SYLLABUS FOR POST GRADUATE PROGRAMME
TWO YEAR COURSE EXAMINATIONS UNDER
CHOICE BASED CREDIT SYSTEM (CBCS)

M.Sc. CHEMISTRY

Shailabala Women's Autonomous College, Cuttack
Accredited with 'A' grade by N.A.A.C. (U.G.C.)(2006 & 2017)
ESTD. 1913
सत्यमेव जयते नानृतं सत्येन पन्था वितितो देवयानः ।

https://www.shailabalawomenscollege.ac.in

2023-24

2024-25

Program Outcomes (POs) for M.Sc Programme

PO1	Disciplinary Knowledge	Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	Critical Thinking and Problem solving	Inculcate critical thinking to carry out scientific investigation objectively. Formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	Effective Communication	Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.
PO4	Social competence	Elicit views of others, present complex information in a clear and concise way and help reach conclusions in group settings.
PO5	Research-related skills and Scientific temper	Infer scientific literature, build a sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO6	Trans-disciplinary knowledge	Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO7	Personal and professional competence	Perform independently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO8	Effective Citizenship and Ethics	Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO9	Environment and Sustainability	Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes

PO10	Self-directed and Life-long learning	Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Program Specific Outcomes (PSOs) M.Sc. Chemistry

PSO 1	Acquires ability to synthesise, separate and characterise compounds using laboratory and instrumentation techniques.
PSO 2	Develops analytical skills and problem solving skills requiring application of chemical principles.
PSO 3	Understand and predict the nature, structure and bonding in molecules/ions
PSO 4	Understand theoretical concepts of instruments that are commonly used in most chemistry fields as well as interpret and use data generated in instrumental chemical analysis.
PSO 5	Develop an understanding of eco-friendly chemical processes and impact of chemistry on health and environment.
PSO 6	To be familiarized with the emerging areas of chemistry and their application in various spheres of chemical sciences and to apprise the students of its relevance in future studies.
PSO 7	Lays the foundation for doctoral programs in Chemistry.

COURSE OUTCOMES (COs)

Semester-I

Subject	Subject Code	Outcome
INORGANIC CHEMISTRY-I	**HC-101**	**Outcome:** At the end of the course the student will **CO1**- Understand and apply the knowledge of bonding and stereochemistry of different inorganic compounds and ions. **CO2**- Be able understand the concept stability constant, its determination and application in different fields **CO3**- Analyse reaction mechanism of transition metal complexes **CO4**- Understand the trans effect, mechanism of one electron transfer reaction, outer sphere type reactions **CO5**- Understand the structure and bonding in Metal π- complexes and Metal clusters.
ORGANIC CHEMISTRY-I	**HC-102**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the organic reaction mechanisms and their determination. **CO2**- Apply Structure and reactivity and the quantitative treatments using several equations. **CO3**- Analyse Aliphatic Nucleophillic and Electrophilic Substitution, SET mechanisms and anchimetric assistance. **CO4**- Understand the Aromatic Nucleophillic and Electrophilic Substitution and quantitative treatment of reactivity in substrates and electrophiles. **CO5**- Understand the Mechanism of Elimination reactions and orientation in pyrolytic elimination.

PHYSICAL CHEMISTRY-I	**HC-103**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand and apply the Postulates of quantum mechanics, Schrodinger's equation. **CO2**- Apply Approximation Methods in Quantum chemistry. **CO3**- Analyse the Electronic Structure of Multi electron atoms. **CO4**- Understand the Valence bond Theory (VBT) and Molecular orbital theory(MOT) approaches, Huckel theory of conjugated systems **CO5**- Understand the phase behaviour of one and two components system and to create phase diagrams.
INORGANIC CHEMISTRY PRACTICAL-I	**HC-104**	**Outcome:** CO1- Analyse and identify different cations and anion from a mixture of inorganic salts. CO2- Understand the principles of separation and analysis of different ions and their applications in real fields. CO3- Learn the techniques of chromatographic separation of mixture of cations and anions
Computer Application Course by e-learning centre	**AC-101**	**Outcome:** After the completion of course students will able to acquire basic understanding about Computer, computer programmes, computer languages, understanding the basic concept associated with C- and C^{++} Language and program designing, develop different programs, Run and Retrieve results, use of variables, arithmetic assignment operators and conditional operator, and in future student may be able to develop a big program(s)(Software) which may simulate the behaviour of the chemical reaction/processes/events.

Semester-II

Subject	Subject Code	Outcome
INORGANIC CHEMISTRY-II	**HC 201**	**Outcome:** At the end of the course the student will be able to **CO1**- Apply scientific knowledge to understand CFT and MOT of transition metal complexes. **CO2**- Analyse Orgel and Jahn-Teller diagrams, structure of mixed metal oxides and chemistry of inner transition elements. **CO3**- Understand the Magneto Chemistry and paramagnetic resonance spectroscopy. **CO4**- Understand the Chemistry of lanthanides and actinides and analyse the comparison between lanthanides and actinides. **CO5**- Understand the various Nuclear Chemistry and Nuclear Reactions.
ORGANIC CHEMISTRY-II	**HC 202**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the Conformational analysis of cycloalkanes, Elements of Symmetry, Chirality. **CO2**- Understand the free radical substitution and Free radical rearrangements. **CO3**- Understand the Addition to carbon- carbon multiple bonds and apply the Mechanistic and stereochemical aspects of addition reactions. **CO4**- Understand the Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds. **CO5**- Understand the various Rearrangement reactions in organic chemistry.
PHYSICAL CHEMISTRY-II	**HC 203**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the concepts of laws of classical thermodynamics, entropy and free energy. **CO2**- Understand the Concept of distribution, thermodynamic probability and most probable distribution in statistical thermodynamics.

		CO3- Understand the distribution law and application to metal, Bose- Einstein statistics-distribution law and application to helium. **CO4**- Understand the Electrochemistry of solutions, Debye- Huckel; Onsager treatment and its extension. **CO5**- Understand the Thermodynamics of electrified interface equations.
ORGANIC CHEMISTRY PRACTICAL-I		**Outcome**: Upon completion of this course students will be able to **CO1** purify and separate a mixture of organic samples. **CO2** perform synthesis of derivatives of simple functional groups and purify them. **CO3** understand the use of TLC and column chromatography. **CO4** identify the functional groups present in organic molecules. **CO5** Estimate organic compounds from a mixture of organic samples.
ORGANIC SPECTROSCOPY -I	**CE 201 A**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand and apply Ultra violet and visible spectroscopy, Various electronic transitions, Woodward -Fieser rules for conjugated dienes and carbonyl compounds. **CO2**- Understand the Infrared spectroscopy, Instrumentation and sample handling, and Fermi Resonance **CO3**- Understand and apply Nuclear Magnetic Resonance Spectroscopy,Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements. **CO4**- Understand the Carbon-13 NMR Spectroscopy. **CO5**- Analyse the Mass Spectrometry.
POLYMER CHEMISTRY	**CE 201 B**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand Basic concepts of Polymer Chemistry. **CO2**- Apply the Polymer characterization methods. **CO3**- Analyse and testing of polymers. **CO4**- Understand the Morphology and order in crystalline poymers. **CO5**- Analyse the Properties of commercial Polymers.
ENVIRONMENTAL CHEMISTRY	**OE 201**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the Environment and its composition. **CO2**- Understand the Hydrosphere, water quality standards. Purification and treatment of water. **CO3**- Analyse Atmosphere, Chemical composition of atmosphere- particles, ions and radicals and their formation. **CO4**- Understand the Industrial pollution and disposal of wastes and their management.

Semester-III

Subject	Subject Code	Outcome
SPECTROSCOPY-II	**HC 301**	**Outcome:** At the end of the course the student will be able to **CO1**- Apply Atomic spectroscopy, Energies of atomic orbitals, vector representation of momenta and vector coupling. **CO2**- Analyse Molecular spectroscopy, Energy levels, molecular orbitals, vibronic transitions, vibrational progressions, frank condon principle. **CO3**- Understand the Basic principles, photoelectric effect, ionization process, Koopman's theorem, Photoelectron spectra of simple molecules. **CO4**- Understand the Microwave spectroscopy. **CO5**- Understand the Nuclear Quadrupole Resonance Spectroscopy and Polarography.
PERICYCLIC REACTIONS AND PHOTOCHEMIS	**HC 302**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the Pericyclic reaction, Molecular orbital symmetry, Fourier orbitals of ethylene. **CO2**- Understand the Concept of Suprafacial and antarafacial shifts of H, 3,3 – and

TRY		5,5 – sigmatropic rearrangements.. **CO3**- Understand the Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule(singlet, triplet state), Jablonski diagram. **CO4**- Understand the Photochemistry of alkenes and Photochemistry of carbonyl compounds. **CO5**- Understand the Photochemistry of aromatic compounds and Photochemical formation of smog, photo degradation of polymers.
PHYSICAL CHEMISTRY PRACTICAL	**HC 303**	**Outcome:** At the end of the course the student will be able of handling the conductivity meter, pH meter and potentiometer. Also it gives a real feel of the electrochemistry, such a verification of Debye-Huckel-Onsager equation, neutralisation of weak acids, determination of K_{sp} of sparingly soluble salt and conductometric titrations, which are taught in theory.
BIOCHEMISTRY	**CE 301** **A**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand and apply concept and identification of active site by the use of inhibitors, affinity, labelling and enzyme modifications by the site directed mutagenesis. **CO2**- Enzyme kinetics, Michaelis- Menten and Lineweaver -burk plots, reversible and irreversible inhibition, Transition state theory. **CO3**- Understand Surface active agents, classification of surface active agents, concepts on micelle**.** **CO4**- Understand the structure and biological functions of coenzyme A, thiamine pyrophosphate, pyrophosphate. **CO5**- Apply the Mechanism of reactions catalysed by cofactors, Nucleophillic displacement on a phosphorous atom, multiple displacement reaction and coupling of ATP cleavage to endergonic processes.
BIO-INORGANIC AND SUPRAMOLECULAR CHEMISTRY	**CE 301** **B**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand Metal ions in biological systems and its storage transport and biomineralization. **CO2**- Apply the carboxypeptidase and carbonic anhydrase, Iron enzymes. **CO3**- Understand the Nitrpogen fixation and Photosynthesis.. **CO4**- Understand the Transport and storage of dioxygen. **CO5**- Analyse the self-assembly in supramolecular Chemistry.
ORGANO TRANSITION METAL CHEMISTRY	**CE 302** **A**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the Types routes of synthesis, stability and decomposition pathways organo-copper in organic synthesis **CO2**- Analyse Transition metal π-Complexes with unsaturated organic molecules. **CO3**- Understand Transition metal compounds with bonds to Hydrogen**.** **CO4**- Understand the Coordinative unsaturation, oxidative addition and reductive elimination reactions, Insertion reactions. **CO5**- Apply the Fluxional Organometallic compounds.
SOLID- STATE CHEMISTRY	**CE 302** **B**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand General principles, experimental procedures, co-precipitation as a precursor to solid state reactions , sol-gel method, Crystal defects and non-stoichiometry. **CO2**- Apply the Electronic properties of solids, Metals, insulators and semiconductors. **CO3**- Understand the Optical reflectance, photoconduction-photoelectric effects. **CO4**- Understand the Diffraction methods: X-ray diffraction. **CO5**- Analyse the Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques, Elucidation of structure of magnetically ordered unit cell.

Semester-IV

Subject	Subject Code	Outcome
ORGANIC SYNTHESIS	**HC 401**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the Oxidation of organic molecules using ruthenium tetraoxide, hypervalent iodine, thallium (III) Nitrate. **CO2**- Analyse Reduction of organic molecules using boron based reagents, Aluminium- based reagents, free radical reagent. **CO3**- Understand the Principle of protection of alcohol,amine, carbonyl and carboxyl groups. **CO4**- Understand the One group C-C disconnection. **CO5**- Understand the Application of the disconnection approach in the synthesis of following compounds.
APPLIED CHEMISTRY PRACTICAL	**HC 402**	**Outcome:** At the end of the course the student will be able to perfom a) Determination of DO, COD and BOD of water samples. b) Analysis of ground water sample for sulphate by titrimetry (EDTA) and turbidimetry c) Synthesis of Polymers d) Analysis of fat in a butter sample e) Spectrophotometric estimation of hexavalent chromium in water samples. f) Spectrophotometric estimation of phosphate in cola drinks.
DISSERTATION	**HC 403**	**Outcome:** After completion of the project work the students will 1. Learn the design the experimental set up and perform the experimental as per specific problem selected for project 2. Gain the knowledge and competency to search literature and write the dissertation 3. Learn the skill for presentation of the project work.
SPECTROSCOPY -III	**CE 401 A**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand and apply Electron spin resonance spectroscopy**.** **CO2**- Understand the Vibrational spectroscopy. **CO3**- Understand Classical and quantum theories of Raman effect and spectroscopy**.** **CO4**- Understand the Nuclear magnetic resonance of paramagnetic substances in solution. **CO5**- Apply the Mossbauer spectroscopy.
ANALYTICAL CHEMISTRY	**CE 401 B**	**Outcome:** At the end of the course the student will be able to **CO1**- Understand the Thermos gravimetric analysis(TGA). **CO2**- Apply the principles and applications of voltammetry. **CO3**- Understand the Atomic absorption spectroscopy, in qualitative and quantitative analysis. **CO4**- Create the chromatograms: frontal, elution and displacement methods. **CO5**- Analyse the Statistical methods in chemical analysis, theory of error and treatment of quantitative data, accuracy, and precission.

COURSE STRUCTURE

14 Hard Core Papers each of 05 Credit and 100 Marks

04 Core Elective Papers each of 05 credit and 100 marks

02 Allied Core Papers each of 03 credit and 50 marks

01 Open elective Paper of 04 credit and 50 marks

01 Field Internship Paper of 04 credit and 50 marks

SEMESTER – I

Sl. No	Course	Course Code	Paper Title	Units	Credits	Marks		
						Mid-Sem. (Paper+Assignments)	End-Sem.	Total
1	Hard Core	HC-101	Inorganic Chemistry-I	5	5	20+10	70	100
2	Hard Core	HC-102	Organic Chemistry-I	5	5	20+10	70	100
3	Hard Core	HC-103	Physical Chemistry-I	5	5	20+10	70	100
4	Hard Core	HC-104	Inorganic Chemistry-I (Practical)	—	5	20+10	70	100
5	Allied Core	AC-101	Computer Application Course by e-learning centre	3	3	Mid-sem10 +Practical 10 =20 marks	30	50
TOTAL					**23**	140	310	**450**

SEMESTER – II

Sl. No	Course	Course Code	Paper Title	Units	Credits	Marks		
						Mid-Sem. (Paper+Assignments)	End-Sem.	Total
6	Hard Core	HC-201	Inorganic Chemistry-II	5	5	20+10	70	100
7	Hard Core	HC-202	Organic Chemistry-II	5	5	20+10	70	100
8	Hard Core	HC-203	Physical Chemistry-II	5	5	20+10	70	100
9	Hard Core	HC-204	Organic Chemistry-II (Practical)	—	5	20+10	70	100
10	Core Elective	CE-201	A. Spectroscopy-I OR B. Polymer Chemistry	5	5	20+10	70	100
11	Open Elective Theory (Open for other PG students)	OE-201	Environmental Chemistry OR MOOCs (From SWAYAM/ NPTEL etc.)	4	4	—	50	50
TOTAL					**29**	150	400	**550**

SEMESTER – III

Sl. No	Course	Course Code	Paper Title	Units	Credits	Marks		
						Mid-Sem. (Paper+Assignments)	End-Sem.	Total
12	Hard Core	HC-301	Spectroscopy-II	5	5	20+10	70	100

13	Hard Core	HC-302	Pericyclic Reaction & Photochemistry	5	5	20+10	70	100
14	Hard Core	HC-303	Physical Chemistry (Practical)	__	5	20+10	70	100
15	Core Elective	CE-301	A. Biochemistry OR B. Bio-inorganic and Supramolecular Chemistry (Theory)	5	5	20+10	70	100
16	Core Elective	CE-302	A. Organo transition Metal Complexes OR B. Solid State Chemistry (Theory)	5	5	20+10	70	100
17	Field Internship	FI-301	Field Internship	__	3	__	50	50
TOTAL					**28**	150	400	**550**

SEMESTER – IV

Sl.No	Course	Course Code	Paper Title	Units	Credits	Marks		
						Mid-Sem. (Paper+Assignments)	End-Sem.	Total
18	Hard Core	HC-401	Organic Synthesis	5	5	20+10	70	100
19	Hard Core	HC-402	Applied Chemistry (Practical)	__	5	20+10	70	100
20	Hard Core	HC-403	Dissertation	__	5		100	100
21	Core Elective	CE-401	A. Spectroscopy-III OR B. Analytical Chemistry (Theory)	5	5	20+10	70	100
22	Allied Core	AC-401	Theory: "Women & Society" (For all PG Programs)	3	3	10+5	35	50
TOTAL					**23**	105	345	**450**

Summary

HC-HARD CORE	14 x 100	1400
CE-CORE ELECTIVE	4 x 100	400
OE-OPEN ELECTIVE	1 x 50	50
AC-ALLIED CORE	2 x 50	100
FI-FIELD INTERNSHIP	1 x 50	50
TOTAL MARKS :		2000

SEMESTER	CREDITS	TOTAL MARKS
SEMESTER-I	23	450
SEMESTER-II	29	550
SEMESTER-III	28	550
SEMESTER-IV	23	450
TOTAL	103	2000

Semester-I

HC-101

INORGANIC CHEMISTRY-I

Mid Sem :20+10 End Sem: 70

UNIT-I

Stereochemistry and bonding in main group compounds:

VSEPR, Bent rule and energetics of hybridization, Walsh diagrams (tri-and penta-atomic molecules), dπ-pπ bonds, some simple reactions of covalently bonded molecules. Wade's rule, Styx number, carboranes, isolobal analogy, Lipscom topology, applications of boron compounds.

UNIT-II

Metal-ligand equilibria in solution:

Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of the metal ions and ligands, chelate and macrocyclic effect and their thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.

UNIT-III

Reaction mechanism of transition metal complexes (I):

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic applications of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism.

UNIT-IV

Reaction mechanism of transition metal complexes (II):

Anation reactions, Reactions without metal-ligand bond cleavage, Substitution reactions in square planar complexes, Trans effect, mechanism of one electron transfer reaction, outer sphere type reactions, cross reactions and Marcus-Hush theory, Inner sphere type reactions.

UNIT-V:

Metal π- complexes:

Metal carbonyls, Structure and bonding, preparation, bonding structure and important reactions of Transition metal Nitrosyl, Dinitrogen and Dioxygen complexes ligands. Metal clustures: Metalloboranes, Metallocarboranes, Metal carbonyls and Metal halide clusters.

Books and references:

Advanced Inorganic Chemistry: A Comprehensive Text: F.A. Cotton and G. Wilkinson, John Wiley
Inorganic chemistry, J.E.Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi, 4th edition, Pearson education, (2006)
Advanced Inorganic Chemistry: F.A. Cotton, M. Bochmann, C.A. Murrilo, G. Wilkinson, 6th Edition, Wiley India(2007)
Fundamental concepts of inorganic chemistry, Vol. 2,4,&5; Asim K. Das, CBS publisher, 2nd edition,(2013)
Comprehensive Co-ordination Chemistry eds: G. Wilkinson,R.D. Gillards and J. A. Mc Cleverty, Pergamon (2003)
Inorganic Chemistry; K.F. Purcell & J. C. Kotz, Cengage Learning, Indian Ed.(2010)

HC-102

ORGANIC CHEMISTRY-I

Mid Sem :20+10 End Sem: 70

UNIT-I

Reaction mechanism:

Types of mechanism, types of reactions, thermodynamics and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin- Hammett principle, Potential energy diagrams, transition states and intermediates, methods of determining mechanism, isotope effects, hard and soft acids and bases.

UNIT-II

Structure and reactivity:

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity, resonance and field effect, steric effect, quantitative treatment. The Hammet equation and linear free energy relationships, substituent and reaction constants. Taft equation.

UNIT-III

Aliphatic Nucleophillic Substitution:

The SN^2, SN^1, mixed $SN^1$and SN^2 and SET mechanisms, neighbouring group participation by σ and π bonds, anchimetric assistance, Nucleophillic substitution at an allylic , aliphatic trigonal and a vinylic carbon.

Reactivity effects of substrate, structure, attacking nucleophile, leaving group and reaction medium.

Aliphatic electrophilic substitution:

Bimolecular mechanism-S_E2 and S_Ei. The S_E1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and solvent polarity on the reactivity.

UNIT-IV

Aromatic nucleophilic substitution:

The S_NAr, SN^i Benzyne and SR_N1 mechanism, reactivity – effect of substrate structure, leaving group and attacking nucleophile, the Von-Richter, Sommelet-Hauser and Smiles rearrangements.

Aromatic Electrophillic substitution:

The arenium ion mechanism, orientation and reactivity, energy profile diagrams,the ortho/para ratio. Ipso attack. Orientation in other ring systems, quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction.

UNIT-V

Elimination reactions:

The E2, E1 and E1CB mechanisms. orientation of free double bonds. Reactivity: effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination. Some name reactions involving elimination mechanism (Dehydration of alcohols, dehalogenation of vicinal dihalide, Peterson Elimination reactions, Hydro alkoxy elimination)

Books and References:

Organic chemistry: J. Clayden, N. Greeves, S,Warren and P.Wothers, Oxford University, Press
Advanced organic chemistry reactions , Mechanism and Structure:JerryMarch, John Wiley and Sons.
Advanced organic Chemistry:F.A.Carey and R.J. Sundberg. Plenum
A Guide Book to Mechanism in Organic Chemistry: Peter Sykes, Longman/ Pearson Education
Structure and mechanism in Organic Chemistry: C.K.Ingold. Cornell University Press
Organic Chemistry: R.T.Morrison and R.N.Boyd, Prentice Hall/ Pearson Education.

Reaction Mechanism in Organic Chemistry, S. M. Mukherjee and S. P. Singh , Macmillan
Advanced Organic Chemistry: Reactions and Mechanism: B. Miller and R. Prasad. Pearson-Education.

HC-103

PHYSICAL CHEMISTRY-I

Mid Sem :20+10 End Sem: 70

UNIT-I;

Quantum Chemistry;

Postulates of quantum mechanics, Schrodinger's equation and discussion of solutions of the Schrodinger's equation to some model systems i.e. particle in a box, the Harmonic Oscillator, the Rigid Rotator, the Hydrogen atom.

UNIT-II:

Approximation Methods:

The variation theorem, linear variation principle, perturbation theory (first order and non-degenerate), applications of variation method and perturbation theory to Helium atom

Angular Momentum: Ordinary angular momentum, generalised angular momentum, eigen function for angular momentum, eigen values of angular momentum, operator using ladder operators, addition of angular moments, spin, anti symmetry and Pauli exclusion Principle.

UNIT-III:

Electronic Structure of atoms:

Multi electron atoms, electronic configuration, Russel -Saunders Coupling schemes, magnetic effects, spin- orbit coupling and Zeeman splitting.

UNIT-IV:

Molecular Orbital Theory:

H_2^+ and H_2 molecule: Valence bond Theory (VBT) and molecular orbital theory (MOT) approaches, Homonuclear and heteronuclear diatoms, Huckel theory of conjugated systems, bond order and charge density calculation, applications to ethylene, butadiene, cyclopropenyl radical and cyclobutadiene.

UNIT-V:

Surface Chemistry:
Adsorption: Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation). Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electrokinetic phenomenon), catalytic activity at surfaces.
Micelles: Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration(CMC), factors affecting the CMC.

Books and References:

Physical Chemistry. P.W.Atkins and J.D.Paulo, Oxford, 2013, 10th edition, New Delhi
Introduction to quantum chemistry, A.K.Chandra, Tata Mc Graw Hill, 1997,4th edition, New Delhi.
Quantum Chemistry, R.K.Prasad, New Age International (P) Ltd.
Quantum Chemistry through problems and solutions , R.K.Prasad, New Age International (P) Ltd.
Physical Chemistry, T. Engel and P.Reid, Pearson, 2006, 1st Edition, New Delhi
Physical Chemistry Vol-II, K.L. Kapoor, Mc millan Publication
*Quantum Chemis*try: Ira N. Levine, Prentice Hall.
R. S. Berry, S. A. Rice and J. Ross, *Physical Chem*istry, 2nd Edition, Oxford University Press, Oxford 2007.
D. A. McQuarrie, *Statistical Mechanics*, University Science Books, California (2005).

HC-104

INORGANIC CHEMISTRY-Practical

Mid Sem :20+10 End Sem: 70

1. Qualitative analysis of inorganic mixture

Semi-micro qualitative analysis of inorganic mixtures containing (not more than six radicals) three anions, common cations, less common metal ions (W, Mo, Ce, Th, Zr, V and U) and insoluble (sulphates, oxides, halides)

2. Ion exchange Chromatography:

Separation of mixture of cations and anions by
   a) Paper chromatography
   b) Column chromatography- ion exchange: Co(II)/Ni(II); Cd(II)/Mg(II)

3. Preparation of following compounds and their studies by elemental, IR and electronic spectra measurement.
   a) cis- K[Cr(C2O4)2(H2O)2]
   b) K3[Fe(C2O4)3]
   c) [Ni(NH3)6]Cl2
   d) Ni(dmg)2
   e) Potassium tri-(oxalato) aluminate(III)
   f) Tetraaminecopper(II)sulphate

Books Recommended:
Vogel's Qualitative inorganic Analysis, 7th Ed, Revised by G. Svehela, 4t Ed, Pearson (2007)
An Advanced Course OF Practical Chemistry, Nad, Ghosal and Mahapatra, Central Publisher(2000)
Practical inorganic chemistry, Z.Szafran, R. M.Pike and M.M.Singh, Wiley.

Semester-II

HC-201

INORGANIC CHEMISTRY-II

Mid Sem :20+10 End Sem: 70

UNIT-I:

Metal-Ligand Bonding:

Crystal -Field theory: limitations of crystal Field Theory, Molecular Orbital theory for octahedral, tetrahedral and square planar complexes, σ and π bonding in Molecular Orbital Theory, Applications of MOT to Corelation diagrams.

UNIT-II:

Electronic spectra and magnetic properties of transition metal complexes:

Spectroscopic ground states, correlation, Orgel and Tanabe- Sugano Diagrams for Transition metal complxes(d1- d9 states), calculations of Dq, B and β parameters, Charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchanges coupling and spin cross over.

UNIT-III:

Magneto Chemistry and EPR:

Induction and susceptibility, Lande interval Rule, calculation of g- Values, Van-Vleck's equation and its use, effect of spin orbit coupling, magnetic properties of AET terms with reference to Co(I) and Ni(II) complexes.

Electron paramagnetic resonance spectroscopy: Hyperfine splitting, spin-orbit coupling, significance of g-tensor, Zerofield splitting, Kramer's degeneracy, Application to inorganic systems.

UNIT-IV:

Chemistry of Inner Transition Elements:

Chemistry of lanthanides and actinides, lanthanide contraction, separation of lanthanide elements, oxidation state, spectral and magnetic properties, stereochemistry, use of lanthanide compounds as Shift reagents, Actinide contraction, oxidation states, comparison between lanthanides and actinides.

UNIT-V:

Symmetry and Group theory in Chemistry:

Symmetry elements and symmetry operations, definitions of group, subgroup, relation between orders of a finite group and its subgroup, conjugacy relation and classes, generators, point symmetry group.

Representations of group operators, the great orthogonality theorem (without proof) and its explanation, Irreducible and reducible representation, bases of representation, character of a representation, character tables and their uses.

Books and References:

1. Advanced Inorganic Chemistry, F. A. Cotton, M. Bochmann, C. A. Murillo, G. Wilkinson, 6 th Ed., Wiley India (2007).
2. Inorganic Chemistry, J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 4th Ed., Pearson Education (2006).
3. Chemistry of the Elements, N.N. B. Greenwood and A. Earnshow, Pergamon, 2nd Ed (1997)
4. Inorganic Electronic Spectroscopy, A.B.P.Lever, Elsevier.
5. Magnetochemistry, R.L.Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry eds., G.Wilkison, R.D.Gillars and J.A.McCleverty, Pergamon.
7. Elements of Magneto Chemistry, R. L. Dutta, A. Syamal; 2nd 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, 2nd Ed., (2013).
10. Organometallic Chemistry, R.C. Mehrotra & A. Singh, New Age International, 2nd Ed (2013).
11. Inorganic Chemistry, C. L. Miessler, D. A. Tarr, Pearson, 3rd Ed., (2004)

HC-202

ORGANIC CHEMISTRY-II

Mid Sem :20+10 End Sem: 70

UNIT-I:

Stereochemistry:

Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding.

Elements of Symmetry, Chirality, Molecules with more than one chiral centre, threo and erythron isomerts, methods of resolution, optical purity, enantiotropic and diastereotropic atoms, groups and faces, stereospecific and stereoselective synthesis, asymmetric synthesis, optical activity in the absence of chiral carbon atoms (biphenyls: allenes and spiranes), chirality due to helical shape, stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

UNIT-II:

Free radical reactions:

Types of free radical reactions: free radical substitution, mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead, reactivity in the attacking radicals, the effect of solvents on reactivity, Allylic halogenation(NBS), oxidation of aldehydes to carboxylic

acids, auto-oxidation, coupling of alkynes and acylation of aromatic compounds by diazonium salts, Sandmeyer's reaction. Free radical rearrangements, Hunsdiecker reaction

UNIT-III:

Addition to carbon- carbon multiple bonds:

Mechanistic and stereochemical aspects of addition reactions, hydrogenation, halogenation, hydrohalogenation, hydroboration, oxymercuration, sulfenylation, selenylation, 1.3-dipolar species addition, hydroxylation: Prevost &Woodward hydroxylation, using $KMnO_4$ and OsO_4, Epoxidation, Sharpless asymmetric epoxidation, Michael reaction, Prins reaction, addition to cyclopropane ring, addition to conjugated systems.

UNIT-IV:

Addition to carbon- Hetero multiple bonds:

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles, addition of Grignard' reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, Wittig reaction.

Mechanism of condensation reactions involving Enolates- Aldol, Knoevenagel , Claisen, Mannich, Benzoin, Perkin and Stobbe reactions

UNIT-V:

Rearrangements: A detailed study of the following rearrangements;

Pinacol-Pinacolone , Wagner- Meerwein, Demjanov, Benzil-Benzillic acid, Favorskii, Arndt- Eistert synthesis, Neber, Beckmann, Hoffmann, Curtius, Schmidt, Bayer-Villiger, Shapiro reaction.

Books and References:

1. *Organic chemistry*: J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. *Advanced Organic Chemistry Reactions, Mechanism and Structure*: Jerry March. John Wiley and Sons.
3. *Advanced Organic Chemistry*: FA Carey and RJ. Sundberg. Plenum.
5. *Stereochemistry of Organic Compounds*: D. Nasipuri, New Age International.
6. *Stereochemistry of Organic Compounds*: P. S. Kalsi, New Age International.
7. *Stereochemistry of Organic Compounds*: E. L. Eliel and S. H. Wilen. John Wiley.
Stereochemistry, Conformation and Mechanism: P. S. Kalsi, New Age International.
Advanced Organic Chemistry- reactions, mechanism and structure: Jerry March, John Wiley
Organic Chemistry: R.T.Morrison and R.N.Boyd, Prentice Hall/ Pearson Education
Reaction Mechanism in Organic Chemistry, S. M. Mukherjee and S. P. Singh , Macmillan

HC-203

PHYSICAL CHEMISTRY-II

Mid Sem :20+10 End Sem: 70

UNIT-I:

Classical Thermodynamics:

Brief resume of concepts of laws of thermodynamics, entropy and free energy. The concept of chemical potential and partial molar properties: partial molar free energy, partial molar volume and partial molar heat content and their significance. Determination of these quantities, concept of fugacity and determination of fugacity, activity activity coefficient.

UNIT-II:

Statistical Thermodynamics:

Concept of distribution, thermodynamic probability and most probable distribution, Ensemble averaging, postulates of ensemble averaging, Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws(using Lagrange's method of undetermined multipliers)

UNIT-III:

Partition functions-

Translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition function, Fermi-Dirac statistics, distribution law and application to metal, Bose- Einstein statistics-distribution law and application to helium.

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.

UNIT-V:

Electrodics:

Thermodynamics of electrified interface equations, derivation of electrocapillarity: Lippmann equations(surface excess), methods of determination, structure of electrified interfaces, overpotentials, exchange current density, derivation of Butler-Volmer equation, tafel plot, interface theory of double layer at semi-conductor- electrolyte solution interfaces, effect of light at semiconductor solution interface.

Books and References:

1. Physical Chemistry , P.W.Atkins and J. D. Paulo, Oxford, 2013, 10th edition New Delhi.
2. A textbook of Physical chemistry – H.K. Moudgil
3. Physical Chemistry, T. Engel and P. Reid, Pearson, 2006, 1st edition, New Delhi.
4. Thermodynamics, G. N. Lewis and M. Randall, McGraw Hill, 2nd edition, 1961, New York.
5 .Molecular Thermodynamics, D. A. McQuarrie and Simon. Viva, 2009, 1st edition, New Delhi.
6. Non Equilibrium Thermodynamics, S.R. deGroot and Mazur, Dover, New York.
7. Introductory Statistical Thermodynamics, T. Hill, Dover, 1986, New York.
8. Statistical Thermodynamics, Oxford, Oxford Chemistry Primer vol. 58, 1997.
9. Introduction to Statistical Mechanics, R. Bowley and M. Sanchez, Clarendon press,
10. Statistical Mechanics and Thermodynamics, C. Garrod, Oxford Univ. Press, 1995, New York.
11. Introduction to thermodynamics of irreversible processes, 2nd edition, Interscience, 1961, New York

HC-204

ORGANIC CHEMISTRY PRACTICAL

Mid Sem :20+10 End Sem: 70

1. Organic synthesis:
   a) Preparation of methyl orange
   b) Preparation of anthranilic acid
   c) Preparation of adipic acid by chromic acid oxidation of cyclohexanol
   d) Synthesis of p-Nitro aniline and p- bromo aniline(aromatic electrophilic substitution)
   e) Synthesis of triphenyl methanol from benzoic acid (Grignard's reaction)

2. Qualitative analysis:
   Identification of organic compounds having at least two functional groups.

3. Quantitative Analysis:
   a) Estimation of Phenol/ Aniline using Bromate- bromide solution.
   b) Determination of iodine and saponification value of an oil sample
   c) Determination of ascorbic acid in Vitamin C tablets

Books and References;
1. Experiments and Techniques in Organic Chemistry, D.Pasto, C.Johnson, & M. Miller, Prantice Hall.
2. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
3. Hand Book 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.
5. Macroscale and Microscale Organic Experiments, K.L.Williamson, D.C.Heath.
6. A Text Book of Practical Organic Chemistry (Qualitative). Arthur I.Vogel.

CE-201(A)

ORGANIC SPECTROSCOPY-I

Mid Sem :20+10 End Sem: 70

UNIT-I:

Ultra violet and visible spectroscopy:

Various electronic transitions, beer-lambert's law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Woodward -Fieser rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds, steric effect in biphenyls.

UNIT-II:

Infrared spectroscopy:

Instrumentation and sample handling, characteristics vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols,ethers,phenols and amines. Detail study of vibrational frequencies of carbonyl; compounds (ketones, aldehydes. Esters. Amides.acids, acid anhydrides,lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi Resonance, IR of gaseous, solid and polymeric materials.

UNIT-III:

Nuclear Magnetic Resonance Spectroscopy (NMR):

Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant'J'. classification (ABX, AMX, ABC, A2B2 etc). spin-decoupling.use of NMR in medical diagnostics.

UNIT-IV:

Carbon-13 NMR Spectroscopy:

General considerations, chemical shift (aliphatic,olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants, two dimension NMR spectroscopy-COSY, NOESY, DEPT, APT and INADEQUATE technique.

UNIT-V:

Mass Spectrometry;

Introduction. Ion production- EI, CI, and FAB factors affecting fragmentation, ion analysis, ion abundance, mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Mclafferty rearrangement, nitrogen rule, high resolution mass spectrometry, examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Books and References;
Spectrometric identification of organic compounds, 6th edition: Silverstein, R.M.: Webster, F.X.:Wiley: New York, 1998
Organic structural spectroscopy, Lambert, J.B.: Shurvell, H.F., Prentice Hall, 1998.
Organic spectroscopy:Kemp, W. 3rd edition: Macmillan Education: Hound mills, Basing stoke, Hampshire, 1991.
Levitt, Malcolm H.; *Spin Dynamics-Basics of Nuclear Magnetic Resonance*, Second edition; John Willey & Sons Ltd.

CE-201

(B) POLYMER CHEMISTRY
Mid Sem :20+10 End Sem: 70

UNIT-I:

Basic concepts of Polymer Chemistry:
Importance of polymers, monomers, repeat units, degree of polymerisation, linear, branched and network polymers, Classification of polymers, Polymerisation Process- condensation, addition, radical chain, ionic and coordination and co-polymerisationbs. Polymerization conditions and polymer reactions, Polymerisation in homogeneous and heterogeneous systems.

UNIT-II:

Polymer characterization methods:
Polydispersion- average molecular weight concept, number, weight and viscosity average molecular weights, polydispersity and molecular weight distribution, the practical significance of molecular weight. Measurement of molecular weights- end group, viscosity, light scattering, osmotic and ultracentrifugation methods.

UNIT-III:

Analysis and testing of polymers,
Spectroscopic methods: IR, UV , X-RAY diffraction, Microscopic analysis: optical, SEM, and TEM, thermal analysis- TGA, DSC, DTA, DMA and physical testing- Tensile strength, Flexural strength, Fatigue, Impact Strength, tear resistance, hardness and abrasion resistance.

UNIT-IV:

Morphology and order in crystalline poymers-
Configuration of polymer chains, crystal structure of polymers-crystalline , amorphous structure, factors affecting crystallinity, degree of crystallinity, techniques to determine the degree of crystallinity
Glass transition temperature, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking on glass transition temperature,
Tm- factors affecting Tm (chain flexibility, steric factor, entropy and heat of fusion), relation between Tg and Tm.

UNIT-V:

Properties of commercial Polymers:
Polyethylene, PVC, Poly amides, polyesters, Phenolic resins, epoxy resins and silicone polymers, Functional polymers- Fire retarding polymers and electrically conducting poymers (PANI , Poly acetylene). Polymer in biomedical applications: contact lens, dental polymers, artificial heater, kidney, skin and blood cells.

Books and References;

1. Text book 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

OE-201
CH 206: ENVIRONMENTAL CHEMISTRY
End Sem: 50

UNIT-1:
Environment
Introduction , composition of atmospheres, vertical temperature, heat budgetof the earth atmospheric system, vertical stability atmosphere, biogeochemical cycles of C, N,P,S and O, Bio distribution of elements.

UNIT-II:

Hydrosphere:

Hydrological cycle.Aquatic pollution- inorganic , organic, pesticides, agricultural, industrial and sewage, detergents, oil spills and oil pollutants, water quality parameters-dissolved oxygen, biochemical oxygen demand, solids, metals, content of chloride, sulfate, phosphate, nitrate and micro-organism, water quality standards.
Purification and treatment of water.

UNIT-III:

Atmosphere:

Chemical composition of atmosphere- particles, ions and radicals and their formation. Chemical and petrochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals, chlorofluoro hydrocarbon, green house effect, acid rain, air pollution controls and their chemistry.
Analytical methods for measuring air pollutants, continuous monitoring instruments.
UNIT-IV:

Industrial pollution:
Pollution obtained due to cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, polymers industry, steps to reduce pollution. Radionuclide analysis, solid waste management, disposal of wastes and their management.

Books and References;
1. Environmental Chemistry , S.E. Manahan, Lewis Publishers
2. Environmental Chemistry, A.K. De, Wiley Eastern.
3. Environmental Chemistry with Green Chemistry, A. K. Das, Books & Allied (P) Ltd., Kolkata, 1 st Edn, 2010.
6. Hand Book of Environmental Analysis, Pradyot Patnaik, Lewis Publishers (1997)

Semester-III

HC-301
SPECTROSCOPY-II

Mid Sem :20+10 End Sem: 70

UNIT-I:

Atomic spectroscopy:

Energies of atomic orbitals, vector representation of momenta and vector coupling, electronic configuration, Russel-saunders terms and coupling schemes, magnetic effects, spin-orbit coupling and Zeeman splitting, spectra of hydrogen atom and alkali metal atoms.

UNIT-II:

Molecular spectroscopy:

Energy levels, molecular orbitals, vibronic transitions, vibrational progressions, frank condon principle, electronic spectra of diatomic molecules, electronic spectra of poly atomic molecules, emission spectra, radiative and non-radiative decay, internal conversion, spectra of transition metal complexes (d1 and d9 system), charge transfer spectra.

UNIT-III:

Photoelectron spectroscopy

Basic principles, photoelectric effect, ionization process, Koopman's theorem, Photoelectron spectra of simple molecules (H_2,O_2,N_2,CO,H_2O), spectroscopy of core electrons, electron spectroscopy of Chemical Analysis, Chemical information from ESCA, Auger electron spectroscopy- basic idea.

UNIT-IV:

Microwave spectroscopy:

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor, Stark effect, nuclear and electron spin interaction and effect of external field, applications.

UNIT-V:

Nuclear Quadrupole Resonance Spectroscopy Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splittings, Applications.

Polarography: Current-Voltage Relationship, theory of polarographic waves, instrumentation, qualitative and quantitative application.

Books and References
1. Modern Spectroscopy, J.M. Hollas, John Wiley, 4th edition, Sussex.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L.Ho, Wiley Inter science.
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood, 1st edition, 1990.
4. Introduction to Molecular Spectroscopy, G.M.Barrow, McGraw Hill
5. Basic Principles of Spectroscopy, R.Chang, McGraw Hill.
6. Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley.
7. Introduction to Magnetic Resonance, A. Carrington and A.D. Maclachalan, Harper & Row.
8. Inorganic spectroscopic methods, A.K. Brisdon, Oxford Chem. Primers, 1997, New York.
9. Spectroscopy, S. Walker and H. Straw, Chapman and Hall ltd.
10. Energy levels in atom and molecules, W.G. Richards and P.R. Scott, Oxford, Oxford Chemistry Primer vol. 26, 1994, New York.
11. Atomic Spectra, T.P. Softley, Oxford, Oxford Chemistry Primer, Vol. 19, New York.
12. Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont.
13. Electronic Absorption Spectrocopy and related Techniques- D. Sathyanarayanan
14. Fundamental concept of Inorganic Chemistry vol-7- A.K. Das and Mahua Das, CBS Publisher
15. Fundamental of Molecular Spectroscopy- C. N Banwell, Tata McGraw Hill

HC-302

PERICYCLIC REACTIONS AND PHOTOCHEMISTRY

Mid Sem :20+10 End Sem: 70

UNIT-I:

Pericyclic Reaction:

Molecular orbital symmetry, Fourier orbitals of ethylene, 1,3- butadiene, 1,3,5 -hexatriene and allyl systems, classification of pericyclic reaction, WoodWard -Hoffmann corelation diagrams, FMO and PMO approach. Electrocyclic reactions- conrotatory and disrotatorymotions. 4n,4n+2 and allyl systems, Cycloadditions- antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleo tropic reactions.

UNIT-II:
Sigmatropic Rearrangements:
Suprafacial and antarafacial shifts of H, 3,3 – and 5,5 – sigmatropic rearrangements. Some variants of Claisen rearrangement (Johnson, Ireland, Abnormal, Asymmetric aromatic), Cope, and Aza-cope rearrangements. Fluxional tautomerism, Ene reaction

UNIT-III:
Photo chemical reactions:

Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule(singlet, triplet state), Jablonski diagram, Excimer,Exciplex, Quantum yield/quantum efficiency, transfer of excitation energy(sensitisation and quenching), Actinometry, types of photochemical reactions- photo dissociation , gas phase photolysis.
UNIT-IV:

Photochemistry of alkenes:
Intramolecular reactions of the olefinic bonds- geometrical isomerism, cyclisation reactions, rearrangement of 1,4 and 1,5-dienes, di-π methane arrangements
Photochemistry of carbonyl compounds:
Intramolecular reactions of carbonyl compounds- saturated, cyclic and acyclic, β,γ unsaturated and α,β-unsaturated compounds, Norrish type I and II Reaction, Paterno-Buechi reaction, photo-dimerization of carbonyl compounds.

UNIT-V:

Photochemistry of aromatic compounds :

Ring isomerisation, additions, and substitutions, Cyclisation reaction.
Miscellaneous photochemical reactions:
Photo-Fries Rearrangement, Photo-Fries reactions of anilides, Barton reaction, singlet molecular oxygen reactions, Photochemical formation of smog, photo degradation of polymers.

Books and References;
1. Pericyclic Reactions, S. M. Mukherji, Macmillan, India.
2. Conversion of Orbital Symmetry, R.B. Woodward and R. Hoffman
3. Organic Reactions and Orbital Symmetry,R. C. Storr, T. L Gilchrist
4. Fundamentals of Photochemistry, K.K.Rohtagi-Mukherji, Wilcy-Eastern.
5. Molecular Photochemistry, N.J.Turro, W.a.Benjamin.
6. Introductory Photochemistry, A.Cox and T.Camp. McGraw-Hill.
7. Photochemistry, R.P.Kundall and A.Gibert, Thomson Nelson.
8. Organic Photochemistry, J.Coxon and B.Halton, Cambridge University Press.

HC-303

PHYSICAL CHEMISTRY PRACTICAL

Mid Sem :20+10 End Sem: 70

Chemical kinetics:

1.Saponification of ethyl acetate with sodium hydroxide by chemical method.

2. Comparison of strength of acids by ester hydrolysis.

3. Determination of energy of activation of acid catalysed hydrolysis of methyl acetate.

Adsorption:

1. Adsorption of acetic acid and oxalic acid on animal charcoal.
2. Construction of phase diagram for a three component system (chloroform- acetic acid-water)

Electrochemistry:

1. Determination of solubility and solubility product of sparingly soluble (eg $PbSO_4$, $BaSO_4$) conductometrically.
2. Determination of the strength of strong and weak acids in a given mixture conductometrically

Potentiometry/ pH metry:

1. Determination of the strength of strong and weak acid in a given mixture using a potentiometer/ pH meter
2. Determination of the strengths of halides in a mixture potentiometrically.
3. Determination of the dissociation constant of acetic acid in acetone by titrating it with KOH in water medium.

Polarimetry:

Determination of rate constant for hydrolysis /inversion of sugar using a polarimeter.

CE-301

(A) BIOCHEMISTRY

Mid Sem :20+10 End Sem: 70

UNIT-I:
Bio physical chemistry- I:

Introduction, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation, nomenclature and classification, Fischer's lock and key and koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity, labelling and enzyme modifications by the site directed mutagenesis.

UNIT-II:

Bio physical chemistry-II:
Enzyme kinetics, Michaelis- Menten and Lineweaver -burk plots, reversible and irreversible inhibition, Transition state theory, Orientation and steric effect, acid base catalysis, covalent catalysis, strain or distortion.

UNIT-III:

Bio-Physical chemistry-III:
Surface active agents, classification of surface active agents, concepts on micelle, micellization, Critical Micellar Concentration, Kraft temperature, Factors affecting theCMC of surfactants, reverse micelles, micro emulsion, Nucleosides and nucleotides, concept of lipids and liposome.

UNIT-IV:

Bio-organic chemistry-I:
Example of some typical enzyme mechanism: chymotrypsin, ribonuclease, lysozyme, carboxypeptidase A. cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes, structure and biological functions of coenzyme A, thiamine pyrophosphate, pyrophosphate, NAD+, NADP+, FMN, FAD, Lipolic acid, Vitamin B12.

UNIT-V:

Bio-organic chemistry-II:
Mechanism of reactions catalysed by cofactors, Nucleophillic displacement on a phosphorous atom, multiple displacement reaction and coupling of ATP cleavage to endergonic processes, transfer of sulfate, addition and elimination reactions, enolic intermediates in the isomerization reactions, β-cleavage and condensation, isomerisation, rearrangement, carboxylation, decarboxylation.

Books and References

1. *Bioorganic Chemistry: A chemical approach to enzyme action*-Hermann Dugas, C. Penny, Springer Verlag.
2. *Biochemistry (The Chemical reactions of living cells)*: D. E. Metzler, (Academic Press)
3. *Enzyme chemistry Impact and applica*tions, Ed. Collin J. Sucklins, chapman and Hall
4. *Enzyme reaction mechanisim*: C. Walsh and W. H. Freeman.
5. *Enzyme structure and mechanisim*: A. Fersht and W. H. Freeman.
6. *Fundamentals of Biochemistry*: A. C. Daeb, New Central Book Agency, pvt. Ltd.
7. *Biochemistry*: C. B. Powar and G. R. Chatwal, Himalaya publishing House.

CE-301
(B) BIO-INORGANIC AND SUPRAMOLECULAR CHEMISTRY
Mid Sem :20+10 End Sem: 70

UNIT-I:
Metal ions in biological systems and its storage transport and biomineralization:

Essential and trace elements, Ferritin, Transferrin and siderophores. Calcium in biology Transported regulation, intracellular Ca^{2+} transport, Ca^{2+} AT pase, Na+/ Ca2+ exchange, mitochondrial influx and efflux, inositoltriphosphate, Ca2+ regulated intracellular processes, Calmodulin, Troponin C.

UNIT-II:
Metalloenzymes:

Zinc enzymes: carboxypeptidase and carbonic anhydrase, Iron enzymes: catalase peroxidase and cytochromes, Cyt-P450: Copper Enzymes, superoxide dismutase, Molybdenum oxatransferase enzymes: xanthine oxidase, Coenzyme Vitamin B12, Sulfur proteins.

UNIT-III:
Nitrogen fixation:
Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Photosynthesis: Chlorophylls, photo system -I and photo system -II in cleavage of water

UNIT-IV:
Transport and storage of dioxygen:

Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin. Hemocyanins and hemerthrin, model synthetic complexes of iron ,cobalt and copper.

UNIT-V:
Supramolecular Chemistry:

Concepts and language:

a) Molecular recognition: molecular receptors for different types of molecules including anionic substrates, design and synthesis of co-receptor molecules and multiple recognition.
b) Supramolecular reactivity and catalysis.
c) Transport processes and carrier designs
d) Supramolecular devices, supramolecular photo chemistry, supramolecular electronic, ionic and switching devices.

Some examples of self-assembly in supramolecular chemistry.

Books and References:

1. *Priciple of Biochemistry (Lehninger)*: D. L Nelson and M. M Cox, W. H. Freeman and company, New York.
2. *Fundamentals of Biochemistry*: D. Voet, J. G. Voet and C. W. Pratt; John wiley and sons.
3. *Inorganic Chemistry of Biological process*- M. Huges.
4. *Bio Inorganic Chemistry* – E. Ochiai

CE-302(A)
ORGANO TRANSITION METAL CHEMISTRY
Mid Sem :20+10 End Sem: 70

UNIT-I:
Alkyl and aryls of transition metals

Types routes of synthesis, stability and decomposition pathways organo-copper in organic synthesis
Compounds of transition metal-carbon multiple bonds, Alkylidenes, alkylidynes, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

UNIT-II:
Transition metal π-Complex:

Transition metal π-Complexes with unsaturated organic molecules, alkenes, alkynes, 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 organic synthesis.

UNIT-III:
Transition metal compounds with bonds to Hydrogen

Transition metal hydrides: Synthesis, properties and reactivity, transition metal dihydrogen compounds: preparation, properties and reactivity.

UNIT-IV:
Catalysis by Transition Metal Complexes-I

Coordinative unsaturation, oxidative addition and reductive elimination reactions, Insertion reactions (Insertion of CO, SO2 and alkenes), reactions of coordinated Co in metal carbonyls. Homogeneous hydrogenation of alkenes, hydro formylation of alkenes, isomerisation of olefins.

UNIT-V:

Catalysis by Transition Metal Complexes-II

Wacker's process, Zeigler Natta polymerisation of ethylene, Monsanto acetic acid, Reduction of CO by Hydrogen (Fischer-Tropsch reaction)

Fluxional Organometallic compounds

Fluxionality and dynamic equilibria in compounds such as η2- olefin,η3- allyl and dienyl complexes.

Books and References;
1. Principles and Application of Organotransition Metal Chemistry, J. P. Collman, L.S. Hegedus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R .H. Carbtree, John Wiley.
3. Metallo-organic Chemistry, A.J.Pearson, Wiley.
4. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, 4th Ed, Willey (2005).
5. Fundamental Concepts of Inorganic Chemistry, Vol. 6; Asim K. Das, CBS Publisher, 2 nd Ed., (2013).
6. Organometallic Chemistry, R.C. Mehrotra & A. Singh, New Age International, 2nd Ed (2013).

CE-302(B)
SOLID- STATE CHEMISTRY
Mid Sem :20+10 End Sem: 70

UNIT-I:

Solid state reactions:

General principles, experimental procedures, co-precipitation as a precursor to solid state reactions , sol-gel method
Crystal defects and non-stoichiometry:
Perfect and imperfect crystals, intrinsic and extrinsic defects-point defects- vacancies Schottky defects and Frenkel defects, Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry defects, line defect-edge dislocation and Screw dislocation and plane defects- Grain boundaries- Tilt boundaries.
UNIT-II:

Electronic properties of solids

Metals, insulators and semiconductors, electronic structure of solids, band theory, band structure of metals, insulators and semiconductors, intrinsic and extrinsic semiconductors, doping semiconductors, p-n- junctions, super conductors (low temperature super conductor, BCS theory, High temperature super conductor)
Surface chemistry:

Surface tension, capillary action, pressure difference across curved surface (Laplace equation). Vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET Equation),surface films on liquids (Electrokinetic phenomenon)
UNIT-III:

Optical properties of solids

Optical reflectance, photoconduction-photoelectric effects, refraction, dispersion, polarization. Magnetic properties of solids:Classification of materials, Quantum theory of paramagnetics- cooperative phenomena, magnetic domains, hysteresius.
UNIT-IV:

Diffraction methods: X-ray diffraction.
Generation of X-rays, properties of X-rays, continuous spectrum, characteristic spectrum, Filters, Bragg condition, Miller Indices, Structure factor and its relation to intensity, identification of unit cells from systematic absences in diffraction pattern, structure factor calculation for NaCl, KCl.
Description of the procedure for an X-ray structure analysis, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, indexing of crystals, Ramchandran diagram or [φ,ψ]plot.
UNIT-V:

Neutron Diffraction
Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques, Elucidation of structure of magnetically ordered unit cell.

Organic Solids

Electrically conducting solids, organic charge transfer complex, organic metals, new superconductors.

Books and References;
1. Solid State Chemistry and its Applications, A.R.West, Wiley, 1989, Singapore. 2 nd Ed., Singapore.
2.Principles of the Solid State, H.V.Keer, Wiley Eastern, 1993, New Delhi
3. Solid State Chemistry, N.B. Hannay.
4. Solid State Chemistry, D.K. Chakrabarty, New Age International., 1996, New Delhi
5. Understanding solids, The Science of Materials, R. J. Tilley, John Wiley & Sons, 2004, Sussex.
6. Applications of neutron Powder diffraction, Kisi and Howard, Oxford Science, 2008, New York.
7. Elements Of X Ray Diffraction, B. D Cullity, Addison-Wesley Publishing Company Inc., 1956, USA.
8. Chemistry of solids: A.K. Galwey., Science paperbacks and Chapman and Hall Ltd

Semester-IV

HC-401
ORGANIC SYNTHESIS
Mid Sem :20+10 End Sem: 70

UNIT-I:
Oxidation:

Oxidation of organic molecules using ruthenium tetraoxide, hypervalent iodine, thallium (III) Nitrate, dichloro dicyanobenzoquinone (DDQ), selenium dioxide, dimethyl sulfoxide, peracids, oxone, dioxiranes, tetramethyl piperidine nitroxide,Ozone, molybdenum, Suzuki coupling, Negishi coupling, Stille coupling, Heck reaction.

UNIT-II:
Reduction:

Reduction of organic molecules using boron based reagents, Aluminium- based reagents, free radical reagent, Silane based reagents, Dissolving metal reduction, Diimide reduction, Wolff- Kishner reduction, Hydrogenation using Pd, Pt, Rh, Ni on solid support.

UNIT-III:
Protecting groups:

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

UNIT-IV:
One group C-C disconnection:

Alcohols and carbonyl compounds, regioselectivity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.Two group C-C disconnection:
Diels-Alder reaction, 1,3- difunctionalised compounds, α,β- unsaturated carbonyl compounds, control in carbonyl condensations, 1,5- difunctional compounds, Micheal addition and Robinson annelation.

UNIT-V:
Ring synthesis:

Saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis Application of the disconnection approach in the synthesis of following compounds. Camphor, longifolene, Cortisone.

Books and References;
1. *Organic chemistry*: J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. *Advanced Organic Chemistry Reactions, Mechanism and Structure*: Jerry March. John Wiley and Sons.
3. *Advanced Organic Chemistry*: FA Carey and RJ. Sundberg. Plenum.
4. *Photo Chemistry and Pericyclic Reactians*: Jagdamba Singh and Jaya Singh, New Age Internatianal.

HC-402
APPLIED CHEMISTRY PRACTICAL
Mid Sem :20+10 End Sem: 70

Analysis of water parameters:

g) Determination of DO, COD and BOD of water samples.
h) Analysis of ground water sample for sulphate by titrimetry (EDTA) and turbidimetry
i) Analysis of water sample for phosphate by molybdenum blue method.
j) Determination of Fluoride in drinking water / ground water by spectrophotometry (alizarin red lake method)

1. Synthesis of Polymers:
   a) Novolac/ resole resin using phenol and formaldehyde
   b) Po;yethylene tetrasulfide by emulsion polymerization
2. Characterisation of polymers;
   a) Determination of viscosity average molecular weight of polystyrene(PS) , poly vinyl alcohol(PVA)
   b) Thermal and spectral analysis (IR) of selected polymers
3. Miscellaneous:
   a) Analysis of fat in a butter sample
   b) Spectrophotometric estimation of hexavalent chromium in water samples.
   c) Spectrophotometric estimation of phosphate in cola drinks.
   d) Verification of beer-lambert's law

Books and References;
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, 6thy Edition.
2. Hand book 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, 17th Edition.

HC-403
DISSERTATION
Seminar/ Presentation-30 Dissertation- 70

The dissertation shall consist of conducting a small project under faculty members of the department. In general the student is expected to do literature review in the assigned topic, and to do some kind of experimental investigation and result analysis. However, final decision regarding the execution of project work rests with the supervisor/co-supervisor and the committee on mutual discussion to the best benefit of the student for academic career. The guideline provided by UGC shall be also taken into account in this regard.

CE-401(A)
SPECTROSCOPY-III:
Mid Sem :20+10 End Sem: 70

UNIT-I:

Electron spin resonance spectroscopy:

Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, applications.

UNIT-II:

Vibrational spectroscopy:

Review of harmonic oscillator, vibrational energies of diatomic molecules, zero point energy,force constant and bond strengths, anharmonicity, morse potential energy diagram, vibration-rotation spectroscopy, P,Q,R Branches, Born-Oppenheimer approximation, breakdown of Oppenheimer approximation, vibrations of polyatomic molecules, selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, normal co-ordinate analysis.

UNIT-III:

Raman spectroscopy:

Classical and quantum theories of Raman effect, pure rotational, vibrational, and vibrational-rotational Raman spectra, selection rules, Mutual exclusion principle, Resonance Raman spectroscopy, coherent anti stokes Raman spectroscopy(CARS).

UNIT-IV:

Nuclear magnetic resonance of paramagnetic substances in solution:

The contact and pseudo contact shifts, factors affecting nuclear relaxation, some applications including biochemical systems, an overview of NMR of metal nuclides with emphasis of Pt^{195} and Sn ^{119} NMR.

UNIT-V:

Mossbauer spectroscopy:

Basic principles, spectral line shape and natural line width, characteristics of Mossbauer nucleides, Dopplers effect, Mossbauer spectra of Fe57 system, parameters to evaluate Mossbauer Spectra; chemical shift or isomeric shift, quadrupole interaction, magnetic field interaction, application of the technique to the studies of bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, Sn^{+2} and Sn^{+4} compounds, nature of M-L bond.

Books and References:

1. Fundamentals of molecular spectroscopy, C.N.Banwell and E. McCash, tata McGraw Hill, 4th edition, 1994, NewDelhi
2. Introduction to spectroscopy, Pavia, Brooks/Cole Cengage, 4th edition, 2009
3. Inorganic electronic spectroscopy, A.P.B.Lever, Elsevier
4. Mossbauer spectroscopy-Greenwood and Gibbs
5. Molecular structure and spectroscopy- Aruldhas
6. Analytical chemistry- theory and practice- U.N.Das
7. Physical methods for Chemistry, R,S, Drago- Saunders company
8. Infrared and raman spectra; inorganic and co-ordination compounds, K. Nakamoto, Wiley

CE—401(B)
ANALYTICAL CHEMISTRY

Mid Sem :20+10 End Sem: 70

UNIT-I:

Thermal analysis:

Thermos gravimetric analysis(TGA): instrumentation, derivative thermogravimetric analysis(DTG), applications of thermogravimetry, Differential thermal analysis(DTA): principle, instrumentation and applications of differential thermal analysis, simultaneous TG-DTA curves,Differential scanning calorimetry(DSC). Principle, basic instrumentation and applications, Thermogravimetric titration, principle and applications

UNIT-II:

Electroanalytical methods:

Classification of electro analytical methods, principles and applications of voltammetry, cyclic voltammetry, anodic stripping voltammetry, polarography, coulometry, conductometry and ion selective electrodes(extensive instrumentations are to be excluded)

UNIT-III:

Atomic absorption spectroscopy:

Principle and instrumentation, flame atomization, hollow cathode lamps, interference in AAS, applications of AAS in qualitative and quantitative analysis.

Chromatography:
Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: TLC and HPLC.

UNIT-IV:
Flame photometric methods:
Basic principle and instrumentation, interference in flame photometry, applications in quantitative analysis.
Nephelometric method: principle and instrumentation applications in analysis.

UNIT-V:
Error analysis;
Statistical methods in chemical analysis, theory of error and treatment of quantitative data, accuracy, and precission, ways of expressing accuracy and precision, Normal errorcurve and its equation, useful statistical tests with equation, test of significance, the F-test, The students t-test, Chi test, the correlation coefficient, confidence limit of the mean, comparison of two standard values ,comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis(least square method for linear plots)

Books and References;

1. Fundamentals of analytical chemistry, D.A. Skog, D.M. West and F.J. Hollar, 7th edition, Harcourt college publishers.
2. Analytical chemistry, Gary D. Christian, 6th edition, John Wiley& sons(Aisa) Pte. Ltd.(Wiley Student Edn)2004
3. Introduction to thermal analysis: techniques and application, M.E. Brown, Kluer Academic Publisher, New York(2004)
4. Instrumental methods of analysis, H.H.Willard, L.L.Merritt and J.A.Dean, East-West Press, New Delhi, 1988.
5. Principle and practice of analytical Chemistry, F.A. Fifield & Dacid Kealy, Blackwell Publishing, 5th edition,2000.
6. Analytical chemistry,(Theory and practice) U.N.Dash
7. Basic concepts of analytical chemistry; S.M.Khopkar, Wiley Eastern.