cycloalkynes, aromatic hydrocarbons, alcohols, aromatic alcohols, phenols, aliphatic aldehydes and ketones, carboxylic acid, amines, halogen compounds, nitro compounds, esters.

**Unit-IV, X-Ray Diffraction:-**

Theory of X-ray diffraction, diffraction of X-ray by crystals, determination of crystal structure (powder as well as single crystal), Instrumentation, determination of lattice parameters, X-ray intensity calculations and application of X-ray.

**Books Recommended**

1. Application of absorption spectroscopy of organic compound - J.R. Dyer.
2. Fundamentals of molecular spectroscopy - Banwell.
3. Organic spectroscopy - Kemp.
4. Organic spectroscopy - Jag Mohan.

5. Spectroscopy of Organic Compounds-P.S.Kalsi.
6. Basic principle of analytical chemistry- S.M.Khopkar.
7. Analytical Chemistry (theory & practical)-U.N.Dash.
8. Organic Chemistry-Morrison, Boyd and Bhattacharjee.
9. Organic Chemistry-McMurry.
10. Instrumental Methods of Chemical Analysis-Gurdeep R. Chatwal, S.K. Anand.

**CC-105 INORGANIC CHEMISTRY PRACTICAL-I**

Analysis of an inorganic mixture containing not more than six radicals. The mixture will include less common metal ions like Mo, W, Ti and V; insoluble like oxides, sulphates, halides and other interfering radicals (Organic radicals are excluded).

**Books recommended**

1. Inorganic Experiments, J. Derck Woollins., VCH
2. Microscale Inorganic Chemistry, Z. Szafran, R.M. Pike and M.M. Singh, Wiley.
3. Practical Inorganic Chemistry, G. Marrand B.W. Rockett, Van Nostrand.
4. An Advanced Course of Practical Chemistry, Nad, Ghosal & Mahapatra, Central Publisher (2000).
5. Vogel's Qualitative Inorganic Analysis, 7<sup>th</sup> Ed. Revised by G. Svehela, 4<sup>th</sup> Ed, Person (2007).

**CC-106 ORGANIC CHEMISTRY PRACTICAL-I**

**Qualitative Analysis**

Identification of unknown organic compounds, Preparation of derivatives.

Identification of multi-

functional compounds in a mixture of two organic compounds.

**Books Recommended for practical Organic Chemistry**

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson, & M. Miller, Prantic eHall
2. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
3. Handbook of Practical Organic Analysis, Qualitative & Quantitative, M.T. Clarke, Edward Arnold (Publisher).
4. Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell Wiley.
5. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath.
6. A Text Book of Practical Chemistry (Qualitative). Arthur I. Vogel.

**SECOND SEMESTER**

**C.C-201, ORGANIC CHEMISTRY-II**

**Unit-I, Stereochemistry:-**

Conformational analysis of mono substituted and disubstituted cyclohexane, conformation and chemical reactivity of cyclohexanes, optical activity in the absence of asymmetric atoms (allenes, spiranes, biphenyls), prochirality, enantiotropic and diastereotopic groups, asymmetric synthesis, Sharpless asymmetric epoxidation, R and E-Z conventions, erythro and threo isomers, stereospecific and stereoselective synthesis, interconversion of E and Z isomers.

**Unit-II, Addition Reactions**

Electrophilic Addition:-

Structure orientation and regioselectivity rearrangement, stereochemistry, acid catalysed hydration and related addition reaction, Electrophilic Addition involving metal cations, hydroxylation of alkenes. Nucleophilic Addition to carbonyl compound and nitriles, Michael Addition reaction.

**Unit-III, Elimination Reactions**

$E_1$ ,  $E_2$  and  $E_1cB$  mechanism, Orientation of the double bond- Saytzeff and Hoffmann rule, Effect of substrate structure, attacking base, leaving group and the medium, pyrolytic eliminations. Cleavage of quaternary ammonium hydroxide.

**Unit-IV, Rearrangements and reactions;**

Pinacol-

Pinacolone, Demjanov, Favorskii, Arndt-Eistert synthesis, Neber, Backmann, Hoffman, Curtius, Schmidt, Baeyer-Villiger, Stobbe condensation, Wittig reaction

**Reagents in organic synthesis;**

DDQ, Dicyclohexylcarbodiimide, 1,3-

Dithiane, Gillman's reagent, Osmium tetroxide, selenium dioxide, Wilkinson's catalyst, phase transfer catalyst, crown ether, PCC, LTA, Ziegler-Natta catalyst.

**Books Recommended**

1. pericyclic Reaction- Ian Fleming; Oxford University Press
2. Conservation of Orbital Symmetry- A.J. Bellamy, Longman.
3. Pericyclic Reactions- S.M. Mukharjee, Macmillan.
4. Advanced Organic Chemistry- Jerry March, John Wiley.
5. Advanced Organic Chemistry- F.A. Carey and R.J. Sundberg, Plenum.
6. A Guide Book to Mechanism in Organic Chemistry- S.M. Mukharjee & S.P. Singh & S.K. Bhattacharjee Macmillan.
7. Reaction Mechanism in Organic Chemistry- S.M. Mukharjee & S.P. Singh & S.K. Bhattacharjee Macmillan.
8. Organic Chemistry- R.T. Morrison, R.N. Boyd, Macmillan- Prentice-Hall.



9. Mechanism & Theory in Organic Chemistry – Thomas H. Lowry and K. S. Richardson – Addison Wesley.
10. Reactions, Rearrangements and Reagents – S. N. Sanyal, Bharati Bhawan.
11. Photochemistry and pericyclic Reaction – Jagadama Singh & Jaya Singh – New Age International.
12. Organic Reactions and their mechanisms – P. S. Kalsi, New Age International.

### **CC-202, INORGANIC CHEMISTRY-II**

#### **Unit I, Metal- Ligand Bonding**

Crystal field Theory and its limitations, Elementary idea of Angular overlap model, Molecular orbital theory for octahedral, tetrahedral and square planar complexes,  $\sigma$  and  $\pi$ -bonding in molecular orbital theory.

#### **Unit II, Electronic Spectra and Magnetic properties of Transition Metal Complexes.**

Spectroscopic ground states, correlation, Orgel and Tanabe- Sugano diagrams for transition metal complexes ( $d^1$ – $d^9$  states), calculations of  $Dq$ ,  $B$  and  $\beta$  parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereo- chemical information, anomalous magnetic moments, magnetic exchanges coupling and spin crossover.

#### **Unit III, Metal $\pi$ -Complexes**

Metal Carbonyls, Structure and bonding, Vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls, preparation, bonding, structure and important reactions of transition metal nitrosyls, dinitrogen and dioxygen complexes, tertiary phosphine as ligands.

#### **Unit-IV, Lanthanides and Actinides;**

Lanthanide contraction, Comparative study: General characteristics, oxidation state, magnetic and spectral properties, separation by ion-exchange method.

#### **Books Recommended:**

1. Advanced Inorganic Chemistry, F. A. Cotton, M. A. Murillo, G. Wilkinson, 6<sup>th</sup> Ed. Wiley India (2007).
2. Inorganic Chemistry, J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 4<sup>th</sup> Ed., Pearson Education (2006).
3. Chemistry of the Elements, N. B. Greenwood and A. Earnshaw, Pergamon.
4. Inorganic Electronic Spectroscopy, A. B. P. Lever, Elsevier.
5. Magnetochemistry, R. L. Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry eds., G. Wilkinson, R. D. Gillies and J. A. McClenerty, Pergamon.

7. Elements of MagnetoChemistry, R.L. Dutta, A. Syamal; 2<sup>nd</sup> Ed. East West Press Pvt Ltd. (2009).
8. Fundamental Concepts of Inorganic Chemistry, Vol. 5; Asim K. Das, CBS Publisher. (2015).
9. Fundamental Concepts of Inorganic Chemistry, Vol. 6; Asim K. Das, CBS Publisher, 2<sup>nd</sup> Ed (2013).
10. Organometallic Chemistry, R.C. Mehrotra & A. Singh, New Age International, 2<sup>nd</sup> Ed (2013).
11. Inorganic Chemistry, C.L. Miessler, D.A. Taff, Pearson, 3<sup>rd</sup> Ed. 2004.

**CC203, PHYSICAL CHEMISTRY-II**

**Unit I Kinetic Theory of Gases**

Maxwell distribution law of velocities, Transport properties, mean free path, viscosity, thermal conductivity and diffusion, Maxwell-Boltzmann distribution law, Joule-

Thomson effect and production of low temperature, determination of Avogadro's number by vertical distribution and lateral distribution of particles in a medium.

**Unit II Surface Chemistry-**

**I Adsorption**

Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, catalytic activity at surfaces estimation of surface area (BET equation), Surface catalysed oxidation of Co to CO<sub>2</sub>, surface films on liquids surface equation of state and its application, Electro-kinetic phenomenon.

**Unit III Surface Chemistry -II**

Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC)/ Kraft

temperature, factors affecting the CMC of surfactants, Counterion binding to micelles, the thermodynamics of micellization-

phase separation and mass action model, solubilisation, microemulsion, reverse micelles.

**Unit IV Electrochemistry**

Electrochemistry of solutions. Debye-Huckel-

Onsager treatment and its extension, ion-solvent interactions. Debye-Huckel-

Bjerrum model. Solution of strong electrolytes. Debye-

Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength.

Thermodynamics of electrified interface. Derivation of electro-capillarity, Lippman equations (surface excess), methods of determination. Structure of electrified interfaces, Helmholtz-Perrin, Guoy-Chapman, Stern models.

Over potentiaks, exchange current density, derivation of Butler- Volmer equation, Tafel plot. Polarography theory, Ilkovic equation; half wave potential and its significance, cyclic voltametry. Introduction to corrosion, homogeneous theory, forms of corrosion, corrosion monitoring and prevention methods.

**Books Recommended**

1. Physical Chemistry, P.W. Atkins and J.D. Paulo, Oxford, 2013, 10<sup>th</sup> edition New Delhi.
2. Physical Chemistry, T. Engle and P. Reid, Pearson, 2006, 1<sup>st</sup> edition, New Delhi.
3. Physical Chemistry of the surfaces, A.W. Adamson and A.P. Gast, John Wiley, 6<sup>th</sup> edition, 1997, New York.
4. Adsorption and Catalysis, D.K. Chakraborty, 1<sup>st</sup> edition, 1992, Narosa, New Delhi.
5. Surfactants and polymers in aqueous solution, Krister Homberg, Bo Jonsson, Bengt Kronberg and Björn Lindman, 2002, John Wiley, Sussex.
6. Surfactants and interfacial phenomena, M.J. Rosen, John Wiley 2<sup>nd</sup> edition, New Jersey.
7. Chemical Kinetics, K.J. Laidler, McGraw-Hill.
8. Kinetic and Mechanism of Chemical Transformations, J. Rajaraman and J. Kuriacose, McMillan.
9. Modern Electrochemistry Vol. I and Vol. II. J.O.M. Bockris and A.K. N. Reddy, Plenum, 3<sup>rd</sup> edition, 1997, London.
10. Fast Reaction - D.N. Hauge
11. Chemical Kinetic and Dynamics - 2<sup>nd</sup> Edn., J. Steinfeld, J.S. Francisco, W.L. Hase, Butterworths (1999).
12. Physical Chemistry, G.K. Vemulapalli, Prentice Hall of India Pvt. Ltd., 1993, New Delhi.
13. Physical Chemistry, George Woodbury, Books/Cole Publishing, 1997, Pacific Grove, USA.

**C.C-204, ANALYTICAL CHEMISTRY-II**

**Unit-I, NMR and  $C^{13}$  NMR:-**

Introduction, basic principle of NMR, Relaxation process, No. of signals, position of signals (chemical shift), factors influencing chemical shift, shielding and deshielding of protons, splitting of signals, spin-spin coupling, calculation the ratio in the height of the signals, coupling constant (J), chemical exchange, NMR spectra of phenylacetylene, n-propanol, m-cresol, isopropyl bromide, acetaldehyde, alpha-bromobutanoic acid, important features of NMR spectroscopy, advantages and limitations of NMR spectroscopy. Applications of NMR spectroscopy.  $C^{13}$  NMR spectroscopy, sensitivity of  $C^{13}$  NMR spectra, chemical shift in  $C^{13}$  NMR, NMR spectra of carbonations.

**Unit-II**

(a) ESR Spectroscopy:-

Introduction, comparison between NMR and ESR, Theory of ESR, Instrumentation, Presentation of ESR spectrum, Hyperfine splitting,

determination of g-

value, linewidth, ENDOR (electron nuclear double resonance), Application of ESR.

(b) Raman Spectroscopy:- Introduction, Theory of Raman Spectroscopy, Stokes and anti-Stokes lines, conditions for Raman spectroscopy, Equivalence of Beer Lambert's law of absorption in Raman scattering, Raman spectra of diatomic molecules, rotational-vibrational Raman spectra, Importance of Raman spectra, IR and Raman spectra are complementary, vibrational Raman spectra of polyatomic molecules. Application of Raman spectroscopy.

### **Unit-III, Chromatographic separation Methods:-**

Chromatographic techniques: Classification, basic principles, theory of chromatography.

- A. Ion Exchange Chromatography:- Ion exchange process, synthesis and structure of ion-exchangers, resin, resolution, retention parameters, selectivity, ion exchange capacity and separation of lanthanides.
- B. Paper and Thin-layer Chromatography:- Stationary and mobile phases; various techniques of development, visualization and evaluation of chromatograms, separation of inorganic compounds.
- C. Liquid-gas Chromatography:- Introduction, methodology, instrumentation and industrial applications.

### **Unit IV, Thermal Methods:-**

Theory, instrumentation and applications of:- (1). Thermo Gravimetric Analysis (TGA), (2). Differential Thermal Analysis (DTA), (3). Differential Scanning Calorimetry (DSC)

#### **Books Recommended**

1. Application of absorption spectroscopy of organic compound - J.R. Dyer.
2. Fundamentals of molecular spectroscopy - Banwell
3. Organic spectroscopy - Kemp.
4. Organic spectroscopy - Jag Mohan
5. Spectroscopy of Organic Compounds - P.S. Kalsi
6. Basic principles of analytical chemistry - S.M. Khopkar
7. Analytical Chemistry (theory & practical) - U.N. Dash
8. Organic Chemistry - Morrison, Boyd and Bhattacharjee.
9. Organic Chemistry - McMurry.
10. Instrumental Methods of Chemical Analysis - Gurdeep R. Chatwal, S.K. Anand



**CC-205. INORGANIC PRACTICAL-II**

- 1) Preparation of the following inorganic compounds.
  - i) Potassium chromioxalate,  $K_2[Cr(C_2O_4)_3]$
  - ii) Tetraammine cupric sulphate,  $Cu[(NH_3)_4]SO_4 \cdot H_2O$
- 2) Determination of total manganese in pyrolusite.
- 3) Determination of percentage of copper present in the given sample of bronze
- 4) Estimation of Cu in a given solution prepared from a sample of

**brass. Books Recommended**

1. Vogel's Textbook of Qualitative Chemical Analysis; J. Mendan, R. C. Denney, J. D. Barnes, N. J. K. Thomas; person, 6<sup>th</sup> Ed (2007).
2. A Text Book of Macro and semi-micro Qualitative Inorganic Analysis; Arthur I. Vogel., orient. L. ongman, 1<sup>st</sup> Ed. (1975).

**C.C-206, ORGANIC CHEMISTRY PRACTICAL-II**

**Organic Synthesis**

Preparation of following organic compounds.

- a) Anthranilic acid
- b) Methyl Orange
- c) *p*-Chlorotolunefrom *p*-toluidine (Sandmeyer reaction)
- d) *p*-Iodotolunefrom *p*-toluidine (Sandmeyer reaction)
- e) Ethylacetoacetate
- f) Aspirin
- g) Benzil
- h) Phthalimide

**Quantitative Analysis**

- (a) Estimation of Phenols using bromate bromide solution.
- (b) Estimation of Anilines using bromate bromide solution.
- (c) Determination of Saponification values of an oil sample.
- (d) Estimation of Nitrogen by Kjeldahl's method.

**Books Recommended**

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson, & M. Miller, Prantic eHall
2. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
3. Handbook of Organic Analysis, Qualitative & Quantitative, M. T. Clarke, Edward Arnold (Publisher).
4. Vogel's Text Book of practical Organic Chemistry, A. R. Tatchell, John Wiley.



6. A Text Book of Practical Organic Chemistry (Qualitative). Arthur I. Vogel.

### THIRD SEMESTER

#### CC-301, BIOINORGANIC & ANALYTICAL CHEMISTRY

##### **Unit I, Metal Ions in Biological Systems and their Storage and Transport**

Essential trace elements, Ferritin, transferrin, and siderophores.

##### **Calcium in Biology**

Transported regulation, Intracellular  $\text{Ca}^{2+}$  transport,  $\text{Ca}^{+}$  ATPase,  $\text{Na}^{+} / \text{Ca}^{+}$  exchange, mitochondrial influx and inositol triphosphate,  $\text{Ca}^{+}$  regulated intracellular processes: Calmodulin, Troponin C.

##### **Metalloenzymes**

Iron enzymes – catalase peroxidase and cytochromes, Cyt-p450  
Copper enzymes- Superoxide dismutase Molybdenum oxotransferase. Enzymes- Xanthine oxidase. (Coenzyme vitamin B<sub>12</sub>.

##### **Sulphur proteins) Unit II Transport and Storage of Dioxygen**

Hemeproteins and oxygen uptake, structure and function of haemoglobin, myoglobin, hemoeyanins and hemerthrin, model synthetic complexes of iron, cobalt and copper

##### **Unit III Analytical Chemistry**

**Atomic absorption spectroscopy-** Principle, difference between atomic absorption spectroscopy and flame emission spectroscopy, advantages of atomic absorption spectroscopy, instrumentation, detection limit and sensitivity.

##### **Unit IV, Fluorimetry and Phosphorimetry**

Instrumentation, comparison of fluorimetry and phosphorimetry, some fluorimetric applications and some phosphorimetric applications.

##### **Books Recommended**

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg., University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valente, University Science Books.
3. Inorganic Biochemistry vols I and II ed. G.L. Eichhorn, Elsevier
4. Progress in Inorganic Chemistry, Vols 18 and 38 ed J.J. Lippard, Wiley
5. Bioinorganic Chemistry, Asim K. Das, Books and Allied, 2<sup>nd</sup> Ed (2007).
6. Analytical Chemistry, Skoog and West.
7. Analytical Chemistry, S.M. Khopkar.
8. Instrumental Analysis, Willard, Merit & Dean.

**C.C-302, PHOTOCHEMISTRY**

**Unit I Photochemical Reactions**

Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

**Determination of Reaction Mechanism**

Classification, rate constants and lifetimes of reactive energy states - determination of rate constants of reaction. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions - photo-dissociation, gas-phase photolysis.

**Unit II Photochemistry of Alkenes**

Intermolecular reactions of the olefinic bond - geometrical isomerism, cyclization reactions, rearrangement of 1,4- and 1,5-dienes.

**Photochemistry of Carbonyl Compounds**

Intermolecular reactions of carbonyl compounds - saturated, cyclic and acyclic  $\beta$ ,  $\gamma$  unsaturated and  $\alpha$ ,  $\beta$ -unsaturated compounds. Cyclohexadienones.

**Unit III Photochemistry of Aromatic Compounds**

Isomerisations, additions and substitutions

**Unit IV Miscellaneous Photochemical Reactions**

Photo-Fries reaction of anilides. Photo-Fries rearrangement. Barton reaction. Singlet molecular oxygen reactions. Photochemical formation of smog. Photodegradation of polymers. Photochemistry of vision.

**Books recommended:**

1. Fundamentals of photochemistry, K.K. Rohtagi - Mukharji, Wiley-Eastern.
2. Molecular photochemistry, N.J. Turro, W.A. Benjamin.
3. Introductory photochemistry, A. Cox and T. Camp. McGraw-Hill.
4. Photochemistry, R.P. Kundall and A. Gibert, Thomson Nelson.
5. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.

**CC-303. PHYSICAL CHEMISTRY PRACTICAL-I**

- 1) Determine the rate constant of acid hydrolysis/base hydrolysis of ester.
- 2) Conductometric titration of strong acid with strong base, weak acid with strong base, mixture of strong acid and weak acid with strong base
- 3) Potentiometric titration of strong acid with strong base
- 4) Study of inversion of cane sugar in acid medium by polarimetry.

**Books Recommended**

1. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
2. Findley's practical Physical Chemistry, B.P. Levitt, Longman.



**CC-304 POLYMER CHEMISTRY PRACTICAL**

1. Synthesis of polymethylmethacrylate by emulsion polymerization.
2. Determination of viscosity average molecular weight of polystyrene in benzene and toluene.
3. Kinetics of addition polymerization of methylmethacrylate using benzoyl peroxide as initiator or.
4. Synthesis of polyethyleneterephthalate by emulsion polymerization.
5. Determination of chain length of polyacrylonitrile using Mark-Houwink equation.
6. Kinetics of polymerization of acrylonitrile using Ce(IV)-cyclohexanol redox system.
7. Determination of viscosity average molecular mass of polyacrylonitrile in DMF.

**CC-305, Research Methodology**

**Unit-I, (a) Scientific Research:-**

Definition, characteristics, types, need of research, Identification of the problem, assessing the status of the problem, formulating the objectives, preparing design, Actual investigation.

**(b) Literature Survey:-** Primary sources (Journals and Patents), Secondary resources (abstract, CA, collective indexes, reviews, awareness service, general treatise, monograph on specific areas, reference books), Basic ideas of literature search on web (Scifinder, scopus, scirus, sciencedirect), Citation index, impact factor of research papers.

**Unit-II, Documentation and scientific writing:-**

Organization and writing of manuscript papers, monographs, authored books, Thesis writing, structure and components of research report, Type of report: Research paper, thesis, Research project reports, pictures and graphics, Citation styles, writing a review paper, Bibliography.

**Unit -III, Statistical Methods of Data Analysis:-** Role of analytical chemistry, classification of analytical methods, classical and instrumental, types of instrumental analysis, selection of analytical chemistry, classification of errors, source and minimisation of errors, absolute and relative errors; accuracy and precision; significant figures, Test of significance (F-test, student T-test, paired test T-test); mean value and deviation, average and standard deviation, median value, range, confidence intervals; least square methods of fitting linear equation, correlation coefficient and coefficient of determination.

**Unit-IV, Computer Applications in Chemistry:-**

Introduction to computer and IT, Data and information, General features of a computer, software and its types, Application of software packages in chemistry, computational chemistry.

Applications of some computer packages (MS-Excel, Origin, Chemdraw) to Chemistry, computer technique used in chemistry with special reference to UV- Visible spectroscopy, FTIR, XRD.

**Books Recommended**

1. Research Methodology: Methods & Technique, C.R. Kothari, Wiley Eastern Ltd, New Delhi 1985.
2. Research Methodology, G.C. Ramamurthy, Dreamtech Press.
3. Research Methodology: A step by step Guide for Beginners 2<sup>nd</sup>. Kumar Ranjit, Pearson Education, Singapore, 2005.
4. Introduction to Research & Research Methodology, M.S. Sridhar.
5. Analytical Chemistry, G.D. Christian, 6<sup>th</sup> Edn., Wiley Student Edition.
6. Computer Chemists, S.K. Pundhiranda. Bansal, Pragati Prakashan, 2008.

**CC-306(OEC). ENVIRONMENTAL CHEMISTRY**

**Unit-I**

**Environment**

Introduction, Composition of Atmosphere, vertical temperature, Heat budget of the earth atmosphere system, vertical stability atmosphere. Biological cycles of C, N, P, S and O, Biodistribution of elements.

**Hydrosphere**

Chemical composition of water bodies, like streams, rivers and wetlands, Hydrological cycle: Aquatic pollution, Inorganic, organic. Pesticide, Agriculture, industrial and sewage. Detergents, Oil spills and oil pollutions. Water quality parameters. Dissolved oxygen, Biochemical oxygen demand, solids, metals, content of chloride, sulphate phosphate, nitrite and micro-organism, Analytical methods of measuring BOD, DO, COD, E. Metals (As, Cd, Cr, Hg and Pb)

**Unit-II**

**Soils**

Composition, micro and macronutrients, pollution, fertilizers, pesticides, plastics and metals. Waste treatment.

**Atmosphere**

Chemical composition of atmosphere, particles ions and radicals and their formation. Chemical and photochemical reactions in atmosphere smog formation, Oxides of N, C, S, O and their effect, pollution by chemical, petroleum, Minerals, chlorofluorohydrocarbons, Greenhouse effect, Acid rain, Air pollution controls and their chemistry, Ambient Air Quality Standard in India.

Analytical methods for measuring air pollutants, continuous monitoring instruments

**Unit-III: Industrial Pollution**

Cement, sugar and distillery, iron and steel, paper and pulp industries and thermal power plants, Disposal of wastes and their management

**Unit-IV: Environmental Toxicology**

Chemical solutions to environmental problems, Biodegradability principles of decomposition, Better industrial processes

Bhopal Gas Tragedy, Chernobyl, Three Mile Island and Minamata

**Books Recommended**

1. Environmental Chemistry, S.E. Manahan, Lewis Publishers
2. Environmental Chemistry, Sharma & Krishna Publishers
3. Environmental Chemistry, A.K. De, Wiley Eastern
4. Environmental Pollution Analysis, S.K. Khopkar, Wiley Eastern.
5. Standard Method of Chemical Analysis, F.J. Welcher, Vol III. Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Cretechman, Gordon and Breach Science Publication.
8. Environmental Chemistry C. Barid, W.H. Freeman
9. Handbook of Environmental Analysis. Pradyatpatnaik, Lewis Publishers (1997)
10. Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WPCF, Washington D.C. 2005, USA, 17<sup>th</sup> Edition (1989).



**FOURTH SEMESTER**

**CC - 401, Organic**

**Synthesis Unit I, Disconnection Approach**

An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis.

**Unit II, Oxidation**

**Introduction. Different oxidative processes.**

Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated and unactivated). Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids, Amines, hydrazines, and sulphides. Oxidations with ruthenium tetroxide, iodobenzene diacetate and thallium(III) nitrate.

**Reduction**

Introduction. Different reductive processes.  
Hydrocarbons-alkanes, alkenes, alkynes and aromatic rings.  
Carbonyl compounds – aldehydes, ketones, acids and their derivatives.  
Epoxides. Nitro, nitroso, azo and oxime groups.  
Hydrogenolysis.

**Unit III, Protecting Groups**

Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

**One Group C-C Disconnections**

Alcohols and carbonyl compounds, regioselectivity, Alkene synthesis use of acetylenes and aliphatic nitro compounds in organic synthesis.

**Two Group C-C Disconnections**

Diels-Alder reaction, 1,3-difunctionalised compounds,  $\alpha,\beta$ -unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Michel addition and Robinson annulations.

**Unit IV, Ring Synthesis**

Saturated heterocyclics, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocyclics in organic synthesis.

**Synthesis of some Complex Molecules**

Application, of the above in the synthesis of following compounds, Camphor, Longifolen, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Frederic amycin A.

**Books Recommended**

1. Designing Organic Synthesis, A programmed introduction to synthon approach, S. Warren, Wiley.
2. Organic synthesis-

CBCS Syllabus of PG-Department of Chemistry, DD University  
Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, VCH, Weinheim, Germany.

3. Some Modern Methods of Organic Synthesis. W. Carruthers, Cambridge Univ. Press.

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4. Modern Synthetic Reactions, H.O. House, W.A. Benjamin
5. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, J. March, Wiley.
6. Principles of Organic Synthesis, R. Norman and J.M. Coxon, Blackie Academic & Professional.
7. Advanced Organic Chemistry Part B, F.A. Carey and R.J. Sundberg, Plenum Press.
8. Organic Chemistry: The Disconnection Approach, S. Warren, John Wiley and Sons.

### **CC-402. Polymer Chemistry (DSE-I)**

#### **Unit I**

Importance of polymers: Basic concepts: Monomers, repeat units, degree of polymerization, Linear, branched and network polymers. Classification of polymers. Polymerization: condensation and co-polymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems.

#### **Unit II, Polymer Characterization**

Polydispersion – average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weights. End-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers – chemical analysis of polymers, spectroscopic methods, X-ray diffraction study, Microscopy. Thermal analysis and physical testing – tensile strength. Fatigue, impact. Tear resistance. Hardness and abrasion resistance.

#### **Unit III, Structure and Properties**

Morphology and order in crystalline polymers – configurations of polymer chain. Crystal structures of polymers. Morphology of crystalline polymers, strain – induced morphology, crystallization and melting. Polymer structure and physical properties – crystalline melting point.  $T_m$  – melting points of homogeneous services, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature,  $T_g$  – Relationship between  $T_m$  and  $T_g$ , effects of molecular weight, diluents, chemical structure, chain topology, branching and crosslinking. Property requirements and polymer utilization.

#### **Unit IV, Polymer Processing**

Plastics, elastomers and fibres. Compounding. Processing techniques: Calendering, die casting, rotational casting, film casting, injection moulding, extrusion moulding, thermoforming, forming, reinforcing and fibre spinning.

#### **Properties of Commercial Polymers**

Polyethylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicone polymers. Functional polymers – fire retarding polymers and electrically conducting polymers. Biomedical polymers – contact lenses, dental polymers, artificial heart kindly, skin and blood cells.



**Books Recommended**

1. Textbook of polymer Science, F.W. Billmeyer, Jr. Wiley.
2. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley- Eastern.
3. Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R. M. Ottanbrite.
4. Contemporary polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.

**C.C-403 ORGANOTRANSITION METAL CHEMISTRY (DSE-II)**

**Unit I, Alkyl and Aryl of Transition Metals**

Types, routes synthesis, stability and decomposition pathways organo- copper in organicsynthesis

**Compound of Transition Metal-Carbon Multiple Bonds**

Alkylidenes, Alkylidynes, low valent carbenes and carbenes – synthesis, nature of bond, structural characteristics, nucleophile and electrophilic reactions on the ligands, role in organicsynthesis.

**Unit II, Transition Metal  $\pi$ -Complexes**

Transition Metal  $\pi$ -Complexes with understand organic molecules, alkenes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organicsynthesis.

Transition Metal Compounds With Bonds to

Hydrogen Transition metal compounds with bond to hydrogen

**Unit III Homogeneous Catalytic Synthesis of Organic Chemistry by Transition Metal Complexes.**

Coordinative unsaturation, Oxidative Addition Reaction, Reduction elimination reaction. Insertion reactions (insertion of CO, SO<sub>2</sub> and alkenes). Reactions of coordinated carbon monoxide in metal carbonyls. Homogeneous hydrogenation of alkenes, hydrobromylation of alkenes, Zeigler-Tropsch reaction).

**Unit IV: Fluxional Organometallic Compounds**

Fluxionality and dynamic equilibrium in compounds such as  $\eta^2$ -olefin,  $\eta^3$ -allyl and dienyl complexes.

**Books Recommended**

1. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegeudus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley
3. Metallo-organic Chemistry, A.J. Person, Wiley

4. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, 4<sup>th</sup> Ed, Wiley (2005)
5. Fundamental Concepts of Inorganic Chemistry, Vol. 6; Asim K. Das, CBS publisher, 2<sup>nd</sup> Ed (2013).
6. Organometallic Chemistry, R.C. Mehrotra & A. Singh, New Age International, 2<sup>nd</sup> Ed (2013).

### CC-404, Dissertation/Project

#### CC-405, ANALYTICAL CHEMISTRY PRACTICAL

1. Determination of  $\text{Na}^+/\text{K}^+$  ions by flame photometry.
2. Verification of Beer-Lambert's Law and determination of unknown concentration by colorimetry/spectrophotometric method.
3. Determination of Dissolved Oxygen (DO) in water samples.
4. Determination of Chemical Oxygen Demand (COD) in water samples.
5. Determination of Biochemical Oxygen Demand (BOD) in water samples.
6. Estimation of metal ions by ion-exchange method.
7. Measurement of  $\text{pH}$  of liquid sample/soils by a  $\text{pH}$  meter.
8. Determination of turbidity of the sample solution by turbidity meter.
9. Titration of strong/weak acid with weak/strong base respectively by conductometric method.

#### **Books Recommended.**

1. Vogel's Text Book of Quantitative Chemical Analysis By J. Mendham, R.C. Denney, J.D. Barnes, M.J.K. Thomas, Pearson Education publishers, 6<sup>th</sup> Edition (2007).
2. Handbook of Environmental Analysis by Pradyot Patnaik, Lewis Publishers, USA (1997).
3. Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WPCF, Washington, DC, USA, 17<sup>th</sup> Edition.

**CC-406, PHYSICAL CHEMISTRY PRACTICAL-II**

- 1) Determination of adsorption of acetic acid and oxalic acid on animal charcoal and verification of Freundlich's isotherm.
- 2) Study of equilibrium constant of following reaction.  
$$KI + I_2 \rightleftharpoons KI_3$$
- 3) Study of complex formation between ammonia and  $Cu^{2+}$ .
- 4) Partition coefficient of iodine between chloroform and water.
- 5) Determination of coordination number of copper in cupramine complex.

**Books Recommended**

1. Experimental Physical Chemistry, B.P. Longman.
2. Findlay's practical Physical Chemistry, revised B.P. Levitt, Longman.
3. Experiments in physical Chemistry, J.C. Ghosh, Bharati Bhavan.
4. Experimental Physical Chemistry, R.C. Behera and B. Behera, Tata McGraw Hill, 1983. New Delhi.