GENERAL REQUIREMENTS

Scheme of Instructions:

A. A Masters Degree program is of 4 semesters-two years duration. A candidate can avail a maximum of 8 semesters – 4 years (in one stretch) to complete Masters degree (including blank semesters, if any). Whenever a candidate opts for blank semesters, he/she has to study the prevailing courses offered by the department when he/she continues his/her studies.

B. A candidate has to earn a minimum of 76 credits, for successful completion of a Master Degree. The 76 credits shall be earned by the candidate by studying Hardcore, Softcore and Open Elective.

C. **Minimum for Pass:** In case a candidate secures less than 30% in C_1 and C_2 put together, the candidate is said to have DROPPED the course, and such a candidate is not allowed to appear for C_3.

D. In case a candidate secures less than 30% in C_3, or secures more than 30% in C_3 but less than 50% in C_1, C_2 and C_3 put together, the candidate is said to have not completed the course and he/she may either opt to DROP the course or to utilize PENDING option.

E. **Credits (Minimum) Matrix:** A candidate has to study a minimum of 16 credits in Softcore and 08 credits in Open Elective (sum total of 4 semesters) for the successful completion of the Masters Degree course.

F. All other rules and regulations hold good which are governed by the University.

GENERAL SCHEME WITH RESPECT TO ASSESSMENT OF CREDITS

Semester	Hard Core (HC)		Total	Soft Core (SC)		Total	Open Elective (OE)
	Theory	Practicals		Theory	Practicals		
I Semester	3+3+3+3=12	(3+3)+(3+3)=06[a]	**18**	2+2+2+2=08	NIL	**08**	NIL
II Semester	3+3+3+3=12	(3+3)+(3+3)=06[a]	**18**	2+2+2+2=08	NIL	**08**	2+2
III Semester	3+0+3+0=06	NIL	**06**	0+(2X2)+0+(2X2)=08	(3+3)+(3+3)=06[a,b]	**14**	2+2+2+2[d]
IV Semester	0+3+0+3=06+04[c]=10	NIL	**10**	(2X2)+0+(2X2)+0=08	(3+3)+(3+3)=06[a,b]	**14**	2+2+2+2[d]
Grand Total	**40**	**12**	**52**	**32**	**12**	**44**	**12**

[a]50% of the students will attend Analytical/Inorganic Practicals and remaining 50% students will attend Organic/Physical Practicals in I or III Semester and *vice-versa* during II or IV Semester.

[b]Practicals are only for chemistry students which are compulsory papers

[c]Dissertation/Project work

[d]Papers are common for both III and IV Semesters and the candidate can opt any paper of his/her choice in aforesaid semesters and should ascertain that the paper/s already studied in III Semester are not repeated in the IV Semester.

SCHEME OF STUDY AND EXAMINATION

FIRST SEMESTER
HARD CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA HCT: 1.1.	Fundamentals of Chemical Analysis	03	03	100	25	25	02	50
CHI HCT: 1.2.	Concepts and Models of Inorganic Chemistry	03	03	100	25	25	02	50
CHO HCT: 1.3.	Stereochemistry and Organic Reaction Mechanisms	03	03	100	25	25	02	50
CHP HCT: 1.4.	Chemical Thermodynamics, Chemical Kinetics and Electrochemistry	03	03	100	25	25	02	50

PRACTICALS

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA HCP: 1.5.	Analytical Chemistry Practicals	06	03	100	25	25	06	50
CHI HCP: 1.6.	Inorganic Chemistry Practicals	06	03	100	25	25	06	50
CHO HCP: 1.7.	Organic Chemistry Practicals	06	03	100	25	25	06	50
CHP HCP: 1.8.	Physical Chemistry Practicals	06	03	100	25	25	06	50

Note: 50% of the students will attend Analytical and Inorganic practicals and remaining 50% of the students will attend Organic and physical practicals in I semester and *vice-versa* during II semester.

SOFT CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA SCT: 1.1.	Applied Analysis - I	02	02	100	25	25	02	50
CHI SCT: 1.2.	Chemical Applications of Group Theory	02	02	100	25	25	02	50
CHO SCT: 1.3.	Reaction Mechanisms and Heterocyclic Chemistry	02	02	100	25	25	02	50
CHP SCT: 1.4.	Solid State Chemistry and Semiconductors; Biophysical Chemistry	02	02	100	25	25	02	50

SECOND SEMESTER
HARD CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA HCT: 2.1.	Separation Techniques	03	03	100	25	25	02	50
CHI HCT: 2.2.	Coordination Chemistry	03	03	100	25	25	02	50
CHO HCT: 2.3.	Synthetic Organic Chemistry	03	03	100	25	25	02	50
CHP HCT: 2.4.	Quantum Chemistry; Nuclear Chemistry and Photo Chemistry and Microwave and Infrared Spectroscopy	03	03	100	25	25	02	50

PRACTICALS

Note: It is same as that of I Semester. Students who will have studied Analytical/Inorganic or Organic/Physical Practicals will get interchanged during II Semester.

SOFT CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA SCT: 2.1.	Applied Analysis - II	02	02	100	25	25	02	50
CHI SCT: 2.2.	Inorganic Polymers and Industrial Inorganic Chemistry	02	02	100	25	25	02	50
CHO SCT: 2.3.	Photochemistry, Pericyclic reactions and Organometallic Chemistry	02	02	100	25	25	02	50
CHP SCT: 2.4.	Pharmacokinetics	02	02	100	25	25	02	50

OPEN ELECTIVE (<u>for Non-Chemistry Students only</u>)

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CH OET: 2.1.	Fundamentals of Isolation, Separation, Purification and Characterization Techniques	02	02	100	25	25	02	50
CH OET: 2.2.	Basic Principles of Chemistry	02	02	100	25	25	02	50

<u>THIRD SEMESTER</u>

HARD CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA HCT: 3.1.	Instrumental Methods of Analysis	03	03	100	25	25	02	50
CHO HCT: 3.2.	Spectroscopy	03	03	100	25	25	02	50

SOFT CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks	Semester End Exams (C_3)

					C_1	C_2	Duration	Max. Marks
CHI SCT: 3.1.	Organometallic Chemistry	02	02	100	25	25	02	50
CHI SCT: 3.2.	Structural Methods in Inorganic Chemistry	02	02	100	25	25	02	50
CHP SCT: 3.3.	Applications of Chemical Kinetics and Chemistry of Nanomaterials and Corrosion	02	02	100	25	25	02	50
CHP SCT: 3.4.	Statistical Thermodynamics and Phase Rule; Radiation Chemistry and Polymer Chemistry	02	02	100	25	25	02	50

PRACTICALS

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA SCP: 3.5.	Analytical Chemistry Practicals	06	03	100	25	25	06	50
CHI SCP: 3.6.	Inorganic Chemistry Practicals	06	03	100	25	25	06	50
CHO SCP: 3.7.	Organic Chemistry Practicals	06	03	100	25	25	06	50
CHP SCP: 3.8.	Physical Chemistry Practicals	06	03	100	25	25	06	50

Note: 1. 50% of the students will attend Analytical and Inorganic practicals and remaining 50% of the students will attend Organic and Physical practicals in III semester and *vice-versa* during IV semester.

2. Practicals papers are only for chemistry students which are compulsory

OPEN ELECTIVE (for Non-Chemistry Students only)

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA OET: 3.1.	Separation Techniques of Biochemistry and	02	02	100	25	25	02	50

	Biology							
CHI OET: 3.2.	Biological Inorganic Chemistry	02	02	100	25	25	02	50
CHO OET: 3.3.	Basic Concepts in Organic Chemistry	02	02	100	25	25	02	50
CHP OET: 3.4.	General Aspects of Physical Chemistry	02	02	100	25	25	02	50

FOURTH SEMESTER
HARD CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHI HCT: 4.1.	Bioinorganic Chemistry	03	03	100	25	25	02	50
CHP HCT: 4.2.	Solid State Chemistry and Applications of Quantum Chemistry; Advanced Chemical Kinetics and Biopharmaceutics	03	03	100	25	25	02	50

SOFT CORE

THEORY

Papers	Title	Contact Hours/ week	Credit	Max. Marks/paper	Internal Assessment Marks		Semester End Exams (C_3)	
					C_1	C_2	Duration	Max. Marks
CHA SCT: 4.1.	Applied Analysis III	02	02	100	25	25	02	50
CHA SCT: 4.2.	Applied Analysis IV	02	02	100	25	25	02	50
CHO SCT: 4.3.	Biomolecules	02	02	100	25	25	02	50
CHO SCT: 4.4.	Chemistry of Natural Products	02	02	100	25	25	02	50

PRACTICALS

Note: It is same as that of III Semester. Students who will have studied Analytical/Inorganic or Organic/Physical Practicals will get interchanged during IV Semester.

OPEN ELECTIVE (for Non-Chemistry Students only)

Note: All the papers are same as that of III Semester. A candidate can opt any paper/s of his or her choice provided that the same paper/s is not repeated in the IV Semester.

SCHEME OF EXAMINATION FOR C_1, C_2 AND C_3 COMPONENTS

Preamble: In view of the CBCS syllabus, following is the model distribution of marks for C_1, C_2 and C_3 Components. At a glance, the model includes both theory (HC/SC/OE) as well as practicals (HC/SC) assessment of marks.

The following is the scheme which will be followed for the assessment of marks for both theory (HC/SC/OE) as well as practicals (HC/SC) irrespective of the credit associated with each paper. 50% of the marks will be assessed for the internals (C_1 and C_2) and remaining 50% will be for the semester end examinations (C_3). Each paper carries 100 marks and hence 50 marks will be allotted to internals and remaining 50 marks will be for Semester End Examinations. Out of 50 marks for internals, 25 marks will be allotted to each C_1 and C_2 components. The distribution of marks for C_1 and C_2 varies with HC and SC papers.

Each theory paper (HC/SC/OE) consists of three components namely C_1, C_2 and C_3. C_1 and C_2 are designated as Internal Assessment (IA) and C_3 as Semester End Examination. Each

paper (HC/SC/OE) carries **100 Marks** and hence the allotment of marks to C_1, C_2 and C_3 Components will be 25, 25 and 50 marks respectively. i.e.,

C_1 Component	: 25 Marks	} Internal Assessment Marks
C_2 Component	: 25 Marks	
C_3 Component	: 50 Marks	Semester End Examination
Total	**: 100 Marks**	

The above will be followed in common for all the theory (HC/SC/OE) and practical (HC/SC) papers in all the four semesters.

1. THEORY:

1.1. HARD CORE (03 CREDIT PAPERS)

1.1.1 Distribution of Marks for C_1 and C_2 Components:

IA consists of 25 marks; it will be divided into three parts viz., ***Internal Test, Home Assignment and Seminar***. Internal tests will be conducted during the 8th week of the semester for C_1 and 16th week of the semester for C_2. Home Assignment will be concerned for C_1 Component and Seminar for C_2 Component only. Hence, a teacher may give only one assignment (or in their personal interest one more may be given). Since each paper has three units, the marks shall be divided equally. Allotment of marks for C_1 and C_2 is as follows: Out of 25 Marks for IA for C_1, Internal test will be conducted for 30 Marks (10 Marks from each unit and reduced to 20 Marks) and Home Assignment will be given for 05 Marks (Each Home Assignment from every unit will be assessed for 05 Marks and finally reduced to 05 Marks). IA for C_2 will be distributed as follows: Internal test will be conducted for 30 Marks (10 Marks from each unit and reduced to 20 Marks) and Seminar will be assigned for 05 Marks for the favor of IA. Please note that actual Seminar will be assessed for 20 Marks and finally 05 Marks will be distributed to each theory HC paper. i.e.,

C_1		**C_2**	
Internal Test	: 30 Marks (10+10+10) **Reduced to 20 Marks**	Internal Test	: 30 Marks (10+10+10) **Reduced to 20 Marks**
Home Assignment	: 15 Marks (05+05+05) **Reduced to 05 Marks**	Seminar	: 20 Marks (05+05+05+05) **Distributed 05 Marks to**

			each HC paper
Total	**: 25 Marks**	**Total**	**: 25 Marks**

1.1.2 Distribution of Marks for C_3 Component (Semester End Examination):

The question paper is of 2 hr duration with Max. Marks 50. The following question paper pattern will be followed for all the theory papers (HC/SC/OE). Question paper will have 3 parts A, B and C. All the three parts will cover all the units of the paper with equal marks distribution. Part A is of Short Answer Type questions which will have ten questions and each question carries one mark. A student has to answer all the ten questions (*No Choice*). Part B carries 20 Marks and comprises of eight questions wherein a student has to answer any five questions. Each question carries four marks. Part C also carries 20 Marks which will have four questions and a student has to answer any two. Each question carries ten marks. i.e.,

Model Question Paper Pattern:

Max. Duration: 2 Hr **Max. Marks: 50**

Note: *Question paper has three parts, answer all the parts*.

PART A

Ten Short Answer Type Questions, each question carries one mark **10 x 1 = 10**

PART B

Eight questions and any five should be answered. Each question carries four marks. An examiner may give one four marks question or (2+2) questions. **5 x 4 = 20**

PART C

Four questions and any two should be answered. Each question carries ten marks. An examiner may distribute ten marks as (3+3+4) or (5+5) or (4+6) or as examiner's wish.

2 x 10 = 20

1.2 SOFT CORE/OPEN ELECTIVE (02 CREDIT PAPERS):

1.2.1 Distribution of Marks for C_1 and C_2 Components:

IA consists of 25 marks; it will be divided into two parts viz., ***Internal Test and Home Assignment***. Internal tests will be conducted during the 8th week of the semester for C_1 and 16th

week of the semester for C_2. As far as Home Assignment is concerned, the concerned teacher will assign one or two Home Assignments to each student. Since each paper has two units, the marks will be divided equally. Allotment of marks for C_1 and C_2 is as follows: Out of 25 Marks for IA, Internal tests will be conducted for 20 marks and Home Assignment for 05 Marks. i.e.,

C_1		**C_2**	
Internal Test	: 20 Marks (10+10)	Internal Test	: 20 Marks (10+10)
Home Assignment	: 10 Marks (05+05) **Reduced to 05**	Home Assignment	: 10 Marks (05+05) **Reduced to 05**
Total	**: 25 Marks**	**Total**	**: 25 Marks**

1.2.2 Distribution of Marks for C_3 Component (Semester End Examination):

The above discussed pattern (1.1.2) holds good in this case also.

2. PRACTICALS (03 CREDIT PAPERS):

The following scheme will be applicable for both HC and SC in all the four semesters (SC for chemistry students only which are compulsory papers).

Each practical (HC/SC) consists of three components namely C_1, C_2 and C_3. C_1 and C_2 are designated as Internal Assessment (IA) and C_3 as Semester End Examination. Each practical (HC/SC) carries **100 Marks** and hence the allotment of marks to C_1, C_2 and C_3 Components will be 25, 25 and 50 marks respectively. i.e.,

C_1 Component	: 25 Marks	Internal Asessment Marks
C_2 Component	: 25 Marks	
C_3 Component	: 50 Marks	Semester End Examination
Total	**: 100 Marks**	

2.1 Distribution of Marks for C_1 and C_2 Components:

IA consists of **25 Marks**; it will be divided into three parts viz., ***Internal Test, Continuous Assessment and Record***. Continuous assessment refers to the daily assessment of each student based on his/her attendance, skill, results obtained etc. Thus, 10 marks are allotted for Continuous Assessment. Internal tests will be conducted for 10 Marks during the 8^{th} week of the semester for C_1 and 16^{th} week of the semester for C_2. Finally, remaining 05 Marks will be for the record. i.e.,

C_1		C_2	
Internal Test	: 10 Marks	Internal Test	: 10 Marks
Continuous Assessment	: 10 Marks	Continuous Assessment	: 10 Marks
Record	: 05 Marks	Record	: 05 Marks
Total	**: 25 Marks**	**Total**	**: 25 Marks**

5.1.2 Distribution of Marks for C_3 Component (Semester End Examination):

The end examination will be conducted for **50 Marks/paper** with a maximum duration of 6 hours. Two experiments will be given to each student which carries 20 Marks each. Each student will be subjected to Viva-Voce Examination for which 10 Marks is allotted. i.e.,

Two Experiments	: 20+20 Marks
Viva-Voce	: 10 Marks
Total	**: 50 Marks**

2.3 Project Work/Dissertation:

Each student is expected to undergo Project Work/Dissertation under the guidance of the faculty of the department during the IV Semester.

2.3.1 Distribution of Marks for C_1 and C_2 Components:

IA consists of **25 Marks**; it will be divided into three parts viz., ***Attendance, Continuous Assessment and Work Progress***. Continuous assessment refers to the daily assessment of each student based on his or her skill, results obtained, literature survey etc. C_1 will be assessed during the 8^{th} week of the semester and C_2 during the 16^{th} week of the semester. Hence, the concerned guide will prepare the marks list based on the above said parameters for both C_1 and C_2 Components.

2.3.2 Distribution of Marks for C_3 Component (Semester End Examination):

The end examination will be conducted for **50 Marks**. Every student is suppose to prepare a hard copy of the findings of the work in the form of dissertation and submitted for evaluation. This part will be assessed for 40 Marks. Each student will be subjected to Viva-Voce Examination for which 10 Marks is allotted. i.e.,

Evaluation of Dissertation	: 40 Marks
Viva-Voce	: 10 Marks
Total	**: 50 Marks**

FIRST SEMESTER

THEORY – HARD CORE

CHA HCT: 1.1. FUNDAMENTALS OF CHEMICAL ANALYSIS

UNIT – I

Analytical Chemistry - Meaning and analytical prospective, scope and function: Analytical problems and their solutions, trends in analytical methods and procedures.

Language of analytical chemistry - Analysis, determination and measurement. Techniques, methods, procedures and protocols. Classifying analytical techniques. selecting an analytical method - accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Scale of operation, equipment, time and cost. Making the final choice

Errors and treatment of analytical data: Limitations of analytical methods – Error: determinate and indeterminate errors, minimization of errors. Accuracy and precision, distribution of random errors, the normal error curve. Statistical treatment of finite samples - measures of central tendency and variability: mean, median, range, standard deviation and variance. Student's t-test, confidence interval of mean. Testing for significance - comparison of two means and two standard deviations. Comparison of an experimental mean and a true mean. Criteria for the rejection of an observation - Q-test. Propagation of errors: determinate errors and indeterminate errors.

Standardization and calibration: Comparison with standards - direct comparison and titrations. External standard calibration - the least squares methods, regression equation, regression coefficient. Internal standard methods and standard-addition methods. Figures of merit of analytical methods - sensitivity and detection limit, linear dynamic range.

[16 HOURS]

UNIT – II

Obtaining and preparing samples for analysis: Importance of sampling, designing a sample plan-random, judgement, systematic-judgement, stratified and convenience sampling. Type of sample to collect - grab and composite samples. *Insitu* sampling. Size of sample and number of samples. Implementing the sampling plan - solutions, gases and solids. Bringing solid samples into solution - digestion and decomposing.

Titrimetric analysis: An overview of titrimetry. Principles of titrimetric analysis. Titration curves. Titrations based on acid-base reactions - titration curves for strong acid and strong base, weak acid and strong base and weak base and strong acid titrations. Selecting and evaluating the

end point. Finding the end point by visual indicators, monitoring *p*H and temperature. Quantitative applications – selecting and standardizing a titrant, inorganic analysis - alkalinity, acidity and free CO_2 in water and waste waters, nitrogen, sulphur ammonium salts, nitrates and nitrites, carbonates and bicarbonates. Organic analysis - functional groups like carboxylic acid, sulphonic acid, amine, ester, hydroxyl, carbonyl. Air pollutants like SO_2. Quantitative calculations. Characterization applications - equivalent weights and equilibrium constants. **Acid-base titrations in non-aqueous media:** Role of solvent in acid-base titrations, solvent systems, differentiating ability of a solvent, some selected solvents, titrants and standards, titration curves, effect of water, determining the equivalence point, typical applications - determination of carboxylic acids, phenols and amines.

[16 HOURS]

UNIT – III

Precipitation titrations: Titration curves, feasibility of precipitation titrations, factors affecting shape - titrant and analyte concentration, completeness of the reaction, titrants and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr and the Fajan's methods, typical applications.

Complexometric titrations: Complex formation reactions, stability of complexes, stepwise formation constants, chelating agents, EDTA - acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, derivation of EDTA titration curves, effect of other complexing agents, factors affecting the shape of titration curves - completeness of reaction, indicators for EDTA titrations - theory of common indicators, titration methods employing EDTA - direct, back and displacement titrations, indirect determinations, titration of mixtures.

Redox titrations: Balancing redox equations, calculation of the equilibrium constant of redox reactions, calculating titration curves, detection of end point, visual indicators and potentiometric end point detection. Quantitative applications - adjusting the analyte's oxidation state, selecting and standardizing a titrant. Inorganic analysis - chlorine residuals, dissolved oxygen in water, water in non-aqueous solvents. Organic analysis - chemical oxygen demand (COD) in natural and waste waters, titrations of mercaptans and ascorbic acid with I_3^- and titration of organic compounds using periodate.

[16 HOURS]

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001, John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Principles and Practice of Analytical Chemistry, F.W. Fifield and Kealey, 3rd edition, 2000, Blackwell Sci., Ltd. Malden, USA.
7. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.

CHI HCT: 1.2. CONCEPTS AND MODELS OF INORGANIC CHEMISTRY

UNIT – I

Structures and energetics of ionic crystals: Introduction, MX (NaCl, CsCl, ZnS) and MX_2 (fluorite, rutile, β-crystobalite and cadmium iodide) types. The perovskite and spinel structures. Thermodynamics of ionic crystal formation. Lattice energy, Born-Haber cycle, Born-Lande equation. Applications of lattice energetics. Ionic radii, factors affecting the ionic radii, radius ratio rules.

Structures and energetics of inorganic molecules: Introduction, Energetics of hybridization. VSEPR model for explaining structure of AB, AB_2E, AB_3E, AB_2E_2, ABE_3, AB_2E_3, AB_4E_2, AB_5E and AB_6 molecules. M.O. treatment of homonuclear and heteronuclear diatomic molecules. M.O. treatment involving delocalized π-bonding (CO_3^{2-}, NO_3^-, NO_2^-, CO_2 and N_3^-), M.O. correlation diagrams (Walsh) for triatomic molecules.

[16 HOURS]

UNIT – II

Modern concept of acids and bases: Lux-Flood and Usanovich concepts, solvent system and leveling effect. Hard-Soft Acids and Bases, Classification and Theoretical backgrounds.

Non-aqueous solvents: Classification of solvents, Properties of solvents (dielectric constant, donor and acceptor properties) protic solvents (anhydrous H_2SO_4, HF and glacial acetic acid) aprotic solvents (liquid SO_2, BrF_3 and N_2O_4). Solutions of metals in liquid ammonia, hydrated electron. Super acids.

Supercritical fluids: Properties of supercritical fluids and their uses as solvents. Supercritical fluids as media for inorganic chemistry

Complex hydrides of boron and aluminium, halogens in positive oxidation states, astatine and pseudo halogens.

[16 HOURS]

UNIT – III

Electron deficient compounds: Diborane and its reactions, higher boranes, polyhedral boranes (preparations, properties, structure and bonding). Wade's rules, carboranes and metallocarboranes

Lanthanides: Review of important properties (spectral, magnetic etc.). Abundance and extraction, General principles: conventional, solvent extraction and ion exchange methods. Separation from monazite. Chemistry of principal oxidation states (II, III and IV) Uses: lanthanides as shift reagents, high temperature super conductors.

Actinides: Occurrence and preparation of elements, Isolation of the elements: thorium and uranium, enrichment of uranium for nuclear fuel, uranium hydrides, oxides and chlorides. Chemical reactivity and trend. Chemistry of trans-uranium elements.

[16 HOURS]

References:

1. Basic Inorganic Chemistry – 3rd edition. F.A. Cotton, G. Wilkinson and P.L. Gaus, John Wiley and Sons (2002).
2. Inorganic Chemistry, 3rd edition. James E. Huheey, Harper and Row Publishers (1983).
3. Inorganic Chemistry, 3rd edition. G.L. Miessler and D.A. Tarr, Pearson Education (2004).
4. Inorganic Chemistry, 2nd edition. D.F. Shriver, P.W. Atkins and C.H. Langford, Oxford University Press (1994).
5. Inorganic Chemistry, 2nd edition. C.E. Housecroft and A.G. Sharpe, Pearson Education Ltd. (2005).
6. Introduction to Modern Inorganic Chemistry, K.M. Mackay and R.A. Mackay, Blackie Publication (1989).

7. Concepts and Models of Inorganic Chemistry 3rd edition. B.E. Douglas, D.H. McDaniel and Alexander, Wiley (2001).

CHO HCT: 1.3. STEREOCHEMISTRY AND REACTION MECHANISMS

UNIT – I

Stereoisomerism: Projection formulae [Fly wedge, Fischer, Newman and Saw horse], enantiomers, diasteroisomers, racemic mixture and their resolution, configurational notations of simple molecules, *DL* and *RS* configurational notations.

Stereoselectivity: Stereoselective reactions, diasteroselective reactions, stereospecific reactions, regioselective and regiospecific reactions.

Optical isomerism: Conditions for optical isomerism, optical isomerism due to chiral centers and molecular dissymmetry, allenes and biphenyls, criteria for optical purity.

Geometrical isomerism: Due to C=C, C=N and N=N bonds, E, Z conventions, determination of configuration by physical and chemical methods.

Conformational isomerism: Elementary account of conformational equilibria of ethane, butane and cyclohexane.

Conformational analysis: Conformation of cyclic compounds such as cyclopentane, cyclohexane, cyclohexanone derivatives and decalins. Conformational analysis of 1,2, 1,3, and 1,4-disubstituted cyclohexane derivatives and *D*-Glucose, Effect of conformation on the course/rate of reactions.

[16 HOURS]

UNIT – II

Structure and reactivity: Acids and bases, Structural effect on acidity and basicity, hydrogen bonding resonance, inductive and hyperconjugation effects.

Basics of organic reactions: Meaning and importance of reaction mechanism, classification and examples for each class.

Substitution reactions: Mechanism of nucleophilic substitution reactions - Kinetics, mechanism and stereochemical factors affecting the rate of $S_N1, S_N2, S_Ni, S_N1', S_N2'$ and S_Ni' reactions, Neighbouring group participation.

Aromatic nucleophilic substitution: S_N1, S_N2 and benzyne mechanism, Bucherer reaction.

Aromatic electrophilic substitution: Mechanism of nitration, halogenation, sulphonation, Friedel-Crafts alkylation and acylation, Mannich reaction, chloromethylation, Vilsmeier-Haack reaction.

Reaction Intermediates: Formation, structure, stability, detection and reactions of carbocations (classical and non-classical), carbanions, free radicals, carbenes, nitrenes, nitrile oxides, nitrile imines, nitrile ylides and arynes.

[16 HOURS]

UNIT – III

Molecular rearrangements: Introduction

Carbon to carbon migration: Pinacol-pinacolone, Wagner-Meerwein, Benzidine, Demjanov, benzylic acid, Favorskii, Arndt-Eistert synthesis, Fries rearrangement, Steven's rearrangement, dienophine rearrangement

Carbon to nitrogen migration: Hofmann, Curtius, Lossen, Schmidt and Beckmann rearrangements.

Miscellaneous rearrangements: Sommelet-Hauser, Wittig, Smiles, Neber, Japp-Klingemann rearrangement, Meisenheimer rearrangements, Bayer-Villeger rearrangement, Allylic rearrangements.

[16 HOURS]

References:

1. H. Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mc Graw Hill, New York, 1987.
2. Organic Chemistry by Morrison & Boyd.
3. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.
4. E.L. Eliel and S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley and Sons, New York. 1994.
5. Introduction to Stereochemistry by K. Mislow.
6. Basic Principles of Organic Chemistry by Roberts & Caserio
7. N.S. Issacs, Reactive Intermediates in Organic Chemistry, John Wiley and Sons, New York.1974.
8. R.K. Bansal, Organic Reaction Mechanism, Wiley Eastern Limited, New Delhi, 1993.
9. J. March, Advanced Organic Chemistry, Wiley Interscience, 1994.
10. E.S. Gould, Mechanism and Structure in Organic Chemistry, Halt, Rinhart & Winston, New York, 964.
11. A Guide Book to Mechanism in Organic Chemistry by Petersykes
12. Stereochemistry and Mechanism through Solved Problems by P.S. Kalsi.
13. Text book of Organic Chemistry by P.S. Kalsi.

14. F.A. Carey and Sundberg, Advanced Organic Chemistry – Part A & B, 3rd edition, Plenum Press, New York, 1990.
15. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd edition, Wiley Eastern Limited, New Delhi, 1991.
16. S.K. Ghosh, Advanced General Organic Chemistry, Book and Alleied (P) Ltd, 1998.

CHP HCT: 1.4. CHEMICAL THERMODYNAMICS, CHEMICAL KINETICS AND ELECTROCHEMISTRY

UNIT – I

Concepts of entropy and free energy: Entropy as a measure of unavailable energy. Entropy change during spontaneous process. Helmholtz and Gibbs free energies. Thermodynamic criteria of equilibrium and spontaneity. Variation of free energy with temperature and pressure. Third law of thermodynamics - calculation of absolute entropies.

Partial molar properties: Partial molar volumes and their determination by intercept method and from density measurements. Chemical potential and its significance. Variation of chemical potential with temperature and pressure. Formulation of the Gibbs Duhem equation. Derivation of Duhem-Margules equation.

Fugacity: Determination of fugacity of gases. Variation of fugacity with temperature and pressure. Activity and activity coefficients. Variation of activity with temperature and pressure. Determination of activity co-efficients by vapour pressure, depression in freezing point, solubility measurements by electrical methods.

Thermodynamics of dilute solutions: Raoult's law, Henry's law. Ideal and non-ideal solutions.

[16 HOURS]

UNIT – II

Kinetics of complex reactions: Parallel, consecutive and reversible reactions. Determination of order of reaction. Arrhenius equation, energy of activation and its experimental determination. Simple collision theory - mechanism of bimolecular reaction. Lindemann's theory, Hinshelwood's theory for unimolecular reaction (No derivation). Activated complex theory of reaction rate, classical thermodynamic treatment, partition function, statistical thermodynamic treatment. Kinetics of reactions in solution - Salt effect, effect of dielectric constant (single sphere and double sphere model), effect of pressure, volume and entropy change on reaction rates. Cage effect with an example. Kinetics of heterogeneous reactions - Langmuir's theory, unimolecular and bimolecular surface reactions.

Fast reactions: Study of kinetics by flow techniques, equation for contact time, stopped flow and continuous flow methods. Relaxation method, equation for relaxation time, temperature jump and pressure jump methods, flash photolysis, pulse radiolysis and shock tube method. Potential energy surface, theoretical calculation of energy of activation.

[16 HOURS]

UNIT – III

Arrhenius theory of strong and weak electrolytes and its limitations, Debye-Huckel theory of strong electrolytes, Debye Huckel-Onsager equation, Debye-Huckel limiting equation for activity co-efficients, Debye-Huckel equation for appreciable concentrations. A brief survey of Helmholtz-Perrin, Gouy-Chapman and Stern electrical double layer (No Derivation). Liquid junction potential and its determination. Transport Number**:** Determination of transport number by Hittorf method and e.m.f method. True and apparent transport numbers. Abnormal transport numbers, effect of temperature and concentration on transport number.

Irrversible electrode process: Introduction, reversible and irreversible electrodes, reversible and irreversible cells. Polarization, over voltage - ohmic over voltage, concentration over voltage activation over voltage, experimental determination of over voltage. Equations for concentration over potential, diffusion current – stationary current, potential curves, thickness of diffusion layer, diffusion controlled current – potential curves at a dropping mercury electrode, polarography, half wave potential, application in qualitative and quantitative analysis. Energy barrier and electrode kinetics, Butler-Volmer equation, Tafel equation. Hydrogen over voltage and Oxygen over voltage. Effect of temperature, current density and *p*H on over voltage.

[16 HOURS]

References:

1. Thermodynamics for Chemists by S. Glasstone, Affiliated East-West Press, New Delhi, (1965).
2. Chemical Thermodynamics by I.M. Klotz, W.A. Benzamin Inc. New York, Amsterdam (1964).
3. Basic Physical Chemistry by W.J. Moore, Prentice Hall of India Pvt. Ltd., New Delhi (1986).
4. Text Book of Physical Chemistry by Samuel Glasstone, MacMillan Indian Ltd., 2nd edition (1974).
5. Theoretical Chemistry by S. Glasstone.
6. Elementary Statistical Thermodynamics by N.D. Smith Plenum Press, NY (1982).

7. Elements of Physical Chemistry by Lewis and Glasstone.
8. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990)
9. Chemical Kinetics by K.J. Laidler.
10. Chemical Kinetics by Frost and Pearson.
11. Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.
12. Chemical Kinetics by L.K. Jain.
13. Chemical Kinetics by Benson.
14. Kinetics in Analytical Chemistry by H.B. Mark and G.A. Rechnitz, Wiley Interscience Publishers, John Wiley and Sons, New York.
15. Introduction to Electrochemistry by S. Glasstone.
16. Advances in Photochemistry - Rohatgi Mukherjee.
17. Principle and Applications of Photochemistry by R.P. Wayne, Elsevier, New York, (1970).

PRACTICALS – HARD CORE

CHA HCP: 1.5. ANALYTICAL CHEMISTRY PRACTICALS

[96 HOURS]

PART – I

1. Determination of total acidity of vinegar and wines by acid-base titration.
2. Determination of purity of a commercial boric acid sample, and Na_2CO_3 content of washing soda.
3. Analysis of chromate-dichromate mixture by acid-base titration.
4. Determination of replaceable hydrogen and relative molecular mass of a weak organic acid by titration with NaOH.
5. Determination of ephedrine and aspirin in their tablet preparations by residual acid-base titrimetry.
6. Determination of purity of aniline and assay of chlorpromazine tablets by non-aqueous acid-base titration.
7. Periodate determination of ethylene glycol and glycerol (Malprade reaction).
8. Determination of carbonate and bicarbonate in a mixture by *p*H-metric titration and comparison with visual acid-base titration.
9. Determination of purity of a commercial sample of mercuric oxide by acid-base titration.
10. Determination of benzoic acid in food products by titration with methanolic KOH in chloroform medium using thymol blue as indicator.

11. Determination of the *p*H of hair shampoos and *p*H determination of an unknown soda ash.
12. Analysis of water/waste water for acidity by visual, *p*H metric and conductometric titrations.
13. Analysis of water/waste water for alkalinity by visual, *p*H metric and conductometric titrations.
14. Determination of carbonate and hydroxide-analysis of a commercial washing soda by visual and *p*H-titrimetry.
15. Determination of ammonia in house-hold cleaners by visual and conductometric titration.
16. Potentiometric determination of the equivalent weight and Ka for a pure unknown weak acid.
17. Spectrophotometric determination of creatinine and phosphorus in urine.
18. Flame emission spectrometric determination of sodium and potassium in river/lake water.
19. Spectrophotometric determination of *p*Ka of an acid-base indicator.

PART – II

1. Determination of percentage of chloride in a sample by precipitation titration - Mohr, Volhard and Fajan's methods.
2. Determination of silver in an alloy and Na_2CO_3 in soda ash by Volhard method.
3. Mercurimetric determination of blood or urinary chloride.
4. Determination of total hardness, calcium and magnesium hardness and carbonate and bicarbonate hardness of water by complexation titration using EDTA.
5. Determination of calcium in calcium gluconate/calcium carbonate tablets/injections and of calcium in milk powder by EDTA titration.
6. Analysis of commercial hypochlorite and peroxide solution by iodometric titration.
7. Determination of copper in an ore/an alloy by iodometry and tin in stibnite by iodimetry.
8. Determination of ascorbic acid in vitamin C tablets by titrations with $KBrO_3$ and of vitamin C in citrus fruit juice by iodimetric titration.
9. Determination of iron in razor blade by visual and potentiometric titration using sodium metavanadate.
10. Determination of iron in pharmaceuticals by visual and potentiometric titration using cerium(IV) sulphate.
11. Determination of nickel in steel by synergic extraction and boron in river water/sewage using ferroin.

12. Determination of total cation concentration of tap water by ion-exchange chromatography.
13. Determination of magnesium in milk of magnesium tablets by ion-exchange chromatography.
14. Cation exchange chromatographic separation of cadmium and zinc and their estimation by EDTA titration.
15. Gas chromatographic determination of ethanol in beverages.
16. Determination of aspirin, phenacetin and caffeine in a mixture by HPLC.
17. Solvent extraction of zinc and its spectrophotometric determination.
18. Anion exchange chromatographic separation of zinc and magnesium followed by EDTA titration of the metals.
19. Separation and determination of chloride and bromide on an anion exchanger.
20. Thin layer chromatographic separation of amino acids.

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Practical Clinical biochemistry methods and interpretations, R. Chawla, J.P. Bothers Medical Publishers (P) Ltd., 1995.
7. Laboratory manual in biochemistry, J. Jayaraman, New Age International Publishers, New Delhi, 1981.
8. Practical Clinical Biochemistry by Harold Varley and Arnold.Heinmann, 4th edition.

CHI HCP: 1.6. INORGANIC CHEMISTRY PRACTICALS

[96 HOURS]

PART – I

1. Determination of iron in haematite using cerium(IV) solution (0.02M) as the titrant, and gravimetric estimation of insoluble residue.
2. Estimation of calcium and magnesium carbonates in dolomite using EDTA titration, and gravimetric analysis of insoluble residue.
3. Determination of manganese dioxide in pyrolusite using permanganate titration.
4. Quantitative analysis of copper-nickel in alloy/mixture:
    i. Copper volumetrically using KIO_3.
    ii. Nickel gravimetrically using DMG
5. Determination of lead and tin in a mixture: Analysis of solder using EDTA titration.
6. Quantitative analysis of chloride and iodide in a mixture:
    i. Iodide volumetrically using KIO_3
    ii. Total halide gravimetrically
7. Gravimetric analysis of molybdenum with 8-hydroxyquinoline.
8. Spectrophotometric determinations of:
    a. Titanium using hydrogen peroxide
    b. Chromium using diphenyl carbazide in industrial effluents
    c. Iron using thiocyanate/1,10-phenanthroline method in commercial samples
    d. Nickel using dimethylglyoxime in steel solution
9. Micro-titrimetric estimation of :
    a) Iron using cerium(IV)
    b) Calcium and magnesium using EDTA
10. Quantitative estimation of copper(II), calcium(II) and chloride in a mixture.
11. Circular paper chromatographic separation of: (Demonstration)
    a. Iron and nickel
    b. Copper and nickel

PART – II

Semimicro qualitative analysis of mixtures containing **TWO** anions and **TWO** cations (excluding sodium, potassium and ammonium cations) and **ONE** of the following less common cations: W, Mo, Ce, Th, Ti, Zr, V, U and Li.

References:

1. Vogel's Text Book of Quantitative Chemical Analysis – 5th edition, J. Basset, R.C. Denney, G.H. Jeffery and J. Mendhom.
2. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel, 3rd edition.
3. Spectrophotometric Determination of Elements by Z. Marczenko.
4. Vogel's Qualitative Inorganic Analysis – Svelha.
5. Macro and Semimicro Inorganic Qualitative Analysis by A.I. Vogel.
6. Semimicro Qualitative Analysis by F.J. Welcher and R.B. Halin.
7. Quantitative Chemical Analysis by Daniel C. Harris, 7th edition, (2006).

CHO HCP: 1.7. ORGANIC CHEMISTRY PRACTICALS

[96 HOURS]

PART – I

1. Preparation of *p*-nitro aniline from acetanilide.
2. Preparation of n-butyl bromide from n-butanol.
3. Preparation of *p*-nitroiodobenzene from paranitroaniline.
4. Preparation of aniline from nitrobenzene.
5. Preparation of ß-*D*-Glucose penta acetate.
6. Preparation of phenoxy acetic acid.
7. Preparation of cyclohexanone from cyclohexanol.
8. Preparation of chalcone.
9. Preparation of *S*-Benzylthiuronium chloride.
10. Condensation of anthracene and maleic anhydride (Diels-Alder reaction).
11. Preparation of m-nitrobenzoic acid from methyl benzoate.

PART – II

Qualitative analysis: Separation of binary mixtures, identification of functional groups and preparation of suitable solid derivatives.

CHP HCP: 1.8. PHYSICAL CHEMISTRY PRACTICALS

[96 HOURS]

PART – I

1. Study of kinetics of hydrolysis of an ester using HCl/H_2SO_4 at two different temperatures, determination of rate constants and energy of activation.
2. Study of kinetics of reaction between $K_2S_2O_8$ and KI, first order, determination of rate constants at two different temperatures and E_a.
3. Conductometric titration of a mixture of HCl and CH_3COOH against NaOH.
4. Conductometric titration of a mixture of HCl, CH_3COOH and $CuSO_4$ against NaOH.
5. Potentiometric titration of KI *vs* $KMnO_4$ solution.
6. Determination of dissociation constant of a weak acid by potentiometric method.
7. Potentiometric titration of $AgNO_3$ *vs* KCl.
8. To obtain the absorption spectra of coloured complexes, verification of Beer's law and estimation of metal ions in solution using a spectrophotometer.
9. Spectrophotometric titration of $FeSO_4$ against $KMnO_4$.
10. Determination of heat of solution of benzoic acid by variable temperature method (graphical method).
11. Thermometric titration of hydrochloric acid with NaOH.
12. Determination of molecular weight of a compound using Bekmann's cryoscopic method using benzene or/and water as solvent.
13. Potentiometric titration of Fe(II) vs V(V).
14. Kinetics of photodegradation of indigocarmine (IC) using TiO_2 as photocatalyst and study the effect of $[TiO_2]$ and [IC] on the rate of photodegradation.
15. Conductometry – To determine the degree of hydrolysis and hydrolysis constant of aniline hydrochloride.
16. Conductometric titration of potassium iodide with mercuric perchlorate.
17. Determination of the molecular weight of a polymer material by viscosity measurements (cellulose acetate/methyl acrylate).
18. Analysis of a binary mixture (Gylcerol & Water) by measurement of refractive index.
19. Determination of degree of association of benzoic acid in benzene by distribution method.
20. Study of kinetics of reaction between CAT and indigocarmine spectrophotometrically and determination of rate constant.
21. Determination of energy of activation for the bromide-bromate reaction.
22. Conductometric titration of sodium sulphate against barium chloride.
23. Potentiometric titration of a mixture of halides (KCl+KBr) against $AgNO_3$.

24. Determination of redox potential of Fe^{2+} ions by potentiometric method.
25. Determination of partial molar volume of NaCl-H_2O system.
26. G.M. Counter – determination of G.M. plateau and dead time.
27. Verification of inverse square law using gamma emitter.
28. Determine the concentration of KI potentiometrically by calibration method

PART – II

1. Study of kinetics of hydrolysis of an ester using HCl/H_2SO_4 at two different concentrations, determination of rate constants and compare the rate constants.
2. Study of kinetics of reaction between $K_2S_2O_8$ and KI, second order, determination of rate constant and E_a.
3. Conductometric titration of a mixture of HCl and $ClCH_2COOH$ against NaOH.
4. Conductometric titration of a mixture of HCl, HCOOH and $CuSO_4$ against NaOH.
5. Potentiometric titration of KCl *vs* $KMnO_4$ solution.
6. Determination of dissociation constant of acetic acid by potentiometric method.
7. Potentiometric titration of $AgNO_3$ *vs* KBr.
8. Verification of Beer's law and calculation of molar extinction coefficient for $CuSO_4$ system.
9. Spectrophotometric titration of $FeSO_4$ against $K_2Cr_2O_7$.
10. Determination of heat of solution of salicylic acid by variable temperature method (Graphical method).
11. Thermometric titration of sulphuric acid with NaOH.
12. Potentiometric titration of Fe(II) *vs* Ce(IV).
13. Kinetics of photodegradation of indigocarmine (IC) using ZnO as photocatalyst and study the effect of [ZnO] and [IC] on the rate of photo degradation.
14. Conductometry – To determine the degree of hydrolysis and hydrolysis constant of aniline hydrochloride.
15. Conductometric titration of potassium iodide with mercuric perchlorate.
16. Determination of the molecular weight of a polymer material by viscosity measurements (polyvinyl alcohol/polystyrene).
17. Binary analysis of two miscible liquids by viscometric method (Ethanol & Water)
18. To study the salt effect on kinetics of reaction between $K_2S_2O_8$ and KI.
19. Study of kinetics of reaction between CAT and indigocarmine spectrophotometrically and determination of rate constant.

20. G.M. Counter – determination of G.M. plateau and dead time.
21. Verification of inverse square law using gamma emitter.
22. Kinetics of acid hydrolysis of an ester and study of effect of dielectric constant of the medium (using CH_3OH).
23. *p*H titration of (a) (CH_3COOH+HCl) *vs* NaOH (b) $CuSO_4$ *vs* NaOH and determination of K_a.
24. Kinetics of acid hydrolysis of an ester and study of effect of dielectric constant of the medium (using CH_3OH).
25. Conductometric titration of formic acid/oxalic acid against NaOH and NH_4OH.
26. Conductometric titration of orthophosphoric acid against NaOH.
27. Determine the concentration of KI potentiometrically by calibration method
28. Determination of energy of activation for the bromide-bromate reaction.

References:

1. Practical Physical Chemistry – A.J. Findlay.
2. Experimental Physical Chemistry – F. Daniels *et al*.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico-Chemical Experiments – J. Rose.
7. Practical Physical Chemistry – S.R. Palit.
8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994).
11. Experimental Physical Chemistry – R.C. Das. and B. Behera, Tata Mc Graw Hill.

THEORY – SOFT CORE

CHA SCT 1.1: APPLIED ANALYSIS I

UNIT – I

Air pollution, analysis and control: Historical overview - global implications of air pollution, sources of pollutants, classification of pollutants. Sources and effects of particulates, carbon monoxide, sulphur oxides, nitrogen oxides, hydrocarbons and photochemical oxidants on human health, vegetation and materials. Standards for air pollutants.

Air quality monitoring: Sampling methods and devices for particulates and gaseous pollutants. SO_2: ambient air measurements and stack gas measurements - Turbidimetric, colorimetric, conductometric and coulometric methods, NOX: Griess-ilosvay and Jacobs-Hockheiser colorimetric methods, chemiluminiscent technique, CO: NDIR, amperometric, FID and catalytic oxidation methods. Hydrocarbons: total and individual hydrocarbons by gas chromatography. Oxidants and ozone: colorimetric, coulometric, titrimetric and chemiluminescence methods.

Air Pollution control: Atmospheric cleaning processes, approaches to contaminant control-detection and control at source.

Control devices for particulates: Gravitational settlers, centrifugal collectors, wet collectors, electrostatic precipitation and fabric filtration.

Control devices for gaseous pollutants: adsorption, absorption, condensation and combustion processes. Automative emission control-catalytic converters.

[16 HOURS]

UNIT - II

Water pollution and analysis: Water resources, origin of wastewater, types of water pollutants; their sources and effects, chemical analysis for water pollution control - objectives of analysis, parameters of analysis, sample collection and preservation. Environmental and public health significance and measurement of colour, turbidity, total solids, acidity, alkalinity, hardness, chloride, residual chlorine, chlorine demand, sulphate, fluoride, phosphates and different forms of nitrogen in natural and waste/polluted waters, heavy metal pollution - public health significance of Pb, Cd, Cr, Hg, As, Cu, Zn and Mn, general survey of the instrumental techniques for the analysis of heavy metals in aquatic systems, organic loadings - significance and measurement of DO, BOD, COD, TOD, and TOC, phenols, pesticides, surfactants and tannin and lignin as water pollutants and their determination.

[16 HOURS]

References:

1. Standard Methods of Chemical Analysis, A.J. Weleher (Part B), Robert E. Kriegor Publishing Co. USA, 1975.
2. Environmental Chemistry, S.E. Manahan Willard grant press, London, 1983.
3. Environmental Chemical Analysis, Iain L Marr and Malcolm S. Cresser, Blackie and Son Ltd., London, 1983.
4. Chemistry for Environmental Engineering, Chair N. Sawyer and Perry L.M Canty, Mcgraw Hill Book, Co., New York, 1975.
5. The Air Pollution Hand Book, Richard Mabey, Penguin, 1978.
6. The Pollution Hand Book, Richard Mabey, Ponguin 1978.
7. Soil Chemical Analysis, M.L. Jackson, Prentice Hall of India Pvt, Ltd., New Delhi, 1973.
8. Experiments in Environmental Chemistry, P.D. Vowler and D.W. Counel, Pergamon press, Oxford 1980.
9. Manual Soil Laboratory Testing, vol I, K.H. Head, Pentech Press, London 1980.
10. A Text Book of Environmental Chemistry and Pollution Control, S.S. Dara, S. Chand and co. Ltd. New Delhi 2004.
11. Air pollution Vol II edition by A.C. Stern, Academic Press New York, 1968.
12. Instrumental Methods for Automatic Air Monitoring Systems in Air Pollution Control, Part-III edition by W. Stranss, John-Wiley and Sons, New York, 1978.
13. Analysis of Air pollutants, P.O. Warner, John Wiley and Sons, New York, 1976.
14. The Chemical Analysis Air pollutants, Interscience, New York, 1960.
15. The Analysis of Air Pollutants, W. Liethe, Ann Arbor Science Pub. Inc. Michigan 1970.
16. Environmental Chemistry, A. K. De.

CHI SCT 1.2: CHEMICAL APPLICATIONS OF GROUP THEORY

UNIT – I

Molecular symmetry: Symmetry elements and symmetry operations, rotation axis, rules for orientation of molecules, plane of symmetry, rotation-reflection axis, centre of symmetry and identity element of symmetry. Products of symmetry operations. General relations among symmetry elements and symmetry operations.

Group theory: Concept of a group, definition of a point group, procedure for classification of molecules into point groups. Subgroups. Schoenflies and Hermann-Maugin symbols for point groups. Multiplication tables for the symmetry operations of simple molecules. Matrix notation

for the symmetry elements and for geometric transformations. Class of a group and similarity transformation.

[16 HOURS]

UNIT – II

Representation of groups: Reducible and irreducible representations. The Great Orthogonality theorem and its consequences. Labeling of irreducible representations. Group theory and hybrid orbitals to form bonds. Character tables (C_s, C_i, C_2, C_{2v}, C_{2h} and C_{3v}).

Applications of group theory: Applications of group theory to crystal field theory. Bonding in octahedral and tetrahedral complexes. Symmetry and dipole moments, symmetry and optical activity.

Molecular vibrations: Introduction, symmetry of normal vibrations, determining the symmetry types of normal modes, selection rules for fundamental vibration transitions.

Representation of vibrational modes in non-linear molecules. Group theory and linear molecules (Integration method).

[16 HOURS]

References:

1. Chemical Applications of Group Theory, 3rd edition, F.A. Cotton, John Wiley and Sons (2006).
2. Molecular Symmetry and Group Theory – Robert L Carter, John Wiley and Sons (2005).
3. Symmetry in Chemistry - H. Jaffe and M. Orchin, John Wiley, New York (1965).
4. Vibrational Spectroscopy - Theory and Applications- D.N. Sathyanarayana, New Age International Publications, New Delhi (1996).
5. Group Theory and its Chemical Applications - P.K. Bhattacharya, Himalaya Publications, New Delhi (1998).

CHO SCT 1.3: REACTION MECHANISMS AND HETEROCYCLIC CHEMISTRY

UNIT – I

Reaction Mechanism II: Mechanism of Addition reactions: Addition to C-C multiple bonds involving electrophiles, nucleophiles and free radicals. Markownikoff's rule and anti-Markownikoff's rule, hydroboration and it's application.

Typical additions to carbonyl compounds: Addition of hydride, water, alcohol, thioalcohol, bisulphite, HCN, Grignard reagents and amino compounds.

Mechanism of reactions of carboxylic acids and their derivatives: Mechanism of ester hydrolysis, formation and hydrolysis of amides, decarboxylation reactions.

Elimination reactions: Mechanism and stereochemistry of eliminations - E_1, E_2, E_1cB. *cis* elimination, Hofmann and Saytzeff eliminations, competition between elimination and substitution, Chugaev reaction.

[16 HOURS]

UNIT – II

Heterocyclic chemistry: Nomenclature of heterocyclic systems, Structure, reactivity, synthesis and reactions of furan, pyrrole, thiophene, indole, pyridine, quinoline, isoquinoline, pyrazole, imidazole, pyrone, coumarin, chromones, pyrimidines and purines.

[16 HOURS]

References:

1. H. Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mac Grow Hill, New York, 1987.
2. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II 1984.
3. Principles of Organic Synthesis, ROC Norman and Coxon
4. R.K. Bansal, Organic Reaction Mechanism, Wiley Eastern Limited, New Delhi, 1993.
5. J. March, Advanced Organic Chemistry, Wiley Interscience, 1994.
6. E.S. Gould, Mechanism and Structure in Organic Chemistry, Halt, Rinhart & Winston, New York, 1964.
7. A Guide Book to Mechanism in Organic Chemistry – Petersyke.
8. F.A. Carrey and Sundberg, Advanced Organic Chemistry - Part A and B, 3rd edition, Plenum Press, New York, 1990.

CHP SCT 1.4: SOLID STATE CHEMISTRY AND SEMICONDUCTORS; BIOPHYSICAL CHEMISTRY

UNIT – I

Solid state chemistry: Types of imperfections, classification of imperfections, point defects, Schottky defects, Frenkel defects, disordered crystals, line defects, dislocation types, plane defects, small-angle and large-angle boundaries, stacking faults, crystal growth and twinning.

Semiconductors: Band theory, energy bands, intrinsic and extrinsic semiconductors. Conductivity: electrons and holes, temperature dependence on conductivity, Optical properties:

absorption spectrum, photoconductivity, photovoltaic effect and luminescence. Junction properties: metal-metal junctions, metal-semiconductor junctions, p-n junctions, transistors, industrial applications of semiconductors: Mixed oxides, spinels and other magnetic materials.

Superconductors: Meissner effect, type I and II super conductors, isotope effect, basic concepts of BCS theory, manifestations of the energy gap, Josephson devices.

[16 HOURS]

UNIT – II

Electrokinetic phenomena: Electrophoresis - principles of free electrophoresis, zone electrophoresis, gel electrophoresis and its applications in qualitative and quantitative study of proteins. Determination of isoelectric point of a protein. Electroosmosis and streaming potential and its biological significance. Biological significance of Donnan membrane phenomenon. Micelles and its involvement during digestion and absorption of dietary lipids. Diffusion of solutes across biomembranes and its application in the mechanism of respiratory exchange. "Salting In" and "Salting Out" of proteins. Osmotic behaviour of cells and osmo-regulation and its application in the evolution of excretory systems of organisms. Effect of temperature and *p*H on the viscosity of biomolecules (albumin solution). Significance of viscosity in biological systems - mechanism of muscle contraction, detection of intrastrand disulfide bonds in proteins, polymerization of DNA and nature of blood flow through different vessels. Effect of temperature, solute concentration (amino acids) on surface tension. Biological significance of surface tension - stability of Alveoli in lungs, interfacial tension in living cells (Danielli and Davson model). Application of sedimentation velocity and sedimentation equilibrium method for molecular weight determination of proteins.

[16 HOURS]

References:

1. Introduction to Solids, Azaroff.
2. Solid State Chemistry and its Applications, Anthony R. West.
3. Basic Solid State Chemistry, 2nd edition, Anthony R. West.
4. Solid State Chemistry: An Introduction, 3rd edition, Lesley E. Smart and Elaine A. Moore.
5. Introduction to Solid State Physics - C. Kittel, 5th edition, Wiley Eastern Ltd.
6. New Directions in Solid State Chemistry - C.N.R. Rao and J. Gopalakrishna, Cambridge University Press, Cambridge (1999).
7. Advances in Technologically Important Crystals - Binay Kumar, R.P. Tandon, Macmillan India Ltd.

8. Introduction to Physical Organic Chemistry, R.D. Gilliom, Madison – Wesley, USA (1970).
9. Physical Organic Chemistry, Reaction Rate and Equilibrium Mechanism – L.P. Hammett, McGraw HillBook, Co., (1970).
10. Biophysical Chemistry, Principle and Technique – A. Upadhyay, K. Upadhyay and N. Nath, Himalaya Publishing House, Bombay, (1998).
11. Essentials of Physical Chemistry and Pharmacy – H. J. Arnikar, S. S. Kadam, K.N. Gujan, Orient Longman, Bombay, (1992).

SECOND SEMESTER

THEORY – HARD CORE

CHA HCT: 2.1. SEPARATION TECHNIQUES

UNIT – I

Chromatography: Definition, principles and mechanism of separation, classification of chromatographic techniques. General descriptions of column chromatography - frontal analysis, displacement analysis and elution analysis. General theory of column chromatography: characterizing a chromatogram - retention time, retention volume and baseline width. Chromatographic resolution, capacity factor, column selectivity. Column efficiency - band broadening - rate theory and plate theory. Peak capacity, non ideal behavior. Optimizing chromatographic separations using capacity factor, column selectivity and column efficiency - Van Deemter equation, and its modern versions, Golay equation and Huber-Knox equations.

Gas chromatography (GC): Principles, instrumentation **-** mobile phase, chromatographic columns, stationary phases, sample introduction, temperature control, and detectors for gas chromatography. Quantitative and qualitative applications.

High performance liquid chromatography (HPLC): Principles, instrumentation - columns (analytical and guard columns), stationary phases, mobile phases, choosing a mobile phase, isocratic *vs* gradient elution, HPLC plumbing, sample introduction. Detectors for HPLC - spectroscopic, electrochemical and others, quantitative applications.

[16 HOURS]

UNIT – II

Ion exchange chromatography (IEC): Definitions, requirements for ion-exchange resin, synthesis and types of ion-exchange resins, principle, basic features of ion-exchange reactions, resin-properties-ion-exchange capacity, resin selectivity and factors affecting the selectivity, applications of IEC in preparative, purification and recovery processes. IEC with eluent suppressor columns. Single Column Ion Chromatography.

Size-exclusion chromatography: Theory and principle of size-exclusion chromatography, experimental techniques of gel-filtration chromatography (GFC) and gel-permeation chromatography (GPC), materials for packing - factors governing column efficiency, methodology and applications.

Thin layer chromatography: Principle, apparatus and methodology, applications, HPTLC

Affinity chromatography: Definitions, separation-mechanism-matrices, matrix activation, role of spacer arms and applications.

Supercritical fluid chromatography (SFC): Properties of supercritical fluids, instrumentation and operating variables, comparison of SFC with other types of chromatography, applications.

Supercritical fluid extraction: Advantages of supercritical fluid extraction, instrumentation, supercritical fluid choice, off-line and on-line extractions, typical applications of supercritical fluid extraction.

[16 HOURS]

UNIT – III

Electrophoretic methods - Electrophoresis & Capillary Electrophoresis**:** Theory **-** electrophoretic mobility, electroosmotic mobility, electroosmotic flow velocity, total mobility, migration time, efficiency, selectivity and resolution. Instrumentation - capillary tubes, hydrodynamic and electrokinetic methods of sample injection, applying electric field and detectors. Capillary electrophoresis methods - capillary zone electrophoresis, micellar electrokinetic capillary chromatography, capillary gel electrophoresis and capillary electrochromatography.

Solvent extraction: Theory - Nernst partition law, efficiency and selectivity of extraction.

Extraction systems: Extraction of covalent neutral molecules, extraction of uncharged metal chelates and synergic extraction, extraction of ion-association complexes - non chelated complexes, chelated complexes and oxonium systems. Use of salting out agents. Methods of extraction - batch and continuous extractions. applications.

Solid Phase Extraction (SPE): Principles, apparatus and instrumentation. Solid phase sorbents, extraction formats - Automated solid phase extraction. Solid phase micro extraction (SPME). Applications of SPE and SPME.

[16 HOURS]

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993 Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003 Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Introduction to Instrumental Analysis, Robert. D. Braun, Pharm. Med. Prem. India, 1987.
7. Instrumental Method of Analysis, W.M. Dean and Settle, 7th edition, 1986, CBS Publishers, New Delhi.
8. Instant Notes of Analytical Chemistry, Kealey and Haines, Viva Books Pvt. Ltd., 2002.
9. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.
10. Principles and Practice of Analytical Chemistry, F. W. Fifield and Kealey, 5th edition, 2000, Blackwell Sci., Ltd. Malden, USA.

CHI HCT: 2.2. COORDINATION CHEMISTRY

UNIT – I

Preparation of coordination compounds: Introduction, Preparative methods - simple addition reactions, substitution reactions, oxidation-reduction reactions, thermal dissociation reactions, reactions of coordinated ligands, the trans-effect, other methods. Geometries of metal complexes of higher coordination numbers (2-12).

Stability of coordination compounds: Introduction, trends in stepwise stability constants, factors influencing the stability of metal complexes with reference to the nature of metal ion and ligands, the Irving-William series, chelate effect.

Determination of stability constants: Theoretical aspects of determination of stability constants of metal complexes by spectrophotometric, *p*H metric and polarographic methods.

Crystal field theory: Salient features of CFT, d-orbital splitting in octahedral, tetrahedral, square planar and tetragonal complexes, Jahn-Teller distortions, measurement of 10 Dq and factors affecting it. Evidences for metal-ligand covalency.

[16 HOURS]

UNIT – II

Molecular Orbital Theory: MOT to octahedral, tetrahedral and square planar complexes without and with pi-bonding. MO energy diagrams for octahedral complexes with sigma ligands having pi-systems.

Electronic spectra: Introduction, selection rules and intensities, electronic spectra of octahedral and tetrahedral complexes, Term symbols for d^n ions, Orgel and Tanabe-Sugano diagrams, charge-transfer spectra. Ligand-field transition, Optical rotatory dispersion and Circular dichroism.

Magnetic properities: Introduction, magnetic susceptibility and its measurements, spin and orbital contributions to the magnetic moment, the effects of temperature on μeff, spin-cross over, ferromagnetism, antiferromagnetism and ferrimagnetism.

[16 HOURS]

UNIT - III

Reaction and Mechanisms: Introduction

Substitution reactions - Inert and labile compounds, mechanisms of substitution.

Kinetic consequences of Reaction pathways - Dissociation, interchange and association. Experimental evidence in octahedral substitution - Dissociation, associative mechanisms, the conjugate base mechanism, the kinetic chelate effect.

Stereochemistry of reactions- Substitution in trans and its complexes, isomerization of chelate rings.

Substitution reactions of square-planar complexes - kinetics and stereochemistry of square-planar substitutions, evidence for associative reactions, explanations of the trans effect.

Electron-transfer processes: Inner-sphere mechanism and outer-sphere mechanism, conditions for high and low oxidation numbers.

Metal-metal bonding: Evidences and factors favoring of M-M bonding, Wade's-Mingo's-Lauher rules, bi, tri, tetra, penta and hexa nuclear metal clusters.

[16 HOURS]

References:

1. Physical Inorganic Chemistry - A Coordination Chemistry Approach- S.F.A. Kettle, Spektrum, Oxford, (1996).
2. Inorganic Chemistry - 2nd edition, C.E. Housecroft and A.G. Sharpe, Pearson Education Ltd., (2005).
3. Inorganic Chemistry - 3rd edition, G.L. Miessler and D.A. Tarr, Pearson Education, (2004).
4. Inorganic Chemistry - 2nd edition, D.F. Shriver, P.W. Atkins and C.H. Langford, Oxford University Press, (1994).
5. Inorganic Chemistry- 3rd edition, James E. Huheey, Harper and Row Publishers, (1983).
6. Basic Inorganic Chemistry- 3rd edition, F.A. Cotton, G. Wilkinson and P.L. Gaus, John Wiley and Sons, (2002).

CHO HCT: 2.3. SYNTHETIC ORGANIC CHEMISTRY

UNIT – I

Reductions: Catalytic hydrogenations (homogeneous and heterogeneous) - catalysts, solvent, equipment and reduction of functional groups, catalytic hydrogen transfer reactions. Wilkinson catalyst. Bakers yeast, $LiAlH_4$, $NaBH_4$, metal dissolving reactions (Birch reduction). Leukart reaction (reductive amination), diborance, Meerwein-Ponndorf-Verley reduction, Wolf-Kishner reduction, Clemensen reduction.

Oxidations: Oxidation with chromium and manganese compounds (CrO_3, $K_2Cr_2O_7$, PCC, PDC, Sarret reagent, Jones reagent, MnO_2, $KMnO_4$), oxygen (singlet and triplet), ozone, peroxides and peracids, lead tetra acetate, periodic acid, OsO_4, SeO_2, NBS, chloramine-T, Sommelet oxidation, Oppenauer oxidation.

[16 HOURS]

UNIT – II

Reagents in organic synthesis: Use of following reagents in organic synthesis and functional group transformations: Lithium disopropylamide (LDA), Gilmann reagent, dicyclohexyl carbodimide (DCC), dichloro dicyano quinone (DDQ), trialkyl silyl halides, trimethyl silyl cyanide, phase transfer catalyst, crown ethers, cyclodextrins, Fenton's reagent, Ziegler-Natta catalyst, diazomethane, tributyl tinhydride, stannous chloride, Sharpless epoxidation, Woodward and Prevost hydroxylation, Stark enamine reaction, Phosphorus ylides – Wittig and related reactions, 1,3-dithiane anions - Umpolung reaction, sulphur ylides – reactions with aldehydes and ketones, Peterson reactions - synthesis of alkenes.

Microwave induced organic synthesis, ionic liquids in organic synthesis, polymer supported reagents and synthesis, the use of ultra sound in organic synthesis.

[16 HOURS]

UNIT – III

Protecting groups: Protection of hydroxyl, carboxyl, carbonyl, thiol and amino groups. Illustration of protection and deprotection in synthesis.

Name reactions: Keto-enol tautomerism, mechanism and synthetic applications of aldol condensations, Claisen reaction, Schmidt reaction, Perkin reaction, Knoevenagel, benzoin and Stobbe condensation, Darzens glysidic ester condensation, Cannizaros reaction, Tischenko reaction. Michael addition, Robinson's annulation reaction.

Retrosynthesis: Introduction to disconnection approach: Basic principles and terminologies used in disconnection approach. One group C-X and two group C-X disconnections. Synthons and synthetic equivalents.

Retrosynthesis and synthesis of benzofurans, *p*-methoxy acetophenone, saccharine, α-bisabolene, nuciferal, penicillin-V.

[16 HOURS]

References:

1. H. Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mac Grow Hill, New York, 1987.
2. Organic Chemistry - Morrison and Boyd
3. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. 1 & II, 1984.
4. J. March, Advanced Organic Chemistry, Wiley Interscience, 1994.
5. E.S. Gould, Mechanism and Structure in Organic Chemistry, Halt, Rinhart & Winston, New York, 1964.

6. F.A. Carey and Sundberg. Advanced Organic Chemistry – Part A & B, 3rd edition, Plenum Press, New York. 1990.
7. Principles of Organic Synthesis - ROC Norman and Coxon
8. S.K. Ghosh, Advanced General Organic Chemistry, Book and Allied (P) Ltd. 1998.
9. Heterocyclic Chemistry – Joule & Smith
10. Heterocyclic Chemistry – Achaeson
11. Basic Principles of Heterocyclic Chemistry – L.A. Pacquette
12. Comprehensive Heterocyclic Chemistry – Kartritzky series, Pergamon Press, New York, 1984.

CHP HCT: 2.4. QUANTUM CHEMISTRY; NUCLEAR CHEMISTRY AND PHOTO CHEMISTRY AND MICROWAVE AND INFRARED SPECTROSCOPY

UNIT – I

Wave-particle duality of material particles, deBroglie equation, Heisenberg Uncertainty principle, Concept of operators (operator–operand), Algebra of operators, commutative and non-commutative operators, linear operator, Laplacian operator, Hamiltonian operator, Eigen value, Eigen function, class Q function, Hermitian operator, turn over rule, atomic units. Wave equation for stretched strings, Schrodinger wave equation for particles, Eigen values and Eigen functions, postulates of quantum mechanics. Application of Schrodinger equation to a free particle and to a particle trapped in a potential field (one dimension and three dimensions). Degeneracy, Wave equation for H-atom, separation and solution of R, ϕ and θ equations. Application of Schrodinger equation to rigid rotator and harmonic oscillator. Approximate methods – Necessity of approximate methods, perturbation method, the theory of perturbation method – first order and second order correction, application to He-atom (first order correction only) – calculation of first ionization potential and binding energy. Variation theorem: statement and proof

[16 HOURS]

UNIT – II

Nuclear chemistry: Radioactive decay – General characteristics, decay kinetics, parent – daughter decay growth relationships, determination of half-lives, Nuclear stability – packing fraction, binding energy, Brief survey of alpha, beta and gamma decays. Nuclear reactions – Bethe's notation, types of nuclear reactions – specific nuclear reactions, photonuclear reactions, Oppenheimer – Phillips process, spallation reactions. Definition of Curie and related

calculations.. Szilard-Chalmers process. Geiger-Muller counters – G.M. Plateau, dead time, coincidence loss, determination of dead time.

Photochemistry: Introduction to photochemistry, quantum yield and its determination, factors affecting quantum yield, Actinometry - Uranyloxalate and potassium ferrioxalate actinometers, acetone and diethylketone actinometers. Term symbols and significance. Photosensitization: by mercury, dissociation of H_2. Photochemical kinetics of: Decomposition of CH_3CHO, formation of HCl. Photodegradation: Photocatalyst – ZnO, TiO_2, principle, application of ZnO/TiO_2 in the photo degradation of dyes (IC), pesticides (DDT) and in industrial effluents. Effect of photo degradation on COD value.

[16 HOURS]

UNIT – III

Microwave spectroscopy: Rotation spectra of diatomic Molecules **-** rigid and non rigid rotator model. Rotational quantum number and the selection rule. Effect of isotopic substitution on rotation spectra. Relative intensities of the spectral lines. Classification of polyatomic molecules based on moment of inertia - Linear, symmetric top, asymmetric top and spherical molecules. Rotation spectra of polyatomic molecules (OCS CH_3F and BCl_3). Moment of inertia expression for linear tri-atomic molecules. Experimental techniques - Microwave spectrometer. Applications - Principles of determination of Bond length and moment of inertia from rotational spectra. Stark effect in rotation spectra and determination of dipole moments.

Vibration spectroscopy*:* Vibration of diatomic molecules, vibrational energy curves for simple harmonic oscillator. Effects of anharmonic oscillation. Vibration - rotation spectra of carbon monoxide. Expressions for fundamental and overtone frequencies. Vibration of polyatomic molecules – The number of degrees of freedom of vibration and their symmetry. Parallel and perpendicular vibrations (CO_2 and H_2O). fundamental, overtone, combination and difference bands. Fermi resonance. Force constant and its significance. Theory of infrared absorption and theoretical group frequency. Intensity of absorption band and types of absorptions. Correlation chart. Important spectral regions - hydrogen stretching region, double and triple bonds regions, fingerprint region. Applications: Structures of small molecules: XY_2 – linear or bent, XY_3 – planar or pyramidal. Coordination compounds (*N*,*N* dimethyl acetamide, urea, DMSO and nitrite complexes). Factors affecting the group frequency – Physical state, vibrational coupling, electrical effect, hydrogen bonding, steric effect and ring strain.

Raman spectroscopy: Introduction, Raman and Rayleigh scattering, Stokes and anti-Stokes lines, polarization of Raman lines, depolarization factor, polarizability ellipsoid. Theories of Raman spectra - classical and quantum theory. Rotation-Raman and vibration-Raman spectra.

Comparison of Raman and IR spectra, rule of mutual exclusion principle. Advantages of Raman spectra.

[16 HOURS]

References:

1. Elements of Physical Chemistry – Lewis and Glasstone.
2. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990).
3. Basic Physical Chemistry by W.J. Moore, Prentice Hall, New Delhi, (1986).
4. Physical Chemistry – G.M. Barrow, McGraw Hill International Service (1988).
5. Introduction to Electrochemistry by S. Glasstone.
6. Modern Electrochemistry Vol. I and II by J.O.M. Bockris and A.K.N. Reddy, Pentium Press, New York (1970).
7. Electrochemistry –Principles and Applications by E.G. Potter.
8. Electrochemistry by Reiger, Prentice Hall (1987).
9. Treatise on Electrochemistry, G. Kortum 2nd edition, Elsevier, London (1965).
10. Quantum Chemistry – A.K. Chandra. 2nd edition, Tata McGraw Hill Publishing Co. Ltd., (1983).
11. Quantum Chemistry – Eyring, Walter and Kimball. John Wiley and Sons, Inc., New York.
12. Quantum Chemistry – I.N. Levine. Pearson Education, New Delhi, (2000).
13. Theoretical Chemistry – S. Glasstone. East West Press, New Delhi, (1973).
14. Quantum Chemistry – R.K. Prasad, New Age International Publishers, (1996).
15. Valence Theory – Tedder, Murel and Kettle.
16. Quantum Chemistry – D.A. McQuarrie.
17. Theoretical Inorganic Chemistry – Day and Selbin.
18. Nuclear Chemistry by Friedlander and Kennedy, John Wiley and Sons (1987).
19. Nuclear Physics and Chemistry by G. Harvey.
20. Essentials of Nuclear Chemistry by H.J. Arnikar, Eastern Wiley (1990).
21. Nuclear Chemistry by U.N. Dash, Sultan Chand and Sons (1991).
22. Source Book on Atomic Energy by S. Glasstone, 3rd edition Van Nonstrand (1967).
23. Nuclear Chemistry by Friedlander and Kennedy, John Wiley and Sons (1987).
24. Essentials of Nuclear Chemistry by H.J. Arnikar, Eastern Wiley (1990).
25. Fundamentals of Molecular Spectroscopy, C.N. Banwell and E.M. McCash. 4th edition, Tata McGraw Hill, New Delhi.
26. Introduction to Spectroscopy - Pavia, Lampman and Kriz, 3rd edition, Thomson.

27. Spectroscopy, B.P. Straughan and S. Walker, John Wiley & Sons Inc., New York, Vol. 1 and 2, 1976.
28. Vibration Spectroscopy Theory and Applications, D.N. Satyanarayana, New Age International, New Delhi.

PRACTICALS – HARD CORE

Analytical Chemistry/Inorganic Chemistry

[96 HOURS EACH]

Organic Chemistry/Physical Chemistry

[96 HOURS EACH]

Experiments are as in FIRST SEMESTER. Every student will carry out experiments on a rotation basis in the FIRST and SECOND semesters.

THEORY – SOFT CORE

CHA SCT 2.1: APPLIED ANALYSIS II

UNIT – I

Food analysis: Objectives of food analysis. Sampling procedures. Detection and determination of sugars and starch. Methods for protein determination. Oils and fats and their analysis - iodine value, saponification value and acid value. Rancidity - detection and determination (peroxide number). Tests for common edible oils. Analysis of foods for minerals - phosphorus, sodium, potassium and calcium. General methods for the determination of moisture, crude fibre and ash contents of food. Analysis of milk for fat and added water. Non-alcoholic beverages -determination of chicory and caffeine in coffee; caffeine and tannin in tea. Alcoholic beverages -methanol in alcoholic drinks and chloral hydrate in toddy. Food additives - chemical, preservatives - inorganic preservatives - sulphur dioxide and sulphites, their detection and determination. Organic preservatives - benzoic acid and benzoates, their detection and determination. Flavouring agents - detection and determination of vanilla and vanillin. Coloring matters in foods - classification, certified colors, detection of water soluble dyes, color in citrus fruits, beet dye in tomato products, mineral color. Pesticide residues in foods - determination of chlorinated organic pesticides. Control food quality - codex alimentarius, Indian standards.

[16 HOURS]

UNIT – II

Drugs and pharmaceutical analysis: Importance of quality control; drugs and pharmaceuticals. Sources of impurities in pharmaceutical chemicals. Analytical quality control in finished/final products. Common methods of assay. Analysis of common drugs; Analgesics - aspirin, paracetamol; Anthelmintics - mebendazole; Antiallergies - chlorpheneramine malleate; Antibiotics - penicillin, chloromecytin; Anti-inflammatory agents - oxyphenbutazone; Antimalarials - primaquine phosphate; Antituberculosists - INH; Narcotics - nicotine, morphine; Expectorants - Benadryl; Sedative - diazepam; Vitamins - A. C, B1, B2, B6, niacin and folic acid. Estimation of drug residues in biological samples.

[16 HOURS]

References:

1. Food Analysis, A.G. Woodman, McGraw Hill. 1971.
2. Chemical Analysis of Foods, H.E. Cox and Pearson.
3. Analysis of Foods and Food Products, J.B. Jacob.
4. A First Course in Food Analysis, A.Y. Sathe, New Age Internationals (P) Ltd., Publishers, Bangalore, 1999.
5. Analytical Agricultural Chemistry, S.L. Chopra and J.S. Kanwar, Kalyani Publishers, New Delhi, 1999.
6. Pharmaceutical Analysis, (Ed). T. Higuchi and E.B. Hanssen, John Wiley and Sons, New York, 1997.
7. Pharmaceutical Analysis - Modern Methods, Part A and B, (Ed). James W. Hunson.
8. Quantitative Analysis of Drugs in Pharmaceutical Formulations, P. D. Sethi, 3rd edition. CBS Publishers and Distributors, New Delhi, 1997.

CHI SCT 2.2: INORGANIC POLYMERS AND INDUSTRIAL INORGANIC CHEMISTRY

UNIT – I

Introduction, classification, phosphate containing polymers, preparation, properties, structure. Polymers containing boron- preparation, properties, structure, degree of polymerization,

Borazine - Preparation, properties, structure, derivatives of borazine

Heterocyclic inorganic ring system: Sulphur-nitrogen ring, nitrogen-phosphorous ring

Phosphonitrilic or phosphazine polymers: Preparation, properties, structure and applications.

Silicates: Structure, classification - silicates with discrete anions, silicates containing chain anion, silicates with layer structure, silicones with three dimensional net work and applications.
Silicone: General methods of preparation, properties. Silicone polymers - silicone fluids, silicone greases, silicone resins, silicone rubbers and their applications.
Iso and heteropoly acids – of molybdenum, tungsten and vanadium, industrial applications of iso and heteropoly acids.

[16 Hours]

UNIT – II

Inorganic fibers: Introduction, properties, classification, asbestos fibers, optical fibers, carbon fibers, Applications.
Zeolites: Introduction, types of zeolites, manufacture of synthetic zeolites and applications.
Mineral fertilizers: **Phosphorous containing fertilizers** - Economic importance, importance of superphosphate, ammonium phosphates and their synthesis.
Nitrogen containing fertilizers - Importance and synthesis of ammonium sulfate, ammonium nitrate and urea.
Potassium containing fertilizers - Economic importance and manufacture of potassium sulfate.
Inorganic pigments: General information and economic importance.
White pigments – titanium dioxide pigments, zinc oxide pigments.
Colored pigments – Iron oxide, chromium oxide, mixed-metal oxide pigments and ceramic colorants.
Corrosion protection pigments, luster pigments, luminescent pigments, magnetic pigments.

[16 Hours]

References:

1. Inorganic Polymers – G.R. Chatwal, HPH (1996).
2. Coordination Chemistry: Joan Ribas Gispert, Wiley – VCH Verlag GmbH & Co. kGaA, University of Barcelona, Spain (2008).
3. Inorganic Chemistry Principles of Structure and Reactivity: James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, Delhi University, New Delhi (2006)
4. Chemistry of the Elements – N.N. Greenwood and A. Earnshaw, Pergamon Press (1985).
5. Industrial Inorganic Chemistry – 2nd edition. K.H. Buchel, H.H. Moretto and P. Woditsh, Wiley - VCH (2000).

CHO SCT 2.3: PHOTOCHEMISTRY, PERICYCLIC REACTIONS AND ORGANOMETALLIC CHEMISTRY

UNIT – I

Photochemistry and concerted reactions: Introduction, light absorption and electronic transitions, Jablonski diagram, intersystem crossing, energy transfer, sensitizers, quenchers.
Photochemistry of olefins, conjugated dienes, aromatic compounds, ketones, enones, photooxidations, photoreductions, Norrish type I and II reactions, Paterno-Buchi reaction, Barton reaction, Di-pi-rearrangements.
Electrocyclic reactions: Stereochemistry, symmetry and Woodward-Hofmann rules for electrocyclic reactions, FMO theory of electrocyclic reactions, correlation diagram for cyclobutadiene and cyclohexadiene systems.
Cycloaddition reactions: Classification, analysis by FMO and correlation diagram method. **1,3-dipolar cycloadditions**: involving nitrile oxide, nitrile imine, nitrile ylide cycloaddition. Intra and intermolecular 3+2 cycloaddition and their application in organic synthesis. **[4+2] cycloaddition reactions**: Deils-Alder reacion, hetero Diels-Alder reaction and their applications.
Sigmatropic reactions: Classification, stereochemistry and mechanisms. suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties. [3,3] and [5,5]-sigmatropic rearrangement, Claisen, Cope and aza-Cope rearrangement

[16 HOURS]

UNIT – II

Chemistry of organometallic compounds: Synthesis and reactions of organolithium (n-BuLi, PhLi), organomagnesium (Grignard reagent),
Organoaluminium reagents: Preparation, site selective and stereoselctive additions of nucleophiles mediated by organoaluminum reagents, reaction with acid chlorides, allyl vinyl ethers, 1,2-addition to imines and application in the synthesis of natural products.
Organopalladium compounds: Suzuki coupling, Heck reaction.
Organotin reagents: Barton decarboxylation reaction, Barton deoxygenation reaction, Stille coupling, Stille-Kelley coupling reactions, Barton McCombie reaction, Keck stereoselective allylation and other applications.
Organoboron compounds: Introduction and preparations. Hydroboration and its applications. Reactions of organoboranes: isomerization reactions, oxidation, protonolysis, carbonylation, cyanidation. Reaction of nonallylic boron stabilized carbanions: alkylation reactions, acylation reaction, Reactions with aldehydes or ketones (*E* and *Z*-alkenes).
Organosulphur compounds: Introduction. Preparations, reactions, mechanism and synthetic applications of important sulphur containing reagents like dithiane, sulphur ylides etc.
Organosilicon compounds: Introduction, preparations and reactions, Peterson reaction.

[16 HOURS]

References:

1. J. March, Advanced Organic Chemistry, Wiley Inter Science, 1994.
2. F.A. Carey and Sundberg, Advanced Organic Chemistry – Part A & B, 3rd edition, Plenum Press, New York, 1990.
3. Principles of Organic Synthesis ROC Norman and Coxon.
4. Comprehensive Organic Synthesis – B.M. Trost and I. Fleming series, Pergamon Press, New York, 1991.
5. S.K. Ghosh, Advanced General Organic Chemistry, Book and Allied (P) Ltd., 1998.

CHP SCT 2.4: PHARMACOKINETICS

UNIT – I

Introduction**:** Biopharmaceutics, pharmacokinetics, clinical pharmacokinetics, pharmacodynamics, toxicokinetics and clinical toxicology. Measurement of drug concentration in blood, plasma or serum. Plasma level-time curve, significance of measuring plasma drug concentrations. One compartment open model: Intravenous route of administration of drug, elimination rate constant, apparent volume of distribution and significance. Calculation of elimination rate constant from urinary excretion data, clinical application. Two compartment model: Plasma level-time curve, relationship between tissue and plasma drug concentrations, Apparent volumes of distribution. Drug clearance, clinical example. Plasma level-time curve for a three compartment open model. Drug absorption: Factors affecting the rate of drug absorption - nature of the cell membrane, Route of drug administration - oral drug absorption, Intravenous infusion and intravenous solutions, Effect of food on gastrointestinal drug absorption rate.

[16 HOURS]

UNIT – II

Drug Bioavailability: Factors affecting the drug bioavailability, rate of dissolution, *p*H and drug absorption, particle size, clinical applications. *In vitro – in vivo* correlation of rate of dissolution. Drug release: Kinetics of extended-release dosage forms. Relative and absolute availability, Bioequivalence, clinical significance of bioequivalence studies. clinical examples. Kinetics of protein binding with drugs: Effect of protein binding on the apparent volume of distribution. Determination of binding constants and binding sites by *in vitro* methods (known protein concentration and unknown protein concentration), Relationship between protein concentration

and drug concentration in drug-protein binding. Clinical significance. Kinetics of drug elimination and clearance. Renal drug excretion, relation of rate of drug excretion and drug in the plasma. Drug biotransformation reaction, effect of blood flow on elimination half-life and hepatic excretion, drug elimination by capacity limited pharmacokinetics for one component model (IV Bolus). Determination of K_m and V_{max} in patients, bioavailability and protein binding reactions. A brief survey of applications of pharmacokinetics in clinical situations.

[16 HOURS]

References:

1. Applied Biopharmacokinetics and Pharmacokinetics - Leon Shargel, Andrew YuPrentice-Hall International, Inc (4^{th} edition).
2. Essentials of Physical Chemistry and Pharmacy – H.J. Arnikar, S.S. Kadam, K.N. Gujan, Orient Longman, Bombay, (1992).

THEORY – OPEN ELECTIVE

CH OET: 2.1. FUNDAMENTALS OF ISOLATION, SEPARATION, PURIFICATION AND CHARACTERIZATION TECHNIQUES

UNIT – I

Isolation and separation techniques: Solvent extraction, continuous extraction, chromatography [principles of TLC, paper chromatography, column chromatography, ion exchange chromatography, gas chromatography (GC) and HPLC] and electrophoresis.

Purification: Crystallization, sublimation, fractional crystallization, distillation techniques (simple distillation, steam distillation, distillation under reduced pressure, fractional distillation).

Chemistry of biomolecules: A brief survey of alkaloids, terpenes, vitamins, amino acids, peptides, proteins and nucleic acids.

[16 HOURS]

UNIT – II

Spectroscopy: Introduction, electromagnetic radiation

UV-visible spectroscopy – modes of electronic excitations, simple chromophoric-auxochrome theory, solvent effect and choice of solvent, applications. **IR spectroscopy** – principle,

characteristic group frequencies and skeletal frequencies, finger print region, identification of functional groups. **NMR spectroscopy** – general introduction, magnetic properties of nuclei, Larmor precession frequency, resonance condition and relaxation processes. Chemical shift: spin-spin coupling, chemical shift values and correlation for protons bonded to carbon and hetero atoms. **Mass spectroscopy** – principle, ionization process, molecular ion, base peak, identification of compounds from fragmentation patterns.

[16 HOURS]

References:

1. Arthur I Vogel, Elementary Practical Organic Chemistry, Part I, II and III, CBS Publishers and Distributors, New Delhi, India.
2. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I and II, 1984.
3. S K. Ghosh, Advanced General Organic Chemistry, Book and Allied (P) Ltd, 1998.
4. Organic Spectroscopy, William Kemp, English Language Book society, Macmillan, 1987.
5. Application of Absorption Spectroscopy of Organic Compounds, John R. Dyer, Prentice Hall of India Private Ltd., New Delhi, 1974.
6. Spectrometric Identification of Organic Compounds, 4th edition, Robert M. Silverstein, G. Clayton Bassler and Terence C. Morrill, John Wiley & Sons, New York, 1981.

CH OET: 2.2. BASIC CONCEPTS OF CHEMISTRY

UNIT - I

Analytical objectives: Meaning of analytical chemistry. Origin of analytical chemistry. Qualitative and quantitative analysis. The analytical process – steps in an analysis: obtaining a representative sample, preparing the sample for analysis, performing necessary chemical separations, performing the measurement. Methods of analysis – classical methods, principles of titrimetric and gravimetric analysis, typical examples of applications. Instrumental methods of analysis, their classification, their advantages and disadvantages over classical methods. Comparison of different analytical methods. Importance of analytical chemistry in fundamental research, product development, product quality control, monitoring and control of pollutants, assay and medical and clinical studies.

Periodic properties: Atomic size, ionic radii, ionization potential, electron affinity and electronegativity. Applications of electronegativity.

General characterisctics of s-, p-, d- and f-block elements: Comparitive study with reference to electronic configuration, oxidation states, chemical properties, spectra and magnetic properties of d- and f-block elements.

Chemical bonding: Ionic bond – size effect and solubility. Covalent bond – simple binary systems. Hydrogen bond – water and in biological systems.

[16 HOURS]

UNIT - II

Organic Chemistry: General characteristics of organic compounds, importance of organic chemistry, tetravalency of carbon, hybridization, bond length, bond angle, bond energy, representation of organic compounds, nomenclature, classification, isomerism, inductive effect, resonance effect, hyperconjugation, organic reactions and their classification.

Applications of Physical Chemistry: Concepts of entropy and free energy. Partial molar volume and its determination by density measurements. Symmetry elements and symmetry operations with examples of simple molecules. X-ray diffraction. Bragg equation and Miller indices. Order of a reaction and its determination. Energy of activation and its determination. Assumptions of activated complex theory. Fast reactions with examples. Polymers and their classification. Arrhenius theory of strong and weak electrolytes. Assumptions of Debye-Huckel theory of strong electrolytes. Types of electrodes. Corrosion and its prevention. Laws of photochemistry. Quantum yield and its determination. Photodegradation.

[16 HOURS]

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.
3. Basic Inorganic Chemistry- 3rd edition, F.A. Cotton, G. Wilkinson and P.L. Gaus, John Wiley and Sons, (2002).
4. Inorganic Chemistry Principles of Structure and Reactivity: James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, Delhi University, New Delhi (2006)

   Organic Chemistry by Morrison & Boyd.
5. Elements of Physical Chemistry – Lewis and Glasstone.
6. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990).
7. Basic Physical Chemistry by W.J. Moore, Prentice Hall, New Delhi, (1986).
8. Physical Chemistry – G.M. Barrow, McGraw Hill International Service (1988).

THIRD SEMESTER

THEORY – HARD CORE

CHA HCT: 3.1. INSTRUMENTAL METHODS OF ANALYSIS

UNIT – I

Flame photometry and Atomic absorption spectrometry: Energy level diagrams - atomic absorption spectra. Flame characteristics. Flame atomizers and electrothermal atomization. Comparison of spectral interferences, chemical and physical interferences in FP and AAS. Use of organic solvents. Quantitative techniques - calibration curve procedure and the standard addition technique. Typical commercial instruments for FP and AAS, applications. Qualitative analysis and quantitative evaluations. Relative detectabilities of atomic absorption and flame emission spectrometry.

Molecular luminescence spectrometry: Theoretical basis for fluorescence and phosphorescence. Singlet and triplet excited states. Variables affecting luminescence - quantum efficiency, transition types, structure and structural rigidity, temperature and solvent effects, effect of *p*H, dissolved oxygen and concentration effect. Excitation spectra *vs* emission spectra. Fluorescence instrumentation - fluorometers and spectrofluorometers. Sensitivity and selectivity. Modification necessary to measure phosphorescence. General scope of applications of luminescence.

Nephelometry and turbidometry: Principles, instrumentation and applications.

[16 HOURS]

UNIT – II

Classification of electrochemical methods: Controlling and measuring current and potential potentiometers, galvanostats and potentiostats.

Potentiometric methods of analysis. Potentiometric electrochemical cells. The Nernst equation. Liquid junction potentials. Reference electrodes - SHE, calomel electrode and silver/silver chloride electrode. Metallic indicator electrodes - electrodes of first kind and second kind. Redox electrodes. Membrane electodes – membrane potential, selectivity of membranes. Glass ion selective electrodes. Crystalline solid state ion selective electrodes. Liquid-based ion selective electrodes. Gas sensing electrodes. Potentiometric biosensors. Quantitative applications. Activity *vs* concentration. Quantitative analysis using external standards and the method of standard additions. Measurement of *p*H. Clinical and environmental applications.

Electrogravimetric analysis: Theory, apparatus, cell processes, deposition and separation, electrolytic separation of metals, applications.

Coulometric methods of analysis: General discussion, coulometry at controlled potential, apparatus and general technique, applications, coulometric titrations (amperometric coulometric) - principles, apparatus, comparison of coulometric titrations with conventional titrations, automatic coulometric titrations, applications.

Voltammetry: Fundamentals of voltammetry. Cyclic voltammetry**:** Principles and applications. Stripping analysis: Stripping voltammetry - basic principles, electrodes used for stripping analysis, apparatus for stripping analysis, applications, determination of lead in water voltammetry with micro electrodes.

[16 HOURS]

UNIT – III

Thermal method of analysis: Introduction,

Thermogravimetric analysis (TGA): types of thermogravimetric analysis, principles. Factors affecting the results - heating rate, furnace, instrument control/data handling. Applications - purity and thermal stability, evaluation of correct drying temperature, analysis of complex mixture and determination of kinetic parameters of thermal degradation.

Differential thermal analysis (DTA): Theory - variables affecting the DTA curves. Differences between TGA and DTA. General principles. Instrumentation. Applications - analysis of the physical mixtures and thermal behaviour study. Determination of melting point, boiling point and decomposition point.

Differential scanning calorimetry (DSC): Basic principle. Differences between DTA and DSC. Instrumentation - power compensated DSC, Heat flux DSC. Applications - studies of thermal transitions and isothermal crystallization. Pharmaceutical industry for testing the purity of the samples.

Thermomechanical analysis. Dynamic mechanical analysis**.**

Enthalpimetric analysis: Thermometric titrimetry and direct injection enthalpimetry - principle, instrumentation, applications.

[16 HOURS]

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.

3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993 Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003 Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7th Edition, CBS Publishers, New Delhi, 1988.
7. Principles and Practice of Analytical Chemistry, F.W. Fifield and Kealey, 3rd edition, 2000, Blackwell Sci., Ltd. Malden, USA.
8. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.
9. Introduction to Instrumental Analysis, Braun, Pharm. Med. Press. India.
10. Instant Notes of Analytical Chemistry, Kealey and Haines, Viva Books Pvt. Ltd., New Delhi, 2002.

CHO HCT: 3.2. ORGANIC SPECTROSCOPY

UNIT – I

UV Visible spectroscopy: Introduction, electronic transitions, simple chromophoric groups - systems of extended conjugation - aromatic systems - types of auxochromes - Functions of auxochromes - absorption and intesity shift - types of trasitions - transition probability - types of absorption bonds - solvent effects and choice of solvent - effect of polarity on various type of bonds Woodwards empirical rules for predicting the wavelength of maximum absorption for conjugated dienes, cyclic trienes and polyenes, α,ß-unsaturated aldehydes and ketones, benzene and substituted benzene rings.

Optical rotatory dispersion and circular dichroism: Theory of optical rotatory dispersion, octant rule, haloketone rule, Cotton effect and plain curves. Relation between optical rotatory dispersion and structure. Circular dichroism and its application to structure determination - CD/ORD of proteins, CD/ORD of carbohydrates, CD/ORD of Nucleic acids and CD of β-DNA and α-DNA.

IR spectroscopy: Introduction, instrumentation, sample handling, modes of vibrations, Hooks law, Characteristic group frequencies and skeletal frequencies. Finger print region, Identification of functional groups - alkenes, aromatics, cabonyl compounds (aldehydes and ketones, esters and

lactones), halogen compounds, sulphur and phosphorus compounds, amides, lactums, amino acids and amines. Factors affecting group frequencies and band shapes, conjugation, resonance and inductance, hydrogen bonding and ring strain. Tautomerism, *Cis-trans* isomerism. Applications of IR spectroscopy.

[16 HOURS]

UNIT – II

Nuclear magnetic resonance spectroscopy: General introduction and definition, magnetic properties of nuclei (magnetic moment, g factor) and theory of nuclear resonance. Larmor precession frequency, resonance condition and relaxation processes.

Chemical shift: Standards employed in NMR, factors affecting chemical shift, electronegativity, shielding and deshielding mechanism, van der Waals deshielding, H-bonding, diamagnetic and paramagnetic anisotropics. Spin-spin coupling, chemical shift values and correlation for protons bonded to carbon and other nuclei. Instrumentation and sample handling.

Equivalence and magnetic equivalence proton exchange reactions, effects of chiral center, complex spin-spin interaction, stereochemistry, hindered rotation, Karplus curve - variation of coupling constants with dihedral angles. Simplification of complex spectra: isotopic substitution, increasing magnetic field strength, double resonance, spin decoupling, contact shift reagents, FT-NMR: Principle and applications, variable temperature profile, Nuclear Overhauser Effect (NOE).

[16 HOURS]

UNIT – III

^{13}C-NMR spectroscopy: Comparison of ^{1}H-NMR and ^{13}C-NMR. Multiplicity - proton decoupling, noise decoupling, off resonance decoupling, selective proton decoupling, noise decoupling by FT mode, chemical shift, application of ^{13}C-NMR. NMR of ^{31}P, ^{11}B, ^{19}F and ^{15}N.

Application of NMR: structural diagnosis, conformational analysis, keto-enol tautomerism, H-bonding.

Two dimensional NMR spectroscopy: COSY, NOESY and magnetic resonance imaging (MRI)

Mass spectrometry: Principles, instrumentation, different methods of ionization. EI, CI, FD and FAB, Ion separators - single focusing separator with magnetic diffraction, double focusing analyzer, time-of-fight separator and quadrupole analyzer, Mass spectra – molecular ion, base peak, meta-stable peak. General rules for fragmentation pattern. Nitrogen rule, ortho effect, Hydrogen transfer rearrangement and McLafferty rearrangement. Mass spectral fragmentation of

organic compounds (acids, esters, hydrocarbons, halogenated hydrocarbons, alcohols, carbonyl compounds, amines, ethers and heterocyclic compounds).

Composite problems: Problems involving the application of the above spectroscopic techniques for structural elucidation of organic molecules.

[16 HOURS]

References:

1. Spectroscopy, B.P. Straughan and S. Salker, John Wiley and Sons Inc., New York, Vol.2, 1976.
2. Organic Spectroscopy, William Kemp, English Language Book society, Macmillan, 1987.
3. Application of Absorption Spectroscopy of Organic Compounds, John R. Dyer, Prentice Hall of India Private Ltd., New Delhi, 1974.
4. Spectrometric Identification of Organic Compounds, 4th edition, Robert M. Silverstein, G. Clayton Bassler and Terence C. Morrill, John Wiley & Sons, New York, 1981.
5. Organic Spectroscopy, V.R. Dani, Tata MeGraw-Hall Publishing Company Limited, New Delhi. 1995.
6. Interpretation of Carbon-13 NMR Spectra, F.W. Wehrli and T. Wirthin, Heyden, London, 1976.
7. NMR spectroscopy – Powai.

THEORY – SOFT CORE

CHI SCT 3.1: ORGANOMETALLIC CHEMISTRY

UNIT – I

Fundamental concepts: Introduction, Classification of organometallic compounds by bond type, nomenclature, the effective atomic number rule, complexes that disobey the EAN rule, common reactions used in complex formation.

Organometallics of transition metals: Preparation, bonding and structures of nickel, cobalt, iron and manganese carbonyls. Preparation and structures of metal nitrosyls in organometallics.
Ferrocene and ruthenocene: Preparation, structure and bonding.
Complexes containing alkene, alkyne, arene and allyl ligands: preparation, structure and bonding. The isolobal principles.

[16 HOURS]

UNIT – II

Homogeneous catalysis - Industrial Applications: Alkene hydrogenation, hydroformylation, The Wacker's process, Monsanto acetic acid process and L-DOPA synthesis, alkene oligomerizations, water-gas shift reactions.
Heterogeneous catalysis - Commercial Applications: Alkene polymerization: Ziegler-Natta catalysis, Fischer-Tropsch carbon chain growth.
Biological and Medicinal Applications: Organomercury, boron, silicon and aresenic compounds
Zeolites as catalysts for organic transformation: Uses of ZSM - 5
Alkene metathesis, hydroboration, arylation or vinylation of olefins (Heck reaction).

[16 HOURS]

References:

1. Organometallic Chemistry, 2nd edition, R.C. Mehrothra and A. Singh, New Age International Publications (2006).
2. Fundamental Transition Metal Organometallic Chemistry - Charles M. Lukehart, Brooks, Cole Publishing Company (1985).
3. The Organometallic Chemistry of the Transition Metals, 4th edition, Robert H. Crabtree, Wiley Interscience, (2005).
4. Organometallics - A Concise Introdution, 2nd edition, Chistoph Elschenbroich and Albert salzer VCH, (1992).
5. Inorganic Chemistry, 2nd edition, C.E. Housecroft and A.G. Sharpe, Pearson Education Ltd., (2005).
6. Inorganic Chemistry- 3rd edition, G.L. Miessler and D.A. Tarr, Pearson Education, (2004).
7. Basic Organometallic Chemistry - B.D. Gupta and A.J. Elias, Universities Press (2010).

CHI SCT 3.2: STRUCTURAL METHODS IN INORGANIC CHEMISTRY

UNIT - I

NMR spectroscopy: Basic principles, chemical shift and factors affecting it, coupling constants. ^{19}F, ^{31}P - NMR and NMR of paramagnetic complexes. Double resonance technique, The Nuclear Overhauser Effect, Magnetic susceptibility measurements by Evan's method. NMR to solids.

ESR spectroscopy: Theory, presentation of the spectrum, hyperfine coupling, the g value and factors affecting the magnitude of the g value. Zero-field splitting and Kramers' degeneracy. Application to simple inorganic and organic free radicals and to metal complexes.

NQR spectroscopy: Theory, energies of the quadrapole transitions, instrumentation, effect of magnetic field on the spectra, relationship between electric field gradient and molecular structures. Applications - interpretation of e^2Qq data, structural information from NQR data.

[16 HOURS]

UNIT – II

Vibrational spectroscopy: Introduction, theory of infrared absorption, theoretical group frequencies, correlation chart. Applications to coordination compounds - aquo, amine, urea, DMSO, *cis* and *trans* metal complexes. Change in spectra accompanying change in symmetry upon coordination (nitrite, sulphate, nitrate, perchlorate and carbonate)

Mossbauer spectroscopy: Theoretical basis, interpretation of Mossbauer spectra - isomer shift, quadrupole splitting and magnetic hyperfine structures. Application: $I_2Br_2Cl_4$, $Fe_3(CO)_{12}$, Prussian blue, nitroprusside, hexacyanoferrate.

Photoelectron spectroscopy: Introduction, principles, chemical shifts, photoelectron spectra of simple molecules, X-ray photoelectron and Auger electron spectroscopy. Applications.

Mass spectrometry: Theory, experimental techniques, molecular ions, fragmentation and ion reaction, Applications to coordination compounds.

[16 HOURS]

References:

1. Electronic Absorption Spectroscopy and Related Techniques – D.N. Sathyanarayana, Universities Press (2001).
2. Structural Methods in Inorganic Chemistry – E.A.V. Ebsworth, D.W.H. Ranklin and Cradock, Blackwell Scientific Publications (1988).
3. Physical Methods in Inorganic Chemistry – R.S. Drago, Saunders Publishers (1966).

CHP SCT 3.2: APPLICATIONS OF CHEMICAL KINETICS; CHEMISTRY OF NANOMATERIALS AND COROSSION

UNIT – I

Homogenous catalysis: Acid-base catalysis, specific acid and base catalysis. General acid and base catalysis. Oxidation of amino acids and carbohydrates in presence of acid and base catalysis. Acidity functions - Bronstead, Hückel, Hammett and Bunnett hypothesis.

Chain reactions: Rice-Herzfeld mechanism for the thermal decomposition of acetaldehyde, Kinetics of explosive reactions, explosion limits (H_2 and O_2 reaction). Kinetics of autocatalytic and oscillatory chemical reactions, oscillatory chemical reaction of oxidation of malic acid by bromate ion catalyzed by Ce(III). Catalyzed and uncatalyzed reaction: Ru(III) catalyzed oxidation reaction of primary amines by chloramine – T in HCl medium.

[16 HOURS]

UNIT – II

Chemistry of nanomaterials: Nano particles. Synthesis - Laser abalation, chemical vapour transportor (CVT) and sol-gel methods. Metal oxides nanoparticles with supercritical water and precursor method. Synthesis of metal oxides and its composite nanoparticles by solvothermal and hydrothermal methods. Carbon nanotube, carbon nanowires and its composites. Applications of nanomaterials in renewable energy. Inorganic and organic nanoporous aerogels. Heat capacity of solids: Einstein and Debye equations (with derivation).

Corrosion: Manifestations of corrosion, types of corrosion, basis of electrochemical corrosion, theories of corrosion. Local cell theory (Wagner and Traud theory), Current – potential relations (Evan diagram) in corrosion cells. Effect of *p*H, nature of metal and dissolved oxygen (principle of differential aeration) on corrosion. Corrosion inhibition and prevention by painting, phosphating and by using biomaterials, corrosion protection by anodic (passivation) and cathodic protection.

[16 HOURS]

References:

1. Chemical Kinetics by K.J. Laidler.
2. Chemical Kinetics – Frost and Pearson.
3. Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.
4. Chemical Kinetics – L.K. Jain.

5. Chemical Kinetics – Benson.
6. Physical Organic Chemistry, Reaction Rate and Equilibrium Mechanism – L.P. Hammett, McGraw HillBook, Co., (1970).
7. Hand Book of Nanotechnology, Bharat Bhushan, Springer Publisher.
8. Nanotechnology, Richard Booker and Earl Boysen, Wiley.
9. Nanometerials, A.K. Bandopadhyay, New Age International, 2nd edition.
10. Nanotechnology - Importance and Applications, M. H. Fulekar, Ink International publishing.

CHP SCT: 3.4. STATISTICAL THERMODYNAMICS AND PHASE RULE; RADIATION CHEMISTRY AND POLYMER CHEMISTRY

UNIT - I

Statistical mechanics: Introduction, thermodynamic probability relation between entropy and thermodynamic probability. Partition function - translational, rotational and vibrational partition functions.

Phase rule studies: Application of phase rule to the two component systems - compound formation with congruent melting point and incongruent melting points, Roozeboom's classification. Application of phase rule to three component systems. Systems of three liquids.

Energetics of cell reactions: Effect of temperature, pressure and concentration on energetics of cell reactions (calculation of ΔG, ΔH and ΔS). Electrochemical energy sources – batteries, classification, characteristics, primary, secondary and lithium batteries.

[16 HOURS]

UNIT – II

Radiation chemistry: Introduction, units, interaction of electromagnetic radiation with matter, G-value, LET of radiation, dosimetry, Fricke dosimeter. Radiolysis - cysteine, and biphenyl. Radioisotopes as tracers, use of isotopic tracers in the elucidation of reaction mechanism, structure determination and solubility of sparingly soluble substances. ^{14}C dating, medical applications of isotopic tracers. Hazards in radiochemical work and radiation protection.

Polymers: Fundamentals of polymers - monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization - condensation, addition, free radical, ionic, co-ordination polymerization and ring opening

polymerization. Molecular weight and size. Polydispersion. Average molecular weight concepts – number, weight and viscosity average molecular weight. Determination of molecular weights - viscosity method, osmotic pressure method, sedimentation and light scattering method.

[16 HOURS]

References:

1. Text Book of Polymer Science, F.W. Billmeyer, Jr., John Wiley, London (1994).
2. Polymer Science. V. R. Gowrikar, N.V. Vishwanathan and J. Sreedhar, Wiley Eastern, New Delhi (1990).
3. Fundamentals of Polymer Science and Engineering. A. Kumar and S.K. Gupta, Tata – McGraw Hill New Delhi (1978).
4. Polymer Characterization, D. Campbell and J.R. White, Chapman and Hall, New York.
5. Fundamental Principles of Polymer Materials, R.L. Rosen, John Wiley and Sons, New York.
6. Functional Monomers and Polymers by K. Takemoto, Y. Inaki and P.M. Ottenbrite, Marcel Dekker, Inc., New York, 1987.
7. Nuclear Radiation Detection by Price. Nuclear Radiation Detectors by S.S. Kapoor and Ramamoorthy, Wiley Eastern (1986).
8. Fundamentals of Radiochemistry by D.D. Sood, A.V.R. Reddy and N. Ramamoorthy
9. Statistical Themodynamics by B.C. Meclelland, Chapman and Hall, London (1973).
10. Elementary Statistical Thermodynamics by N.D. Smith, Plenum Press, NY (1982).
11. Elements of Classical and Statistical Thermodynamics by L.K. Nash, Addison-Wesley (1970).
12. Statistical Thermodynamics by I.M. Klotz.
13. Introduction to Statistical Thermodynamics by M. Dole, Prantice Hall, (1962).

PRACTICALS – SOFT CORE

CHA SCP: 3.1. ANALYTICAL CHEMISTRY PRACTICALS

[96 HOURS]

PART – III

1. Determination of calcium in limestone by redox, acid-base and complexation titrations.
2. Determination of vitamin C in orange juice by titration with cerium(IV) and with 2,6-dichlorophenol indophenol.

3. Determination of mercury in an algaecide by EDTA titration; and arsenic in ant control preparation by redox titration.

4. Determination of aluminium and magnesium in antacids by EDTA titration.

5. Analysis of a copper-nickel alloy sample for copper and nickel by EDTA titration using masking and selective demasking reactions.

6. Determination of zinc in a sample of foot powder and thallium in a sample of rodenticide by EDTA titration.

7. Determination of saccharin in tablets by precipitation titration.

8. Determination of iodine value and saponification value of edible oils.

9. Determination of ascorbic acid in goose berry/bitter gourd by titrimetry and spectrophotometry using *N*-bromosuccinimide (NBS).

10. Analysis of a mixture of iron(II) and iron(III) by EDTA titration using *p*H control.

11. Potentiometric titration of a mixture of chloride and iodide.

12. Determination of sulpha drugs by potentiometry using $NaNO_2$ and iodometric assay of penicillin.

13. Electrolytic determination of copper and lead in brass.

14. Polarographic determination of copper and zinc in brass.

15. Determination of sodium, potassium and calcium in mineral waters by atomic emission spectrometry.

16. Determination of iron in mustard seeds and phosphorus in peas by spectrophotometry.

17. Analysis of waste water for anionic detergents and phenol by spectrophotometry.

18. Fluorimetric determination of riboflavin (vit. B_2) in tablets.

19. Colorimetric analysis of procaine by diazotization and coupling reaction.

20. Determination of manganese in steel by extraction-free spectrophotometry and molybdenum in steel by extractive spectrophotometry.

PART – IV

1. Analysis of waste waters for DO and COD by titrimetry.
2. Analysis of a ground water sample for sulphate by titrimetry (EDTA) and turbidimetry.
3. Potentiometric determination of formula and stability constant of a silver-ammonia complex ion.
4. Kinetic determination of urinary creatinine and purity of a commercial H_2O_2 sample.
5. Determination of chromium(III) and iron(III) in a mixture by kinetic masking methods.

6. Catalytic determination of traces of selenium in biological materials and iodide in blood serum.
7. Photometric and potentiometric titration of iron(III) with EDTA.
8. Photometric and potentiometric titration of copper with EDTA.
9. Analysis of brackish water for chloride content by a) spectrophotometry (mercuric thiocyanate method), b) conductometry (silver nitrate) and c) potentiometry (silver nitrate).
10. Conductometric titration of sodium acetate with HCl and NH_4Cl with NaOH.
11. Ascorbic acid determination in natural orange juice by coulometry.
12. Spectrophotometric determination of iron in natural waters using thiocyanate and 1,10-phenanthroline as reagents.
13. Determination of fluoride in drinking water/ground water by spectrophotometry (alizarin red lake method).
14. Analysis of waste water for
    a) phosphate by molybdenum blue method
    b) ammonia-nitrogen by Nessler's method
    c) nitrite-nitrogen by NEDA method
15. Analysis of a soil sample for
    a) calcium carbonate and organic carbon by titrimetry.
    b) calcium and magnesium by EDTA titration.
16. Analysis of a soil sample for
    a) Available phosphorus by spectrophotometry.
    b) Nitrate-nitrogen/nitrite nitrogen/ammonia nitrogen by spectrophotometry.
    c) sodium and potassium by flame photometry.
17. Analysis of urine for
    a) urea and uric acid by titrimetry snd spectrophotometry.
    b) Sulphate by precipitation titration after ion-exchange separation.
    c) Sugar by Benedict's reagent.
18. Analysis of blood for
    a) cholesterol by spectrophotometry
    b) bicarbonate by acid-base titration.
19. Ultraviolet spectrophotometric determination of aspirin, phenacetin and caffeine in APC tablets using solvent extraction.
20. Fluorimetric determination of quinine in an antimalarial tablet.

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003 Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Pharmaceutical Drug Analysis by Ashutoshkar, New Age International Publishers, New Delhi, 2005.
7. Practical Pharmaceutical Chemistry, Ed. A. H. Geckett, J. B. Stenlake, 4th edition. Part I and II, CBS Publishers, New Delhi.
8. Quantitative Analysis of Drugs in Pharmaceutical Formulations, P. D. Sethi, 3rd edition, CBS Publishers & Distributors, New Delhi, 1997.
9. Practical Clinical biochemistry methods and interpretations, R. Chawla, J.P. Bothers Medical Publishers (P) Ltd., 1995.
10. Laboratory Manual in Biochemistry, J. Jayaraman, New Age International Publishers, New Delhi, 1981.
11. Practical Clinical Biochemistry, Harold Varley and Arnold.Hein mann, 4th edition.
12. Environmental Science: Laboratory Manual, Maurice A. Strabbe, The C.V. Mosbey Co. Saint Loucs, 1972.
13. Experiments on Water Pollution, D.I. Williams and D. Anglesia, Wayland Publishers Ltd., England, 1978.
14. Experiments on Land Pollution, D.I. Williams and D. Anglesia, Wayland Publishers Ltd., England, 1978.
15. Experiments in Environmental Chemistry, P.D. Vowler and D.W. Counel, Pergamon Press, Oxford 1980.
16. Manual Soil Laboratory Testing, vol. I, K.H. Head, Pentech Press, London 1980.

CHI SCP: 3.2. INORGANIC CHEMISTRY PRACTICALS

[96 HOURS]

PART – III

1. Determination of bismuth, cadmium and lead in a mixture: Analysis of a low melting alloy (Wood's alloy).
2. Simultaneous spectrophotometric determination of chromium and manganese in a steel solution.
3. Quantitative analysis of copper(II) and iron(II) in a mixture:
    i. Copper gravimetrically as CuSCN and
    ii. Iron volumetrically using cerium(IV) solution
4. Determination of chromium(III) and iron(III) in a mixture: Kinetic masking method.
5. Electrogravimetric determination of:
    a) Copper in copper sulphate
    b) Nickel in nickel suphate
    c) Copper and nickel in alloy solution
    d) Lead in lead nitrate.
6. Flame photometric determination of the following metal ions from different samples:
    a) sodium b) potassium c) calcium d) lithium and d) sodium and potassium in a mixture.
7. Polarographic estimation of cadmium and zinc.
8. Determination of iron as the 8-hydroxyquinolate by solvent extraction method.
9. Quantitative determination of nickel using dithizone and 1,10-phenanthroline by synergistic extraction.
10. Spectrophotometric determination of the *p*Ka value of methyl red.

PART – IV

1. Preparation and characterization of:
    a) Chloropentammine cobalt(III) chloride
    b) Estimation of chloride in a complex by potentiometric or ion-exchange method
    c) Record the electronic absorption spectrum of a complex and verify Tanabe Sugano diagram
2. Preparation of *cis*- and *trans*- dichlorobis(ethylenediammine) cobalt(III)chloride. Record the UV-Vis spectra and compare it with *cis*-form. Measure the molar conductance.

3. Preparation of hexamine cobalt(III) chloride and estimate cobalt ion.
4. Determination of magnetic susceptibility of any two compounds/complexes by Gouy method.
5. Determination of the composition of iron-phenanthroline complex by:
   (a) Job's method
   (b) mole-ratio method and
   (c) slope-ratio method.
6. Determine the stability constant of iron-tiron/iron-phenanthroline by Turner-Anderson method.
7. Preparation of tris(oxalate)ferrate(III) and estimate the metal ion.
8. Using chloropentamine cobalt(III) chloride, prepare nitro and nitritopentamine cobalt(III) chloride. Record the IR spectra of the isomers and interpret.
9. Estimate the chloride ion in a given complex by silver nitrate titration after ion-exchange separation.
10. Demonstration Experiments:
    (a) Recording and interpretation of IR and NMR spectra of complexes.
    (b) Spectrochemical series - Evaluation of Dq value.
    (c) DNA interaction with metal complexes by UV-visible absorption and viscosity methods.

References:

1. Advanced Physico-Chemical Experiments – J. Rose.
2. Instrumental Analysis Manual - Modern Experiments for Laboratory – G.G. Guilbault and L.G. Hargis.
3. A Text Book of Quantitative Inorganic Analysis – A.I. Vogel, 5th edition.
4. Experimental Inorganic Chemistry – G. Palmer.
5. Inorganic Synthesis – O. Glemser.
6. Experimental Inorganic/Physical Chemistry- Mounir A. Malati.
7. Quantitative Chemical Analysis – Daniel C. Harris, (2006) 7th edition.
8. Spectrophotometric Determination of Elements – Z. Marczenko

CHO SCP: 3.3. ORGANIC CHEMISTRY PRACTICALS

[96 HOURS]

PART – III

Multi step synthesis

1. Oxidation of cyclohexanol to adipic acid via cyclohexanone
2. Esterification: Preparation of benzoccaine from *p*-nitrotoluene
3. Diazotization (Sandmeyer's reaction): Preparation of *p*-chlorobenzoic acid from *p*-toluidine
4. Molecular rearrangement:
    i. Preparation of *o*-chlorobenzoic acid from phthalic anhydride
    ii. Preparation benzilic acid from benzaldehyde
    iii. Preparation of *o*-hydroxy benzophenone from phenyl benzoate via Fries rearrangement
    iv. Prepartion of benzanilide from benzophenone oxime via Beckmann rearrangement.
5. Grignard reaction: Prepearation of triphenyl carbinol
6. Preparation of luminol from phthalic anhydride
7. Synthesis of isoxazolines and pyrazolines via 1,3-dipolar cycloaddition.
8. Solvothermal synthesis
9. Synthesis of tetralones starting from aryl aldehydes.
10. Synthesis of *m*-chloroiodobenzene from *m*-dinitrobenzene

PART – IV

Isolation of natural products

1. Fractional crystallization: separation of mixture of naphthalene and biphenyl
2. Fractional distillation: Separation of mixture of hexane and toluene.
3. Thin layer chromatography: Separation of plant pigments
4. Column chromatography: Separation of mixture of *o* and *p*-nitro anilines
5. Isolation of piperine from pepper
6. Isolation of caffeine from tea
7. Isolation of azeleic acid from castor oil
8. Estimation of sugars by Fehlings method
9. Determination of enol content by Meyer's method
10. Estimation of ketones by haloform reaction
11. Estimation of sugars by Bertrand's method
12. Estimation of nitro groups

References:

1. Manual of Organic Chemistry - Dey and Seetharaman.
2. Modern Experimental Organic Chemistry by John H. Miller and E.F. Neugil, p 289.
3. An Introduction to Practical Organic Chemistry - Robert, Wingrove etc.
4. A Text Book of Practical Organic Chemistry – A.I. Vogel, Vol.III
5. Practical Organic Chemistry - Mann & Saunders
6. Semimicro Qualitative Organic Analysis by Cheronis, Entrikin and Hodnet .
7. R.K. Bansal, Laboratory Manual of Organic Chemistry, New Age International (P) Ltd. London, 3rd edition, 1996.

CHP SCP: 3.4. PHYSICAL CHEMISTRY PRACTICALS

[96 HOURS]

PART – III

1. Kinetics of reaction between sodium formate and iodine, determination of energy of activation.
2. To study the kinetics of saponification of ethyl acetate by conductivity method, determination of the energy of activation.
3. To study the kinetics of reaction between acetone and iodine - determination of order of reaction w.r.t. iodine and acetone.
4. Conductometric titration of thorium nitrate with potassium tartarate.
5. Determination of mean ionic activity coefficient of a weak electrolyte (acetic acid) by conductometric measurements.
6. To study the acid catalysed kinetics of oxidation of glycine by chloramine-T (CAT) -determination of order of reaction w.r.t. [CAT] and [glycine].
7. Kinetics of decomposition of benzene diazonium chloride, determination of energy of activation and thermodynamic parameters.
8. Potentiometric titration of $Pb(NO_3)_2$ *vs* EDTA.
9. Preparation of Ag/AgCl electrode and to determine the activity of 0.2M HCl.
10. Determination of ionic product of water and study the effect of temperature.
11. Determination of transport number of H^+ by e.m.f. method.
12. Photolysis of monochloro acetic acid.
13. To determine the eutectic point of a two component system (Naphthalene-*m*-dinitrobenzene system).

14. Conductometric method of determination of solubility of sparingly soluble salt.
15. Potentiometric titration of mixture of KCl+KBr+KI *vs* $AgNO_3$.
16. Study of phase diagram of a three component system (e.g. acetic acid-chloroform water and system).
17. Thermodynamics of a cell reaction – construction of an electrochemical cell, study the effect of temperature on the cell reaction and calculation of thermodynamic parameters.
18. Determination of hydroxyl radicals scavenging (antioxidant activity) by spectrophotometric method.
19. Study of *p*H effect (by inhibitors) on electrochemical dissolution of a metal.
20. Kinetics of decomposition of diacetone alcohol by NaOH - determination of energy of activation.
21. Spectrophotometric kinetics of oxidation of indigocarmine by chloramine-T (CAT) - determination of order of reaction w.r.t. [CAT].
22. Kinetic study on Ru(III) catalysed reaction between primary amine and CAT (a) Determination of order of reaction w.r.t. [amine] and [CAT] (b) Determination of E_a and thermodynamic parameters.
23. Kinetics of saponification of ethyl acetate by conductivity method and study the effect of dielectric constant of the medium (using CH_3OH).
24. Study of photolysis of uranyl oxalate (a) determination of intensity of light source (b) study of photocatalysis of oxalic acid.
25. Determination of *p*K value of an indicator (methyl orange).
26. Spectrophotometric analysis of a mixture of (a) $KMnO_4$ and $K_2Cr_2O_7$.
27. Determination of half-wave potential of metal ions in a mixture (Cd^{2+}, Zn^{2+}).
28. Estimation of a metal ion in solution by polarographic method.
29. Coulometric titration I_2 vs $Na_2S_2O_3$.

PART – IV

1. Determination of energy of activation and thermodynamic parameters (ΔH, ΔS, ΔG) for reaction between sodium formate and iodine.
2. To study the kinetics of saponification of ethyl acetate by conductivity method, determination of order of reaction w.r.t. [OH^-].
3. To study the kinetics of reaction between acetone and iodine-determination of order of reaction w.r.t. iodine and H_2SO_4.

4. Determination of mean ionic activity coefficient of a weak electrolyte (formic acid) by conductometric measurements.
5. To study the acid catalysed kinetics of oxidation of glycine by chloramine-T (CAT)- determination of order of reaction w.r.t. [CAT] and $[H^+]$.
6. Kinetics of decomposition of benzene diazonium chloride, determination of energy of activation and thermodynamic parameters.
7. Potentiometric titration of $Pb(NO_3)_2$ *vs* EDTA.
8. Determination of activity of 0.1M HCl by e.m.f. method.
9. Determination of ionic product of water and study the effect of temperature by conductivity method.
10. Determination of transport number of $[Cl^-]$ by e.m.f. method.
11. Determination of rate of photolysis of trichloroacetic acid.
12. To determine the eutectic point of a two component system (Naphthalene-biphenyl system).
13. Conductometric method of determination of solubility of sparingly soluble salt.
14. Study of phase diagram of a three component system (benzene-alcohol-water system).
15. Calculations of thermodynamic parameters by the study of effect of temperature, on the cell reaction for an electrochemical cell.
16. Determination of energy gap for semiconductor (Ge) and effect of temperature on semiconductor by four probe method.
17. Study of *p*H effect (by inhibitors) on electrochemical dissolution of a metal.
18. Spectrophotometric kinetics of oxidation of indigocarmine by chloramine-T (CAT) - determination of order of reaction w.r.t. [CAT].
19. Kinetic study on Ru(III) catalysed reaction between primary amine and CAT (a) Determination of order of reaction w.r.t. [amine] and [CAT] (b) Determination of Ea and thermodynamic parameters.
20. Kinetics of saponification of ethyl acetate by conductivity method and study the effect of dielectric constant of the medium (using CH_3OH).
21. Determination of half- wave potential of metal ions in a mixture (Cd^{2+}, Zn^{2+}).
22. Estimation of a metal ion in solution by polarographic method.
23. Determination of pK value of an indicator (methyl orange).
24. Coulometric titrations (a) I_2 *vs* $Na_2S_2O_3$.
25. Determination of half-life of ^{40}K.

References:

1. Practical Physical Chemistry – A.J. Findlay.
2. Experimental Physical Chemistry – F. Daniels *et al*.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico-Chemical Experiments – J. Rose.
7. Practical Physical Chemistry – S.R. Palit.
8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994).
11. Experimental Physical Chemistry – Das. R.C. and Behera B, Tata Mc Graw Hill

THEORY – OPEN ELECTIVE

CHA ELT: 3.1. SEPARATION TECHNIQUES OF BIOCHEMISTRY AND BIOLOGY

UNIT – I

Principles of chromatography: Distribution coefficients, modes of chromatography, selection of stationary and mobile phases, analyte development and elution. Chromatographic performance parameters - Retention time and volume, capacity factor, plate height and resolution. **Gas-liquid chromatography:** Principle. Apparatus-columns, sample application, mobile phase, stationary phases, detectors. Applications.

HPLC principles: Instrumentation - columns, stationary phase and matrices, sample application, mobile phases, pumps, detectors. Fast protein liquid chromatography [FPLC].

Ion-exchange chromatography: Principle, materials and applications.

Molecular exclusion chromatography: Principle, materials. Applications - purification, relative molecular mass determination, solution concentration, desalting.

Affinity chromatography: Principle, materials-matrix, liquid, practical procedure, applications. Lectin affinity chromatography, metal-chelate chromatography, covalent chromatography. **Thin layer chromatography:** Principle, apparatus - preparation of plates, sample application, plate development, detection of analytes. Applications. Selection of chromatographic systems.

UNIT – II

Electrophoretic techniques: Electrophoresis & Capillary Electrophoresis**:** Theory **-e**lectrophoretic mobility, electroosmotic mobility, electroosmotic flow velocity, total mobility, migration time, efficiency, selectivity and resolution. Instrumentation - capillary tubes, hydrodynamic and electrokinetic methods of sample injection, applying electric field and detectors. Capillary electrophoresis methods - capillary zone electrophoresis, micellar electrokinetic capillary chromatography, capillary gel electrophoresis and capillary electrochromatography.

Concepts of distillation, crystallization, evaporation, dialysis, electro dialysis, osmosis and reverse osmosis.

Centrifugation: Centrifugal force, centrifugal sedimentation, centrifugal decantation, centrifuges, selection of centrifuge tubes. Preparative, density gradient and isopycnic centrifugation. Applications.

Analytical sedimentation: Sedimentation coefficient, sedimentation velocity, applications in biological separations.

Membrane separation: Principles and applications.

References:

1. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.
2. Principles and Techniques of Biochemistry and Molecular Biology, Wilson and Walker, 6th edition, 2006, Cambridge Univ. Press.
3. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
4. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.
5. Separation Techniques in Chemistry and Biochemistry, Roy Keller; M. Dekkar, Inc. 1967.

CHI ELT: 3.2. BIOLOGICAL INORGANIC CHEMISTRY

UNIT - I

An overview of metals in Biology: Introduction, the element content of living systems, biological chemistry of hydrogen, the economical use of resources- abundance and availability. Biological need for and the behaviors of inorganic elements.

Basic coordination chemistry for biologists: Introduction, ionic bonding, covalent bonding, Hard and soft ligands, the chelate effect, coordination geometry, crystal field and ligand field theory.

Metal assimilation pathways: Introduction, metal assimilation in bacteria, plants, fungi and in mammals (iron, copper and zinc).

Storage and homeostasis of metal ions: Introduction, metal storage and homeostasis in bacteria, plants, fungi and in mammals (iron, copper and zinc).

[16 HOURS]

UNIT – II

Sodium and potassium-channels and pumps: Introduction, transport across membranes, potassium channels, sodium channels, the sodium-potassium ATPase, active transport driven by Na^+ gradients, sodium/proton exchangers, other roles of intracellular K^+**.**

The biological chemistry of magnesium and calcium: Introduction, magnesium chemistry, magnesium-dependent enzymes, phosphoryl group transfer - kinases and phosphatases. Comparison of calcium and magnesium. Protein ligands for calcium. **Calcium triggering**-calmodulins.

Iron - Essential for almost all life: Introduction, iron and oxygen, the biological importance of iron. Biological functions of iron-containing proteins. Haemoproteins, iron-sulfur proteins, iron regulation - relationship to genes and evolution.

Metals in brain and their role in various neuro-degenerative diseases: Introduction, metals in brain, calcium, zinc, copper. Disorders of copper metabolism- Wilson's and Menkes diseases. Iron, redox metal ions, oxidative stress and neuro-degenerative diseases (PD and AD).

Metals in medicine: Introduction, *cis*-platin, contrast agents for MRI, radioactive pharmaceuticals, lithium compounds in therapy.

[16 HOURS]

References:

1. The Biological Chemistry of the Elements. The Inorganic Chemistry of Life. J.J.R. Frausto da silva and R.J.P. Williams, Oxford University Press, New York (2001).
2. Bioinorganic Chemistry: A Survey. Eiichiro Ochiai, Elsevier, USA (2008).
3. Biological Inorganic Chemistry. An Introduction, Robert R. Crichton, Elsevier, USA (2008).

CHO ELT: 3.3. APPLICATIONS OF SYNTHETIC PRODUCTS

UNIT – I

Dyes: Colour and constitution, classification, dyeing method and their industrial importance.
Drugs: Basic concepts, classification, sources, the requirement of an ideal drug
Synthetic drugs: Structure and medicinal properties:
Sulphanilamide – an example of sulpha drug-paracetamol, aspirin, oil of wintergreen; Mephensin – a muscle relaxant; Ibuprofen – an anti-inflammatory drug; L-dopa – cures Parkinson's disease; Chloroquine – an antimalarial drug; Chlorpromazine – an antipsychotic agent; Phenobarbital – a barbiturate; Omeprazole – an drug; Ciprofloxacin – an antibacterial drug; Formulation of drugs – introduction and classification.
Polymers: Introduction, biodegradable and non-biodegradable polymers and their industrial importance, plastics (uses and effects on enviornment), natural and synthetic rubbers, polyamides and poly esters like nylon, decron, terelyne. Thermoplastics - poly carbonates, poly acrylates in lens applications, polyurethanes and conducting polymers.

[16 HOURS]

UNIT – II

Soaps and detergents: Production and their cleansing action.
Liquid crystals and their applications.
Surfactants
Cosmetics: Detailed study of formulations and manufacturing of cream and lotions, lipstick and nail polish, shampoos, hair dyes and tooth pastes.
Flavours: Natural flavouring materials and classification
Sweeteners: Natural and synthetic sweeteners.
Insecticides: Introduction, classification, applications and their effect on environment.
Pheromones: Introduction, Sources, biological importance.
Explosives: Introduction, RDX, Gun powder.

[16 HOURS]

References:

1. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.

2. K. Albert, L. Lehninger, D. L. Nelson, M. M. Cox, Principles of Biochemistry, CBZ publishers, 1st edition, New Delhi, 1993.
3. Harper's Biochemistry, Ed. R. Harper, 22nd edition, Prentice Hall Press, New York, 1990.
4. Encyclopedia of Chemical technology – Kirck-Othmer series
5. Harper's Review of Biochemistry – P.W. Martin, P.A. Mayer & V.W. Rodfwell, 15th edition, Maurzen Asian Edition, California, 1981.

CHP ELT: 3.4. GENERAL ASPECTS OF PHYSICAL CHEMISTRY

UNIT – I

Enzyme kinetics: Effect of substrate concentration (Michaelis Menton equation), Effect of *p*H, effect of catalysts and inhibitors (substrate, zeolite, Cr^{3+}, Fe^{2+} ZnO, U.V light), effect of temperature.

Pharmacokinetics: Plasma level-time curve, significance of measuring plasma drug concentrations. Drug Bioavailability: Factors affecting the drug bioavailability

Polymers: Molecular weight and size. Polydispersion. Average molecular weight concepts -number weight and viscosity average molecular weight. Principles of determination of molecular weights - End group analysis, viscosity, osmometry, cryoscopy and ebulliometry method

Chemistry of Nanomaterials: Nanoparticles. Synthesis - Laser abalation, chemical vapour transportor method (CVT) and sol-gel method. Carbon nanotube, Carbon nanowires and its composites. Synthesis of metal oxides and its composite nanoparticles by solvothermal and hydrothermal method. Inorganic and organic nano porous aerogels.

[16 HOURS]

UNIT – II

Corrosion: Manifestations of corrosion, types of corrosion, basis of electrochemical corrosion, theories of corrosion. Local cell theory (Wagner and Traud theory) Current – potential relations (Evan diagram) in corrosion cells. Effect of *p*H, nature of metal and dissolved oxygen (principle of differential aeration) on corrosion. Corrosion inhibition and prevention by painting, phosphating and by using biomaterials, corrosion protection by anodic (passivation) and cathodic protection.

Irrversible electrode process: Introduction, reversible and irreversible electrodes reversible and irreversible cells. Polarization, overvoltage - ohmic overvoltage, concentration overvoltage

activation overvoltage, experimental determination of overvoltage. Polarography and its application.

Photodegradation: Photocatalyst – ZnO, TiO_2, principle, application of ZnO/TiO_2 in the photo degradation of dyes (IC), pesticides (DDT) and in industrial effluents. Effect of photo degradation on COD value.

[16 HOURS]

References:

1. Introduction to Statistical Thermodynamics by M. Dole, Prantice Hall, (1962).
2. Applied Biopharmacokinetics and Pharmacokinetics - Leon Shargel, Andrew Yu Prentice Hall international, Inc. (4^{th} edition).
3. Essentials of Physical Chemistry and Pharmacy – H.J. Arnikar, S.S. Kadam, K.N. Gujan, Orient Longman, Bombay, (1992).
4. Hand Book of Nanotechnology, Bharat Bhushan, Springer Publisher.
5. Nanotechnology, Richard Booker and Earl Boysen, Wiley.
6. Nanometerials, A.K. Bandopadhyay, New age International, 2^{nd} edition.
7. Nanotechnology - Importance and Applications, M.H. Fulekar, Inc. International publishing.
8. Theoretical Chemistry – S. Glasstone. East West Press, New Delhi, (1973).

FOURTH SEMESTER

THEORY – HARD CORE

CHI HCT: 4.1. BIOINORGANIC CHEMISTRY

UNIT – I

Structural and molecular biology: Introduction, The structural building blocks of proteins, the structural building block of nucleic acids. Metal ion interactions with nucleosides and nucleotides.

General features of DNA - metal complex interaction.

Bioenergetics: Introduction, Redox reactions in metabolism, the central role of ATP in metabolism. Kinetic stability of ATP, Mitochondrial flow of electrons from NADH to O_2. Oxidative phosphorylation and respiratory chain.

Sodium and potassium-channels and pumps: Introduction, transport across membranes. Potassium and sodium channels, The sodium-potassium ATPase, Macro cyclic crown ether compounds, cryptands and ionophores.

Biochemistry of calcium: Introduction - comparison of Ca^{2+} and Mg^{2+}. Biological roles of calcium, binding sites of calcium and proteins, storage of calcium, calcium in muscle contraction, calcium in blood clotting process.

Vitamin B_{12} and Coenzymes: Structural feature, names of different forms, chemistry of cobalamin, biochemical functions of cobalamins, model compounds. Special characteristics of B_{12} co-enzyme.

[16 HOURS]

UNIT – II

Metal ion transport and storage:

Iron storage and transport: Transferrin, ferratin, phosvitin and gastroferrin.

Iron transport in microbes: siderophores, *in vivo* microbial transport of iron

Oxygen transport and oxygen uptake proteins: Properties of dioxygen (O_2): Thermodynamic and kinetic aspects of dioxygen as an oxidant, activation of dioxygen through complexation with metal ions.

Haemoglobin (Hb) and Myoglobin (Mb) in oxygen transport mechanism: Introduction to porphyrin system, substituent effects on porphyrin rings, functions of Hb and Mb. Characteristics of O_2^- binding interaction with Hb and Mb. Model compounds for oxygen carriers (Vaska's complex and cobalt(III) – Schiff base complexes). Hemerythrin and hemocyanin.

Electron transport proteins and redox enzymes: Iron – sulfur proteins (rubredoxins and ferredoxins) and cytochromes including cytochrome P450. Catalase and peroxidase: Structure and reactivity.

Superoxide dismutase: Structure and reactivity.

Molybdenum containing enzymes: Aspects of molybdenum chemistry, Xanthine oxidase, aldehyde oxidase, sulfite oxidase, nitrogenase and nitrite reductase.

Non-redox metalloenzymes - Structure and reactivity: Carboxypeptidase-A, alcohol dehydrogenase, leucine aminopeptidase and carbonic anhydrase.

[16 HOURS]

UNIT - III

Therapeutic uses of Metals - Metals in medicine: Introduction, metals and human biochemistry, general requirements.

Disease due to metal deficiency and treatment: Iron, zinc, copper, sodium, potassium, magnesium, calcium and selenium.

Metal complexes as drugs and therapeutic agents: Introduction, antibacterial agents, antiviral agents, metal complexes in cancer therapy, metal complexes for the treatment of rheumatoid arthritis, vanadium diabetes, metal complexes as radio diagnostic agents.

Treatment of toxicity due to inorganics: General aspects of mechanism of metal ion toxicity,

(i) Mechanism of antidote complex with poison, rendering it inert: arsenic, lead, mercury, iron, copper

(ii) Antidote accelerated metabolic conversion of poison to non-toxic product: cyanide and carbon monoxide

[16 HOURS]

References:

1. The Inorganic Chemistry of Biological Process- 2nd edition, M. N. Hughes, John Wiley and Sons, (1988).
2. Bioinorganic Chemistry - R.W. Hay, Ellis Horwood Ltd., (1984).
3. Biological Inorganic Chemistry – An Introduction, R.R. Crichton, Elsevier, (2008).
4. Bioinorganic Chemistry - A.K. Das, Books and Allied (P) Ltd, (2007).
5. Bioinorganic Chemistry - K. Hussain Reddy, New Age International Ltd. (2003).
6. Bioinorganic Chemistry: A Survey - Eiichiro Ochiai, Academic Press, (2008).
7. Bioinorganic Chemistry: A Short Course - 2nd edition, R.M. Roat-Malone, Wiley Interscience, (2007).
8. Medicinal Applications of Coodination Chemistry - Chris Jones and John Thornback, RSC Publishing, (2007).

9. Transition Metal Complexes as Drugs and Chemotherapeutic Agents - N. Farrell, Kluwer Academic Publishers (1989).
10. The Biological Chemistry of the Elements: The Inorganic Chemistry of Life - 2nd edition, J.J.R. Frausto da Silva and R.J.P. Williams, Oxford University Press,(2001).

CHP HCT: 4.2. SOLID STATE CHEMISTRY AND APPLICATIONS OF QUANTUM CHEMISTRY; ADVANCED CHEMICAL KINETICS AND BIOPHARMACEUTICS

UNIT – I

Fundamentals of X-ray crystallography, law of interfacial angles, laws of symmetry, Miller indices, Bragg equation (no derivation), Experimental methods – powder and rotating crystal methods, indexing of powder and rotating crystal photographs. Atomic scattering factor, structure factor, Fourier synthesis and electron density diagrams. Electron diffraction of gases, experimental technique, Scattering-Intensity curves, Wierl equation (no derivation), Radial distribution method determination of bond lengths and bond angles.

Applications of quantum mechanics: Application of variation theorem to a particle in one dimensional box, linear oscillator, H and He-atoms, SCF method for many electron atom. Slater Orbitals – Effective nuclear charge (ENC), expressions for Slater orbitals for 1s, 2s, 3s, 2p and 3d electrons (no derivation), Slater's rules for calculation of ENC - Slater's orbitals for He, carbon and nitrogen. Theories of valence – Introduction, linear and non-linear variation functions, secular equations, coulombic, exchange, normalization and overlap integrals, secular determinants.

[16 HOURS]

UNIT – II

Enzyme kinetics: Effect of substrate concentration (Michaelis Menton equation), Effect of *p*H, effect of catalysts and inhibitors (substrate, zeolite, Cr^{3+}, Fe^{2+} ZnO, UV light), effect of temperature. A brief kinetic and mechanistic applications of glucose oxidase in the oxidation of glucose.

Linear free energy relationship: Hammett equation, Taft equation, Okamoto Brown equation and its application to oxidation of amino acids and aromatic amines. Swain-Scott and Edward equation. Winstein - Grunwald relationship. isokinetic relationship and significance of isokinetic temperature, Exner criterion.

Kinetic isotope effect: Theory of kinetic isotope effect - normal and inverse isotope effect, primary isotope effect, secondary isotope effect, solvent isotope effect.

[16 HOURS]

UNIT – III

Measurement of drug concentration in blood, plasma or serum. Plasma level-time curve, Significance of measuring plasma drug concentrations. One compartment open model: Intravenous route of administration of drug, elimination rate constant, apparent volume of distribution and significance. Plasma level-time curve for a three compartment open model. Route of drug administration - oral drug absorption, intravenous infusion and intravenous solutions, Effect of food on gastrointestinal drug absorption rate. Drug Bioavailability: Factors affecting the drug bioavailability, rate of dissolution, *p*H and drug absorption, particle size, clinical applications. *In vitro – in vivo* correlation of rate of dissolution. Kinetics of protein binding with drugs.

Electrophoresis - principles of free electrophoresis, zone electrophoresis, gel electrophoresis and its applications in qualitative and quantitative study of proteins. Determination of isoelectric point of a protein. Electroosmosis and streaming potential and its biological significance. Biological significance of Donnan membrane phenomenon. Micelles and its involvement during digestion and absorption of dietary lipids. Diffusion of solutes across biomembranes and its application in the mechanism of respiratory exchange. "Salting In" and "Salting out" of proteins. Osmotic behaviour of cells and osmo-regulation and its application in the evolution of excretory systems of organisms.

[16 HOURS]

References:

1. Text Book of Physical Chemistry by Samuel Glasstone, MacMillan Indian Ltd., 2nd edition, (1974).
2. Elements of Physical Chemistry, S. Glasstone, MacMillan.
3. Phase Rule, Gurthu and Gurthu.
4. Solid State Chemistry – N.B. Hannay.
5. Introduction to Solids – Azaroff.
6. Solid State Chemistry and its applications – A.R. West.
7. Principles of the Solid State – H.V. Keer.
8. A Text Book of Physical Chemistry – G.M. Barrow. Mc Graw Hill – Tokyo, (1973).
9. Elements of Physical Chemistry – Lewis and Glasstone.

10. Solid State Chemistry and its Applications - Anthony R. West.
11. Basic Solid State Chemistry, 2nd edition, Anthony R. West.
12. Solid State Chemistry: An Introduction, 3rd edition, Lesley E. Smart and Elaine A. Moore.
13. Introduction to Solid state Physics—C. Kittel, 5th edition, Wiley Eastern, Limited.
14. C.N.R. Rao and J. Gopalakrishna "New Directions in solid state chemistry" Cambridge University Press, Cambridge (1999).
15. Binay Kumar, R.P. Tandon "Advances in technologically important crystals" Macmillan India Ltd.
16. Theoretical Chemistry by S. Glasstone.
17. Statistical Themodynamics by B.C. Meclelland, Chapman and Hall, London (1973).
18. Elementary Statistical Thermodynamics by N.D. Smith Plenum Press, NY (1982).
19. Elements of Classical and Statistical Thermodynamics by L.K. Nash, Addison-Wesley (1970).
20. Statistical Thermodynamics by I.M. Klotz.
21. Introduction to Statistical Thermodynamics by M. Dole, Prantice-Hall, (1962).
22. Applied Biopharmacokinetics and Pharmacokinetics - Leon Shargel, Andrew YuPrentice-Hall international, Inc (Fourth edition).
23. Essentials of Physical Chemistry and Pharmacy – H.J. Arnikar, S.S. Kadam, K.N. Gujan, Orient Longman, Bombay, (1992).
24. Quantum Chemistry – A.K. Chandra. 2nd edition, Tata McGraw Hill Publishing Co. Ltd., (1983).
25. Quantum Chemistry – Eyring, Walter and Kimball. John Wiley and Sons, Inc., New York.
26. Quantum Chemistry – I.N. Levine. Pearson Education, New Delhi, (2000).
27. Theoretical Chemistry – S. Glasstone. East West Press, New Delhi, (1973).
28. Quantum Chemistry – R.K. Prasad, New Age International Publishers, (1996).
29. Valence Theory – Tedder, Murel and Kettle.
30. Quantum Chemistry – D.A. McQuarrie.
31. Hand Book of Nanotechnology, Bharat Bhushan, Springer Publisher.
32. Nanotechnology, Richard Booker and Earl Boysen, Wiley.
33. Nanometerials, A. K. Bandopadhyay, New age International, 2nd edition.
34. Nanotechnology- Importance and Applications, M. H. Fulekar, Ink International publishing.

35. Applied Biopharmacokinetics and Pharmacokinetics - Leon Shargel, Andrew Yu Prentice-Hall International, Inc. (4th edition).
36. Essentials of Physical Chemistry and Pharmacy – H.J. Arnikar, S.S. Kadam, K.N. Gujan, Orient Longman, Bombay, (1992).
37. Biophysical Chemistry, Principle and Technique – A. Upadhyay, K. Upadhyay and N. Nath, Himalaya Publishing House, Bombay, (1998).

THEORY – SOFT CORE

CHA SCT: 4.1 APPLIED ANALYSIS III

UNIT – I

Soil Analysis: Inorganic and organic components of soil, collection and preparation of soil samples for analysis. Measurement of soil *p*H and conductivity. Determination of organic carbon, total nitrogen, 53 available nitrogen, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen. Available phosphorus and sulphur-their determination. Analysis of soil for sodium, potassium and calcium and magnesium. Micronutrient elements and their analysis. Pesticide residues in soil, their separation and determination.

Fuel analysis- Fuels and their classification. Solid fuels and their classes - natural, artificial and industrial solid fuels. Coal and its analysis - proximate analysis and ultimate analysis. Liquid fuels and their types. Aniline point, flash point and fire point and their determination, octane number of liquid fuels. Gaseous fuels and their classes, advantages. Combustion of a carbonaceous fuel – flue gas. Analysis of flue gas or automobile exhaust for CO_2, CO, O_2 and N_2 by Orsat's apparatus. Calorific value of fuel - net and gross calorific values. Determination of calorific value of solid and liquid fuels by bomb calorimeter method.

[16 HOURS]

UNIT - II

Biomedical and forensic analysis: Composition of body fluids and detection of abnormal levels of certain constituents leading to diagnosis of disease. Sample collection and preservation of physiological fluids. Analytical methods for the constituents of physiological fluids (blood, serum, urine).

Blood - estimation of glucose, cholesterol, urea, haemoglobin and bilirubin.

Urine - urea, uric acid, creatinine, calcium phosphate, sodium, potassium and chloride.

Biological significance, analysis and assay of enzymes (pepsin, monoaminoxidase, tyrosinase); and hormones (progesterone, oxytocin, insulin). Chemical, instrumental and biological assays to be discussed wherever necessary.

Forensic analysis: General discussion of poisons with special reference to mode of action of cyanide, organophosphates and snake venom. Estimation of poisonous materials such as lead, mercury and arsenic in biological materials.

CHA SCT: 4.2 APPLIED ANALYSIS IV

UNIT – I

Kinetic methods of analysis: Introduction, basis of kinetic methods, rate law expressions. Classifying chemical kinetic methods – direct-computation integral methods, direct-computation rate methods, curve-fitting methods. Instrumentation. Quantitative applications - enzyme catalyzed reactions, non-enzyme catalyzed reactions, non-catalytic reactions. Determining V_{max}, K_m for enzyme catalyzed reactions. Elucidating mechanism for the inhibition of enzyme catalysis. Determination of enzymes, LDH, GOT and GPT. Determination of substrates – urea, uric acid, blood glucose and blood alcohol. Analysis of closely related compounds - neglect of reaction of slow reacting component method and logarithmic extrapolation method.

Automated methods of analysis: An overview. Principles of automation. Automated instruments: process control. Continuous analyzers. Discrete autoanalyzers. Instruments used in automated process control. Automatic instruments - discrete and continuous flow sampling instruments. Flow injection analysis – principles - dispersion co-efficient. Factors affecting peak height, sample volume, channel length and flow rate, and channel geometry. Applications -limited dispersion applications, medium dispersion applications, stopped flow methods and flow injection titrations. Discrete automatic systems - centrifugal fast scan analyzer, automatic organic elemental analyzers.

Analysis based on multilayer films-general principles, film structures, instrumentation, performance and applications – blood urea nitrogen, blood glucose and potassium.

[16 HOURS]

UNIT – II

Radiometric methods: Radioactive isotopes. Nuclear emissions - α and β-particles, neutrons, gamma rays and miscellaneous nuclear particles. Nuclear reactions, radiochemical decay and activity. Instrumentation and measurement of radioactivity. Radiation detectors - gas ionization, scintillation and semiconductor detectors. Pulse height analysis. Autoradiography. Statistics of radioactive measurements.

Radiochemical analysis: **Neutron activation methods** - neutrons and their sources. Interaction of neutrons with matter. Theory, experimental considerations and applications. **Isotope dilution methods -** direct isotope dilution and inverse isotope dilution methods and their applications. Radiometric titrations. Radiorelease methods. Radioactive tracers.

Radio immunoassay: Principles of immunoassay. Specificity of immuno assays. Preparation of the antibody, incubation period for the assay, separation of the bound and free antigen. Fluorescence immunoassay. Enzyme immunoassay.

[16 HOURS]

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993 Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003 Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7th edition, (1988).
7. Principles and Practice of Analytical Chemistry, F.W. Fifield and Kealey, 3rd edition, 2000, Blackwell Sci., Ltd. Malden, USA.
8. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.
9. Introduction to Instrumental Analysis, Braun, Pharm. Med. Press. India.
10. Instrumental Method of Analysis, W. M. Dean and Settle, 7th edition, 1986, CBS Publishers, New Delhi.
11. Instant Notes of Analytical Chemistry, Kealey and Haines, Viva books Pvt. Ltd., 2002.
12. Soil Chemical Analysis, M.L. Jackson, Prentice Hall of India Pvt. Ltd., New Delhi, 1973.

13. Clinical Chemistry, Principles and Procedures, J.S. Annino, 2nd edition, Boston: Little, Brown, 1960.
14. Methods of Geochemical Analysis, D. Click, Ed., A Multi volume series, NewYork, Inter science.
15. Clinical Chemistry, Principles and Techniques, R.J. Henry, D.C. Cannon and J.W. Winkleman, Eds., 2nd edition, Hagerstorm, M.D: Harper and Row, 1974.
16. Fundamentals of Clinical Chemistry, N.W. Tietz, Ed., 2nd edition, Philaddphia: W.B. Saunders, 1976.

CHO SCT: 4.3. BIO-MOLECULES

UNIT – I

Amino Acids: General structure, Physiological properties

Peptides: Structure and conformation of peptide bond, peptide synthesis: Solution phase and Merrifield's solid phase synthesis, Racemization and use of HOBt, Synthesis of oxytocin and vasopressin, biological importance of insulin, selective cleavage of polypeptide bonds (chemical and enzymatic).

Proteins: Structure determination: *C* and *N* terminal residue determination, primary, secondary, tertiary and quartenary structure determination, denaturing and renaturing of proteins.

Nucleic acids: Introduction, structure and synthesis of nucleosides and nucleotides, protecting groups for hydroxy group in sugar, amino group in the base and phosphate functions. Methods of formation of internucleotide bonds: DCC, phosphodiester approach and phosphoramide methods. Solid phase synthesis of oligonucleotides. Structure of RNA and DNA, Crick-Watson model, role of nucleic acids in the biosynthesis of proteins.

Genetic code, replication of DNA.

[16 HOURS]

UNIT - II

Carbohydrates: Introduction, Ring size determination of monosaccharides, configuration and conformations of monosaccharides, anomeric effect, Hudson's rules, epimerization and mutarotation.

Synthesis, industrial and biological importance of glycosides, amino sugars, sucrose, maltose and lactose.

Polysaccharides: General methods of structure elucidation. Industrial importance and biological importance of cellulose, starch, glycogen, dextran, hemicellulose, pectin, agar-agar. Photosynthesis and biosynthesis of carbohydrates.

Lipids: Nomenclature, classification, purification, synthesis of lipids, phospholipids, sphingolipids, biological importance of lipids: Lecithin, sphingolipids, oils and fats.

Prostaglandins: Introduction, classification and biological importance, constitution of PGE_1.

[16 HOURS]

References:

1. I. L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.
2. K. Albert, L. Lehninger, D.L. Nelson, M.M. Cox, Principles of Biochemistry, CBZ publishers, 1st edition, New Delhi, 1993.
3. Harper's Biochemistry, Ed. R.Harper, 22nd edition, Prentice Hall Press, New York, 1990.
4. Encyclopedia of Chemical Technology – Kirck-Othmer series
5. Harper's Review of Biochemistry – P.W. Martin, P.A. Mayer and V.W. Rodfwell, 15th edition, Maurzen Asian Edition, California, 1981.

CHO SCT: 4.4. CHEMISTRY OF NATURAL PRODUCTS

UNIT - I

Steroids: Introduction, Structure and synthesis of cholesterol. Ergosterol and its irradiation products. Biological importance of bile acids, estrone, progesterone, testosterone, androsterone and corticosterone.

Alkaloids: Introduction, classification, isolation and general methods of structural elucidation. Biological importance of alkaloids. Structure and synthesis of quinine, morphine, reserpine and lysergic acid. Biosynthesis of alkaloids (nicotine and morphine).

[16 HOURS]

UNIT – II

Vitamins: Introduction, constitution and synthesis of thiamine, riboflavin, pyridoxine, biotin, ascorbic acid, vitamin A, E and K groups. Biosynthesis of vitamin C.

[16 HOURS]

References:

I. L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.

1. Essentials of physiological chemistry – Anderson, John Wiley & Sons, New York, 1953.
2. K. Albert, L. Lehninger, D.L. Nelson, M.M. Cox, Principles of Biochemistry, CBZ publishers, 1st edition, New Delhi, 1993.
3. Harper's Biochemistry, Ed. R.Harper, 22nd edition, Prenctic Hall Press, New York, 1990
4. Intrdouction to Alkaloids – G.A. Swan
5. The Alkaloids - K.W. Bently
6. Steroids – L. Fiescher and M. Fiescher
7. Steroids – Shoppe

PRACTICALS – SOFT CORE

Analytical Chemistry/Inorganic Chemistry

[96 HOURS EACH]

Organic Chemistry/Physical Chemistry

[96 HOURS EACH]

Experiments are as in THIRD SEMESTER. Every student will carry out experiments on a rotation basis in the THIRD and FOURTH semesters.

THEORY – OPEN ELECTIVE

All the papers are as in THIRD semester and the candidate can opt any paper of his/her choice in FOURTH semester provided the same paper/s is not repeated again in FOURTH semester.