SAURASHTRA UNIVERSITY

RAJKOT

(ACCREDITED GRADE "A" BY NAAC)

FACULTY OF SCIENCE

Syllabus for

M. Sc. (CHEMISTRY)

Choice Based Credit System

With Effect From: 2016-17

PROGRAM OUTCOME (PO)

The following outcome reflate the terminal skills that all master post graduates should be able to demonstrate program completion.

PO1: The chemistry course is designed to give core knowledge with the skills to critically assess and solve problems, related to chemical science.

PO2: The different papers sub-discipline such as organic, inorganic, physical and analytical chemistry give detail knowledge and applications in respective specialization.

PO3: The Masters students will have working knowledge of chemical instrumentation and laboratory techniques.

PO4: The training will the help students to design and conduct independent work in industry or academia.

PROGRAM SPECIFIC OUTCOME (PSO)

PSO1:

- Understanding of fundamental and advanced concepts of Quantum Chemistry and coordination chemistry.
- Knowledge of fundamentals of inorganic spectroscopy, their interpretation and their applications.
- Study of various chemical reagents and their role in inorganic synthesis and inorganic analysis.
- Study of synthesis and applications of nanomaterials.

PSO2:

- Basic knowledge of Organic chemistry
- Study of various reaction intermediates and reaction pathways.
- Understanding of various organic reactions, rearrangement, cross-coupling reactions and applications.

PSO3:

- Basic understanding of basic area of physical chemistry.
- Knowledge of various theories of physical chemistry such as thermodynamics, electrochemistry and properties of solutions.
- Applications of physical chemistry in various fields.

PSO4:

- Basic understanding of analytical chemistry.
- Knowledge of volumetric methods of analysis and gravimetric analysis.
- Study of spectro-analytical techniques and their applications to various chemical systems.

Semestre-1							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C-101	Inorganic Chemistry	4	30	70	100	2.5	4
C-102	Organic Chemistry	4	30	70	100	2.5	4
C-103	Physical Chemistry	4	30	70	100	2.5	4
C-104	Analytical Chemistry	4	30	70	100	2.5	4
C-105	Practical	12	-	-	150	6	6
C-106	Viva voce	-	-	-	50		2
Total		28	120	280	600	16	24

Semestre-2							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C-201	Inorganic Chemistry	4	30	70	100	2.5	4
C-202	Organic Chemistry	4	30	70	100	2.5	4
C-203	Physical Chemistry	4	30	70	100	2.5	4
C-204	Analytical Chemistry	4	30	70	100	2.5	4
C-205	Practical	12	-	-	150	6	6
C-206	Viva voce	-	-	-	50	-	2
Total		28	120	280	600	16	24

Semestre-3 (PHYSICAL AND MATERIALS CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**

C(PM)-301	Advance Chromatographic Techniques	4	30	70	100	2.5	4
C(PM)-302	Electro Analytical Techniques	4	30	70	100	2.5	4
C(PM)-303	Macromolecular Physical Chemistry-II	4	30	70	100	2.5	4
C(PM)-304	Nuclear And Radio Chemistry Elective-I / Electrochemistry Elective-II	4	30	70	100	2.5	4
C(PM)-305	Practical	12	-	-	150	6	6
C(PM)-307	Viva voce	-	-	-	50	-	2
Total		28	120	280	600	16	24

Semestre-3 (PHARMA-ANALYTICAL CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C(PA)-301	Advance Chromatographic Techniques	4	30	70	100	2.5	4
C(PA)-302	Electro Analytical Techniques	4	30	70	100	2.5	4
C(PA)-303	Advances In Environmental Chemistry	4	30	70	100	2.5	4
C(PA)-304	Selected Topics In Analytical						
	Patent Laws And Case Studies						

C(PA)-305	practical/Dissertation	12	-	-	150	6	6
C(PA)-306	Viva Voce	-	-	-	50	-	2
Total		28	120	280	600	16	24

Semestre-3 (ORGANIC PHARMACEUTICAL CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C(OP)-301	Advance Chromatographic Techniques	4	30	70	100	2.5	4
C(OP)-302	Organic Synthesis-A Disconnection Approach	4	30	70	100	2.5	4
C(OP)-303	Heterocyclic Chemistry	4	30	70	100	2.5	4
C(OP)-304	Chemistry Of Natural Products Elective-I / Synthetic Dyes And Pigments Elective-II	4	30	70	100	2.5	4
C(OP)-305	practical	12	-	-	150	6	6
C(OP)-306	Viva Voce	-	-	-	50	-	2
Total		28	120	280	600	16	24

Semestre-3 (INORGANIC CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**

C(I)-301	Advance Chromatographic Techniques	4	30	70	100	2.5	4
C(I)-302	Molecular Symmetry And Group Theory	4	30	70	100	2.5	4
C(I)-303	Advance Bioinorganic Chemistry	4	30	70	100	2.5	4
C(I)-304	Organometallic Compounds And Catalysis Elective-I / Selected Topics In Inorganic Chemistry elective-II	4	30	70	100	2.5	4
C(I)-305	practical	12	-	-	150	6	6
C(I)-306	Viva Voce	-	-	-	50	-	2
Total		28	120	280	600	16	24

Semestre-4 (PHYSICAL AND MATERIALS CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C(PM)-401	Advance Spectroscopic Techniques	4	30	70	100	2.5	4
C(PM)-402	Instrumental Techniques	4	30	70	100	2.5	4
C(PM)-403	Chemistry Of Materials-I	4	30	70	100	2.5	4
	Reaction Dynamics						

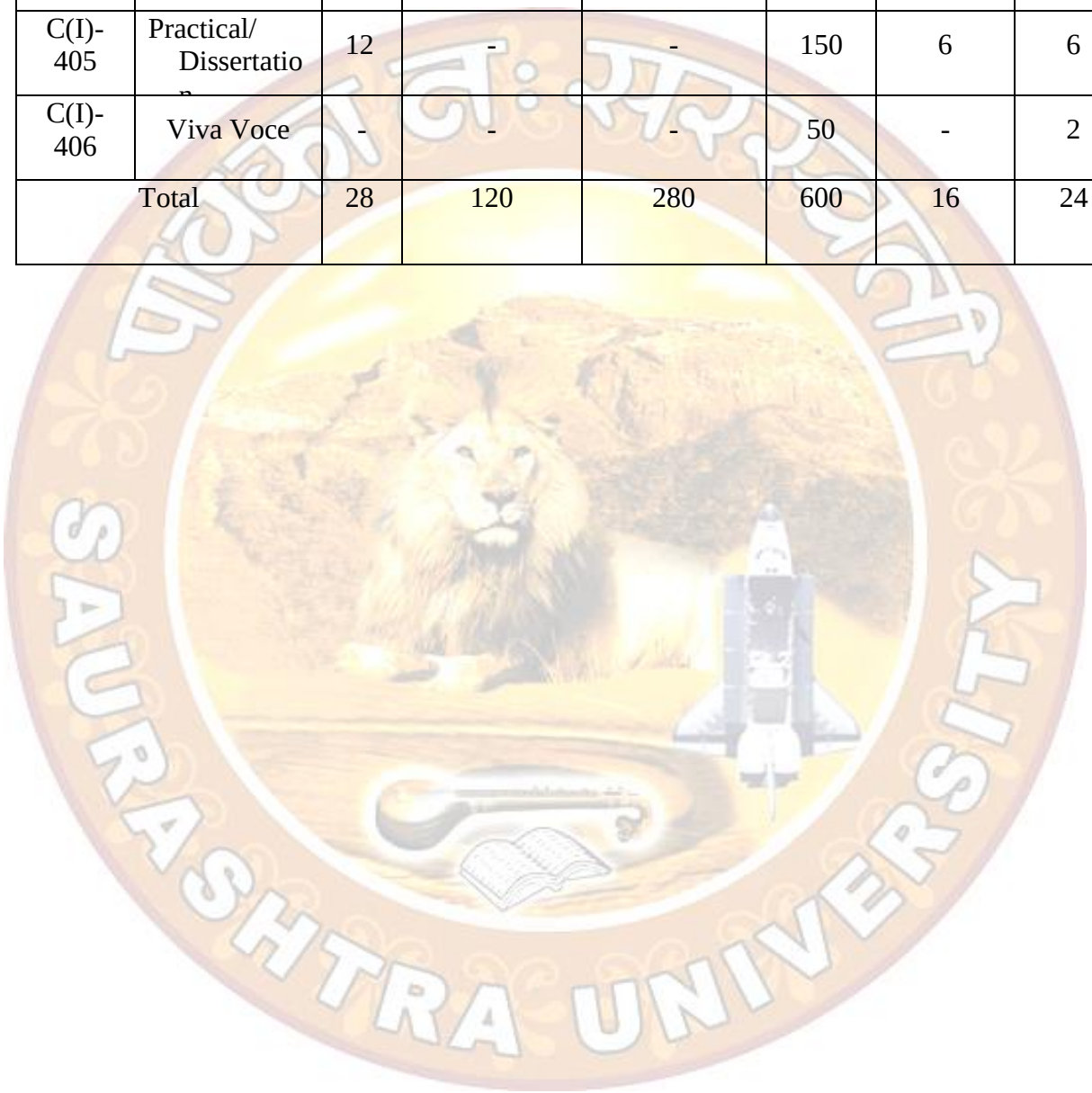
C(PM)-404	Chemistry Of Materials-Ii Elective-II	4	30	70	100	2.5	4
C(PM)-405	Practical/ Dissertatio	12	-	-	150	6	6
C(PM)-406	Viva Voce	-	-	-	50	-	2
Total		28	120	280	600	16	24

Semestre-4 (PHARMA-ANALYTICAL CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C(PA)-401	Advance Spectroscopic Techniques	4	30	70	100	2.5	4
C(PA)-402	Instrumental Techniques	4	30	70	100	2.5	4
C(PA)-403	Pharma Regulatory Affaires	4	30	70	100	2.5	4
C(PA)-404	Applied Analytical Chemistry Elective-I / Selected Topics In Analytical Chemistry Elective-II	4	30	70	100	2.5	4
C(PA)-405	Practical/ Dissertatio	12	-	-	150	6	6
C(PA)-406	Viva Voce	-	-	-	50	-	2
Total		28	120	280	600	16	24

Semestre-4 (ORGANIC PHARMACEUTICAL CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C(OP)-401	Advance Spectroscopic Techniques	4	30	70	100	2.5	4
C(OP)-402	Chemistry Of Synthetic Drugs	4	30	70	100	2.5	4
C(OP)-403	Stereochemistry	4	30	70	100	2.5	4
C(OP)-404	Advanced Stereo Chemistry Elective-I Advanced Medicinal Chemistry Elective-II	4	30	70	100	2.5	4
C(OP)-405	Practical/ Dissertatio	12	-	-	150	6	6
C(OP)-406	Viva Voce	-	-	-	50	-	2
Total		28	120	280	600	16	24
	Catalysis						

Semestre-4 (INORGANIC CHEMISTRY)							
Paper No.	**Title of Paper**	**No. of Hrs. Per week**	**Weightage For Internal Examination**	**Weightage For Semester end Examination**	**Total Marks**	**Duration of Semester end Exam in Hrs.**	**Course Credits**
C(I)-401	Advance Spectroscopic Techniques	4	30	70	100	2.5	4
C(I)-402	Inorganic Spectroscopy	4	30	70	100	2.5	4

C(I)-403	Bonding In Complexes	4	30	70	100	2.5	4
C(I)-404	Coordination Chemistry Elective-I	4	30	70	100	2.5	4
	Catalysis Elective-II						
C(I)-405	Practical/ Dissertation	12	-	-	150	6	6
C(I)-406	Viva Voce	-	-	-	50	-	2
Total		28	120	280	600	16	24



M.Sc. SEMESTER-I
C-101: INORGANIC CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- CO1: Understand structure determination, bonding, and geometry of compound.
- CO2: Know of Inorganic reagent and their role in reaction and synthesis of inorganic compounds.
- CO3: The Knowledge of inorganic spectroscopy such as Mossbauer, ESR, symmetry of structure etc. and their applications in understanding the different inorganic complexes.
- CO4: Student also familiar with knowledge of bio inorganic chemistry, nanomaterial and synthesis and their functionality in the field of inorganic chemistry.

1. Quantum Chemistry and its applications (MO-VB Theory)

Born-Oppenheimer approximation, Hydrogen molecule ion. LCAO-MO and VB treatments of hydrogen molecule, electron density, forces and their role in chemical bonding. Hybridization and valence MO's of H_2O, NH_3 and CH_4. Hackle π-electron theory and its applications to ethylene, butadiene and benzene. Idea of self-consistent field method.

2. Magneto chemistry

Introduction, definition, types of magnetic bodies, Russell-Saunders and LS coupling. Derivation of Russell-Saundersterms, spin-orbit interaction, thermal energy and magnetic property. Magnetic moment for different multiple widths, multiple width large compared to kT, multiple width small compared to kT. Multiple width comparable to kT. Stereo chemical applications of magnetic properties of the first transition series, lanthanides and actinides, determination of magnetic susceptibility by different methods. Derivation of Van Vleck formula for susceptibility.

3. Fundaments of Mössbauer spectroscopy

Introduction of Mössbauer Spectroscopy. Principle and evaluation of Mössbauer effect. Recoil energy, Doppler effect, Experimental techniques. Isomer shift, quadrupole splitting and applications.

4. Uses of Inorganic reagents in inorganic analysis

General discussion and uses of some inorganic reagents: Potassium bromate ($KBrO_3$), potassium iodate($KI0_3$), ammonium vanadate (NH_4VO_3), ceric sulphate [$Ce(S0_4)_2$], ethylenediaminetetra acetic acid (EDTA).

5. Chemistry in nanoscience and technology

Introduction, definition of nanomaterials and Nano technology. History of nanomaterials, causes of interest in nanomaterials, properties and types. Synthesis of nanomaterials, their characterization techniques and applications of nanomaterials.

Reference Books:

1. Introduction to Quantum Chemistry, A. K. Chandra, McGraw-Hill.
2. Advanced Inorganic Chemistry, Cotton Wilkinson, W S E Wiley.
3. Vogel's Text book of Quantitative Inorganic Analysis, ELBS Press.
4. Elements of Magneto Chemistry, Shyamal & Datta East- West Press.
5. Quantum Chemistry, Ira N. Levine, Prentice-Hall International.
6. Textbook of Inorganic Chemistry Vol. I& II, A. Singh & R. Singh, Campus.
7. Physical Methods in Chemistry, R.S. Drago, Saunders College.

8. Introduction to Magneto chemistry, Alan Earnshaw, Academic Press.
9. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.
10. Nano Science and Nanotechnology in Engineering, by V. K. Varadhan, A. S. Pillai, D. Mukharjee, M. Dwivedi and L. Chen, World Scientific Publishing Company, Pvt. Ltd.
11. Nano: the Essentials, T. Pradeep, Tata Mc Graw Hill, 2007.
12. Nanotubes and Nanowires, C.N.R. Rao, A. Govindaraj, Royal Society of Chemistry, 2011.

M.Sc. SEMESTER-I
C-102: ORGANIC CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student will be able to generalize the basic concept of organic chemistry, reaction intermediate and reaction pathway.
- COs2: Understanding of Organic reaction, rearrangement and cross-coupling reaction with their mechanism and application. Preparation and use of reagent in organic synthesis.

1. Organic reactive intermediates and reaction mechanism

Generation, stability and reactivity of intermediates, addition, elimination and substitution reactions. Determination of reaction pathways. Hammett equation and LFER relationship.

2. Name reaction and its application in organic synthesis

Barbier–Wieland degradation , Prins, Barton, Vilsmer-Haack, Bouveault–Blanc reduction, Willgerodt-Kindler reaction, Biginelli reaction, Birch-reduction,Hofmann-Loffler Freytag, Hantzch, Elbs-persulphate, McMurry reaction, Noyori annulation reaction, Passerini, Reformatsky, Suzuki coupling, Stille coupling Sharplessasymetric epoxidation, Stobbecondensation, and Ugi reaction.

3. Rearrangements

Advances in Fries rearrangement, Beckmann rearrangement, Benzilbenzilicacid, Favorskii, Neber, Sommelet Hauser, Curtius, Schimidt, BaeyerVilliger.

4. Important Reagents

DCC, Gilman reagent, PTC andcrown ethers, Merrifield resin, Woodward and Prevost hydroxylation, reagent for hydroboration, TMS-I, Wilkinson's catalyst, DDQ.

Reference Books:

1. Organic Chemistry by G. Marc. Loudon, Oxford University Press (2002).
2. Organic Reaction Mechanism (2nd edition) – V.K. Ahluwalia and R.K. Parasar.
3. Reaction Mechanism and Reagents in Organic Chemistry – Gurdeep R. Chatwal.
4. Organic Chemistry by Morrission and Boyd, Prentice Hall Pvt Ltd (6th edition), (2003).
5. A Text Book of Organic Chemistry-R.K. Bansal, New Age International Pvt.Ltd. 4th edition (2003).
6. Advanced Organic Chemistry (4th edition) – Jerry March.
7. Reactive Intermediates in Organic Chemistry. J. P. Trivedi, University Granth Nirman Board.

8. Organic Chemistry by V.K.Ahluwalia, Madhuri Goyal, Narosa Publishing House, (2000).
9. Organic Synthesis (2nd edition) by M.B. Smith, Mcgraw-Hill, Inc. (2001).
10. Some Modern Methods of Organic synthesis (4th edition), W.Carruthers, Cambridge University Press (2004).
11. Organic Chemistry by J.Clayden, N. Greeves, S. Warren, P. Wothers, Oxford University Press (2000).
12. Organic Chemistry by J. Mcmurry, Asian Books Pvt. Ltd., 5th edition (2001).
13. Name Reaction in Organic Synthesis, Foundation Books Pvt. Ltd. (2006).

M.Sc. SEMESTER-I
C-103: PHYSICAL CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: students will have fundamental knowledge about different types of solutions. Further, it will be easy for them to understand various processes occurring in solutions
- COs2: Students will also have knowledge about different electrochemical reactions and different types of cells.

1. Statistical Thermodynamics

Basic terms: probability, cell, phase, space, micro and macro states, thermodynamic probability, statistical weight factor, assembly, ensemble and its classification and statistical equilibrium. Derivation of Boltzmann-Maxwell, Bose-Einstein and Fermi-Dirac statistics, Partition function and derivations of translational, rotational, vibrational and electronic partition functions and thermodynamic functions such as internal energy, heat capacity, entropy, work function, pressure, heat content, etc. Partition function and third law of thermodynamics. Applications of partition function to monoatomic gases, diatomic molecules, equilibrium constant and equilibrium constants of metathetic reactions. Problems.

2. Fugacity and Activity

Definition, determination of fugacity by graphical, equation of state, approximate and generalized methods. Variation of fugacity with temperature and pressure. Mixture of ideal gases and real gases Activities and Activity coefficients in liquid solution. Problems

3. The Debye-Huckel Theory

Ionic interactions in solutions. Mean ionic activity coefficients (D-H limiting law).Applications of D-H theory: quantitative and qualitative, solubility and D-H theory, solubility of sparingly soluble salt in presence of inert electrolyte. The D-H theory in more concentrated solutions. D-H theory and equilibrium constant. Problems.

4. The properties of solutions

Ideal solutions: Properties, the Duhem-Margules equation, vapour pressure curves. Composition of liquid and vapour in equilibrium, influence of temperature on gas solubility and solid-liquid equilibria.

Non ideal solutions: Deviation from ideal behaviour, liquid and vapour compositions.

Dilute solutions: Determination of molecular weight by freezing and boiling point methods. Problems

5. Electrochemical cells

Classification, chemical cells with and without transference, concentration cells with and without transference, liquid junction potential.

Commercial cells: Dry cell, lead accumulator, nickel iron accumulator, zinc silver accumulator.

Reference Books:

1. Thermodynamics for Chemists by Samuel Glasstone.
2. Statistical Thermodynamics by L. K. Nash.
3. Statistics in Chemistry by P. H. Parsania.
4. Thermodynamics by Gurdeep and Rajesh.
5. Glimpses of Physical Chemistry by Shipra Baluja and Falguni Karia.
6. Chemical Kinetics by Gurdeep Raj.
7. Chemical Kinetics by K. J. Laidler.
8. Electrochemistry by B. K. Sharma

M.Sc. SEMESTER-I
C-104: ANALYTICAL CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: The learners should be able to: Solve problems based on various analytical concepts.
- COs2: Sophisticated instrument procedures.
- COs3: Quantify analysis with proper data handling and analysis.

1. Basic concept of Analytical Chemistry

Introduction, scope and objectives, Classification of analytical methods. Basics of classical and instrumental methods of analysis. Method of selection, sample processing, steps of total quantitative analysis, the tools of analytical chemistry and good laboratory practises.

Basic of volumetric methods of analysis: General principle, concentration units, standard solution and standardization, detection of end point, indirect and back titration techniques. Minimization of titration errors, types of reactions in titrimetric analysis.

Non-aqueous titrations: Role of solvents, properties of solvents, autoprotolysis and dielectric constant. Titration of acids-bases, solvent system, titrants, standard titration curves, effect of water, end point detection, application to determination of carboxylic acid, phenols and amines.

2. Spectro-analytical Techniques

Fundamental of spectroscopy, electromagnetic radiations and their properties. Introduction to absorption and emission spectroscopy. Lambert-Beer law.

Atomic absorption spectroscopy: Basic principle, theory, instrumentation and applications. Advantages over flame photometry.

Fluorometry and Phosphorimetry: Introduction, principle, theory, instrumentation and applications.

UV-Visible spectrophotometric titrations.

3. Edible oil Analysis

Basic terminology, analytical importance and quantitative determination of oil, fat, wax, iodine value, saponification value, RMPK value, hydroxyl value, moisture, etc. **Detection of oil adulterants**: (1) Argemone oil, (2) Rice bran oil, (3) Sesame oil, and (4) Palm oil.

Reference Books:

1. Vogel Textbook of Quantitative Analysis, 3rd and 7th Edition.
2. Analytical Chemistry by Gary D. Christian, 6th edition (1994), John Wiley and Sons Inc. New York,
3. Principle of Instrumental Analysis by Douglas A. Skoog, 5th Edition (1998)-Saunders College of Publishing Philladelphia, London.
4. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal & Sham K. Anand, Himalaya Publishing House Fifth Revised and Enlarged Edition.
5. H.H. Willard, L.L. Merrit, J.A. Dean, Instrumental Methods of Analysis, 5thEdn. Van Nostrand, 1974 and 6thEdn. CBS (1986).
6. Instrumental Methods of Chemical Analysis by B.K. Sharma, Goel Publishing House, Meerut(UP).
7. H. Kaur, Spectroscopy, 6th Edn. Pragati Prakashan, 2001.
8. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch Fundamentals of Analytical Chemistry 8thEdn. Saunders College Pub.2001.
9. G.G. Bizch, M. Spencer, G. Cameron, Food Science, 3rd Edn. Pergamon Press. 1986.
10. Hand Book of Food Analysis by S.N. Mahindru, Swan Publishers, New Delhi.
11. Analytical Chemistry by H. Kaur, Pragati Prakashan Meerut.

M.Sc. SEMESTER-I
C-105: PRACTICALS

6 CREDITS
150 MARKS

INORGANIC CHEMISTRY

1. Inorganic Qualitative Analysis

Analysis of a mixture containing six radicals including one less common metal ion: W, Tl, Ti, Mo,Se, Zr, Th, Ce,V and Li.

Minimum 15 mixtures containing inorganic salts like CuSO4 , KBr , TiO2 , KI, Na2CrO4, $CaCO_3$, $Zr(NO_3)_3$, $NaNO_3$, ZnS, Na_2SO_4, SeO_2, NaCl, K_2SO_4, $(NH_4)\ 2SO_4$, $(NH_4)\ 2MoO_4$, $BaCl_2$, $ZnCO_3$, $Al_2(SO_4)_3$, V_2O_5, ZnS, $Ni(NO_3)_2$, KNO_2, $Th(NO_3)_3$, KCl, $CdCO_3$, $CuCl_2$, $LiCO_3$, K_2SO_4, $AlPO_4$, H_3BO_3, $(NH_4)\ 2SO_4$, $CeSO_4$, $CdCl_2$, $Th(NO_3)_3$, $NaNO_3$, $ZnCO_3$, $AlPO_4$, $LiCO_3$, $Pb(NO_3)_2$, $NaNO_2$, $Zr(NO_3)_3$, Na_2WO_4, $MnSO_4$, $NaHSO_3$, SeO_2, K_2CrO_4, $FeSO_4$, $(NH_4)\ 2SO_4$, $(NH_4)\ 2MoO_4$, Na_3AsO_3, Na_3AsO_4, $(NH_4)\ 2SO_4$, K_2SO_4, $CeSO_4$, As_2O_3, NH_4Cl, $NiSO_4$, $LiCO_3$, $MgCO_3$, $NaNO_2$, $Mg_3(PO_4)_2$, V_2O_5, H_3BO_3, $SrCO_3$, $Th(NO_3)_3$, Na_3AsO_3, Na_3AsO_4, $BaCO_3$ and $LiCO_3$.

2. Inorganic Preparation Binuclear and Mono Nuclear Metal Complexes

Preparation of selected inorganic metal complexes and their estimation by volumetric/gravimetric/colorimetric techniques to determine the percentage purity of the complexes prepared

a) Tetrammine cupric sulphate $[Cu(NH_3)_4\ ]SO_4 \cdot H_2O$.
b) Tri (thiourea) cuprous sulphate $[Cu(NH_2CSNH_2)_3]_2\ SO_4\ 2H_2O]$.
c) Tri (thiourea) cuprous chloride $[Cu(NH_2CSNH_2)_3]Cl$.
d) Hexa ammine nickel(II) chloride $[Ni(NH_3)_6]\ Cl_2$.
e) Hexathiourea–plumbus nitrate $[Pb(NH_2CSNH_2)_6]\ (NO_3)_2$.
f) Potassium trioxalato chromate $K_3\ [Cr(C_2O_4)_3]$.
g) Potassium trioxalato aluminate $K_3\ [Al(C_2O_4)_3]$.
h) sodium trioxalate ferrrate(III) $Na_3\ [Fe(C_2O_4)_3]\ 9H_2O$.

i) Hexamminecobalt(III) chloride $[Co(NH_3)_6]\ Cl_3$.
j) Pentathioureadicuprous nitrate $[Cu(NH_2CSNH_2)_5]\ (NO_3)_2$.
k) Iron(III) acetylacetonate $Fe(acac)_3$ / $Fe(C_5H_7O_2)_3$

3. Quantitative Analysis

Estimation of the metal complexes by different techniques to determine the percentage purity quantitatively of the complexes.

a) Cu-EDTA (Volumetrically) and Cu-KCNS(Gravimetrically).
b) Ni- EDTA (Volumetrically) Ni- DMG (Gravimetrically.)
c) Co- EDTA (Volumetrically).
d) Cr- EDTA–$Pb(NO)_2$ (Volumetrically, Back Titration).
e) Al- EDTA –$ZnSO_4$ (Volumetrically, Back Titration).
f) Oxalate -$KMnO_4$ (Volumetrically).

ORGANIC CHEMISTRY

1. Multistep Preparation

a) m-Nitro aniline from nitrobenzene.
b) Hydro quinone diacetate from hydroquinone.
c) p-Methyl acetanilide from p-toluidine.
d) p-,Bromo-aniline from aniline.
e) 7-Hydroxycoumarine from resorcinol.
f) Hippuric acid from glycine.
g) Aspirin from salicylic acid
h) Phthalamide from phthlic acid.
i) Magneson-II (4,(4' nitro benzene azo 1)naphthol) from p-nitroaniline.
j) Benzimdazol from o-nitroaniline.
k) Resacetophenone from resorcinol.

2. Qualitative Analysis of Bi-functional Compounds:

a) Anthranilic acid
b) p-Aminobenzoic acid
c) o-Chlorobenzoic acid
d) m-Nitrobenzoic acid
e) o/m/p-Nitroaniline
f) Bi-phenyl amine
g) N,N-Dimethyl aniline
h) Resorcinol
i) Ethyl acetoacetate
j) P-Dichlorobenzene
k) o/p-Cresol
l) o/m/p-Toluidine
m) Benzanilide
n) Acetamide
o) α/β-Naphthole,etc.

NOTE: Other bifunctional compounds may be asked in examination.

PHYSICAL CHEMISTRY

Conductometry

1. To determine the concentration of HCl / CH3COOH / Oxalic acid/ HCl + CH3COOH+CuSO4/ Satd BA/ NH4Cl/CH3COONa/ mix of CH3COONa + NH4Cl.

2. To study the complexation of Ni+2 with EDTA.
3. To determine the equivalent conductance and dissociation constant of a weak electrolyte and to verify Oswald's dilution law.
4. To determine the equivalent conductance of a strong electrolyte and hence to verify the Ostwald's equation.
5. To determine the degree of hydrolysis and hydrolysis constant NH4Cl/ CH3COONa.

pH Metry

1. To determine the dissociation constant of benzoic/acetic / lactic acid.
2. To determine the concentration and amount of acid in a mixture of hydrochloric acid and acetic acid.
3. To determine the concentration and dissociation constants of a dibasic acid (oxalicacid).
4. To determine the dissociation constant of acetic acid (Buffer).

Potentiometry

1. To determine the normality and dissociation constant of the given acid (satd. BA).
2. To determine the normality and dissociation constants of the given dibasic acid (oxalicacid).
3. To determine the normality ofhydrochloric acid and acetic acid in the mixture.
4. To determine the standard redox potential and thermodynamic parameters of the Fe^{+2}ion.
5. To determine the concentration of KCl and the solubility product of AgCl.
6. To determine the normality of each halide in the mixture of halides.
7. To determine the standard oxidation potential of the quin hydroneelectrodel.

Spectrophotometry

1. To examine Lambert-Beer law in concentrated solution.
2. To study the rate of iodination.
3. To determine the composition of binary mixture containing potassium permanganate and potassium dichromate

Ultrasonics

1. To determine the acoustical parameters of a given liquid.

Chemical kinetics

1. To determine the reaction velocity and reaction rate constant for the reaction between acetone and iodine.
2. To determine the heat and entropy of vaporization of a given liquid by kinetic approach.
3. To determine the kinetic parameters and temperature coefficient of reaction between $KBrO_3$ and KI.
4. To determine the kinetic parameters and the temperature coefficient of the reaction between $K_2S_2O_8$ and KI.

Thermodynamics

1. To determine the solubility and heat of solution of benzoic acid in toluene.
2. To determine the partial molar volume and the composition of unknown mixture of ethanol/methanol and water.

Partition function

1. To determine the distribution coefficient of benzoic acid between toluene and water at room temperature and hence to prove the dimerization of benzoic acid in toluene.
2. To determine the equilibrium constant for the reaction between iodide and iodine by the method of distribution.

Refractometer

1. To determine the molar refraction and refractive index of a given salt.

2. To study the variation of refractive index with composition of a given liquid and also to determine the composition of unknown mixture.

Polarimeter

1. To determine the concentration of an unknown solution of optically active compound.
2. To determine the specific and molecular rotation of cane sugar and hence intrinsic rotation.

ANALYTICAL CHEMISTRY

1. Preparation and standardization of 0.1N HCl, 0.1N H_2SO_4 and 0.1N HNO_3, against 0.1N NaOH solution as well as other strength of solutions. Find mean, standard deviation and other statistical parameters.
2. Preparation and standardization of 0.1N and 0.5N solution of NaOH and standardized against potassium hydrogen phthalate and succinic acid. Find mean, standard deviation, t-test and F-test.
3. Preparation and standardization of 0.1N or 0.1M I_2 solution and standardized against standard thiosulphate solution and other standardization solutions.
4. To determine the amount of iodine in iodized salt.
5. To determine the amount of vitamin-C (ascorbic acid) in a given sample.
6. To determine the percentage of reducing sugars in Honey sample.
7. To determine the saponification value of an oil or fat sample.
8. To determine the percentage of tannin in tea leaves.
9. To determine the percentage of calcium gluconate in the given commercial sample by complexmetric titration.
10. To determine the amount of aspirin in a given sample.
11. To determine the iodine value of an oil or fat.
12. To estimate the amines using bromate-bromides solution (Bromination) method.
13. To estimate the calcium and magnesium in the given mixture solution of both by EDTA complexometric method. (50ml of mixture solution of $Ca^{+2}$and Mg^{+2} (25ml Ca+2 solution from $CaCO_3$ 10gm/L and 25ml Mg+2 solution (MgCO3 8.4 gm/L) use minimum quantity of dil. HCl (1ml) for Ca^{+2} and Mg^{+2} solution).
14. To determine chloride and bromide ion by precipitation titration method.
15. To determine barium gravimetrically and copper by volumetrically in a given mixture.
16. To determine the total protein content and solid content in sample of milk. (Formaldehyde method).
17. To determine the percentage of phthalic anhydride and maleic anhydride and find mean, and standard deviation.
18. To determine amount of iron (III) in solution by photometric titration (static) with EDTA.
19. To determine the amount of Cu^{+2} using DMG by spectrophotometric method.
20. To determine available chlorine in bleaching materials.

M.Sc. SEMESTER-I
C-106: VIVA VOCE

2 CREDITS
50 MARKS

Based on theory C-101 to C104 and practicals.

M. Sc. SEMESTER-II
C-201: INORGANIC CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Understanding of organometallic type of compound and their synthesis and industrial application
- COs2: Concept of Bioinorganic chemistry is metal ion in body with functioning, metabolic reaction, biological energy transformation system and also bioactive compounds.
- COs3: Ion-exchange chromatography for industrial application as well as working as catalyst and purification processes for inorganic as well as organic compound.

1. Organometallic Compounds

Introduction, nature of bonding in organornetalliccompounds of transition metals.

σ-bonded organometallic compounds: Introduction, classification and synthesis of σ-bonded organotransitionmetal compounds, general characteristics, chemical reactions, bonding and structure.

π-bonded organometallic compounds: Introduction and classification of □-bonded organometallic compounds (a)η^2-alkene complexes: Preparative methods, physical and chemical properties, bonding of structure. (b) η^3allyl (or enyl) complexes: preparation, physical of chemical properties.

2. Fundaments of Bioinorganic Chemistry

Introduction to bioinorganic chemistry. Classification and role of metal ions according to their action in biological system. Essential trace elements and chemical toxicology, Introduction of trace elements. The essential ultratrace metals and non-metals. Iodine and thyroid hormones, toxic elements, toxicity and deficiency. Transport and storage of proteins: Metalloporphyrins, oxygen carriers-hemoglobinand myoglobin, Physiology of blood.

3. Electron spin resonance

Introduction to Electron Spin Resonance. Technique of electron spin resonance, interaction between nuclear spin and electron spin: hyper fine splitting, calculation and energies of Zeeman levels. Calculations of energies, frequency, ESR spectrum when one electron influenced by a single proton and one electron delocalized over two equivalent protons.

4. Ion-Exchangers and their applications

General introduction, classification of ion-exchangers and their applications in the separation of 1. Zinc and Magnesium, 2. Chloride and bromide, 3. Cobalt and Nickel, 4. Cadmium and Zinc.

5. Uses of Organic reagents in Inorganic Analysis

Cupferron, DMG, dithiozone, aluminon, oxine, dithiooxamide, α-benzoinoxime, α-nitro-(3-naphthol, α-nitroso-3-naphthol, diphenyl carbazone, diphenyl carbazide, anthranilic acid, tannin, pyragallol, benzidine. salicylaldoxime, o-phenanthroline.

Reference Books:

1. Advanced Inorganic Chemistry, Cotton Wilkinson, W S E Wiley.
2. Vogel's Text book of Quantitative Inorganic Analysis, ELBS Press.
3. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.
4. Bioinorganic Chemistry, Chatwal andBhagi, Himaliya Publishing House.
5. Physical Methods in Chemistry, R.S.Drago, Saunders College.
6. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley.

7. Metallo-Organic Chemistry, A.J. Pearson, Wiley.
8. The Inorganic Chemistry of Biological Processes, M.N.Hughes, John Wiley & Sons.

M. Sc. SEMESTER-II
C-202: ORGANIC CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student will be able to Recognize and comment of Photo-chemical reaction.
- COs2: Advance concept of Pericyclic reaction
- COs3: Understood the aromatic, non-aromatic and anti-aromatic behaviour of compounds.

1. Photo Chemistry

Fundamental of photochemistry, principles of photo chemistry, singlet and triplet states, properties and nomenclature of excited states. Physical properties of excited molecules as explained by improved Jablonskii diagram, photo chemistry of carbonyl compounds. Photo chemistry of olefins. Recent reactions in photochemistry

2. Pericyclic Reactions

Orbitals, molecular orbital symmetry, molecular orbital of ethylene, 1,3- butadiene, 1,3,5–hexatriene and allyl systems, concerted reactions, classification of pericyclic reactions, derivation of selection rules through construction of correlation diagrams for cyclo-addition reactions and for electrocyclic reactions with 4n and $4n+2\pi$ electrons, conrotatory and disrotatory motions for electrocyclic ring opening and ring closure.

FMO approach for derivation of Woodward-Hoffman selection rules for cycloaddition and electrocyclic reactions, suprafacial and antarafacial cycloadditions.

1,3-Dipolar cycloaddition reactions, classification and applications. Sigmatropic reactions, suprafacial and antarafacial rearrangements, [1,j], sigmatropic rearrangement of hydrogen, [1,j] and [i,j] Sigmatropic reactions of carbon, selection rules for [i,j]-sigmatropic rearrangements using FMOs. The Cope and the Claisen rearrangements.

3. Aromaticity

Concept of aromaticity, non-aromaticity and anti-aromaticity, Huckel's rule and its applications to simple and non-benzenoid aromatic compounds, cyclopentadiene, azulene, tropolone system, annulenes, hetero annulenes, and fullerenes (C60).

Reference Books:

1. Organic Chemistry by G. Marc. Loudon, Oxford University
2. Organic Chemistry by J. Clayden, N. Greeves, S. Warren, P. Wothers, Oxford University Press.
3. Advanced Organic Chemistry (4thedition) by Jerry March.
4. Organic Chemistry by Morrission and Boyd, Prentice Hall Pvt.Ltd (6th edition), (2003).
5. A Text Book of Organic Chemistry – R.K.Bansal, New Age International (P) Ltd. 4th edition (2003).

M. Sc. SEMESTER-II
C-203: MACROMOLECULAR PHYSICAL CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Students will be able to understand the basics of polymer chemistry, types of polymers and polymerization.
- COs2: Various methods for the purification will help to isolate the synthesized polymers.
- COs3: knowledge will help students to understand the application of polymers which is of prime importance in different industries.

1. **Basic Concept of Polymer Chemistry**

   Classification of polymers. Types of polymer chains.Stereo regular polymers.Polymer nomenclature. Functionality and polymerization concept.

2. **Chain Polymerization**

   Free Radical Polymerization: Methods of initiating free radical polymerization.

   Chain transfer reactions. Kinetics of free radical polymerization and chain transfer reactions. Factors affecting radical polymerization and properties of the resulting polymers.

   Ionic (Catalytic) Polymerization: Kinetics of cationic and anionic polymerization.Coordination polymerization.Copolymerization and its kinetics.Evaluation of reactivityratios.

   Methods of Free Radical Polymerization: Bulk polymerization, solution polymerization, emulsion polymerization and solid phase polymerization. Problems.

3. **Polycondensation**

   Reaction route of poly functional compounds. Kinetics of polycondensation reaction. Molecular weight control in polycondensation. Nonlinear polycondensation. Statistics of linear polycondensation. Effect of monomer concentration and temperature on direction of polycondensation reaction. Polycondensation equilibrium and molecular weight of polymer. Factors affecting the rate of polycondensation and molecular weight of the polymer.

   Methods of Polycondensation: Melt, interfacial, solution and solid phase polycondensation. Problems.

4. **Stepwise Polymerization and Ring scission Polymerization**

   Thermodynamics of ring transformation to a linear polymer. Effect of temperature and monomer concentration on ring-polymer equilibrium. Kinetics and mechanism of ring scission polymerization. Effect of activator concentration and temperature on ring scission polymerization and molecular weight of the polymer.

5. **Physico-chemical Transformation Reactions**

   Types of reactions in polymer chemistry. Degradation and its classification. Crosslinking, addition and substitution reactions of functional groups.

6. **Fractionation of Polymers**

   Isolation and purification of polymers. Fractionation of polymers. Methods polymer fractionation: Fractional precipitation, partial dissolution or extraction method, Gradient elution method and gel permeation chromatography method.

Reference Books:

1. A First Course in Polymer Chemistry, Mir Publishers, Moscow.
2. Physical Chemistry of Polymers, ATager, Mir Publishers, Moscow.
3. Text-book of Polymer Science, F. W. Billmeyer, Willey Interscience.
4. Polymer Chemistry, Bruno Vollmert. Springer, New York.
5. Principles of Polymer Systems, F. Rodriguez, McGraw Hill.

6. Polymer Science, V. R. Gowariker, N. V. Vishwanathan and J. Shreedhar, Wiley Eastern Ltd., New Delhi.
7. Physical Chemistry of Macromolecules, D. D. Deshpande, IIT, Bombay
8. Polymer Chemistry An Introduction, Malcolm P. Stevens, Addition-Wesley Publishing Company, Inc.
9. Principles of Polymer Chemistry, A. Ravve, Kluwer Academic/Plenum Publisher, New York.
10. Organic Polymer Chemistry, K. J. Saundars .
11. Macromolecular Physical Chemistry, P. H. Parsania
12. Polymer Materials Science, Technology and Developments, Vol.I, SukumarMaity, AnusandhanPrakasan, Midnapore.

M. Sc. SEMESTER-II
C-204: ANALYTICAL CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: The fundamental knowledge about the innovative approaches for designing of safer chemical products, processes and use of renewable resources for sustainable development.
- COs2: Students should be in a position to used analytical data in chemical sciences.
- COs3: Students understanding the principles of water and air analysis.

1. Environmental Chemistry

Concept and scope of Environmental Chemistry. Terminology and classification of environmental segments, particles, ions and radicals in the atmosphere.

Air pollution: Introduction, major sources of air pollution, air pollutants. Sources of pollutants: gaseous NOx, SOx, CO, hydrocarbons, particulates (Inorganic and Organic particulate matters). Effect of pollutants on humans, animals, materials, and vegetation.

Greenhouse effect and global warming: El Nino and La Nina phenomenon, Asian brown cloud.

Ozone layer: Creation, mechanism of depletion and its effect.

Smog: Sulphurous and photochemical smog, formation mechanism, and its control.

Analysis of air pollutants: Sampling techniques of gases and particulate, analysis of NOx, SOx, CO, H2S, oxidants and ozone by chromatography and spectrophotometric methods. Analysis of particulates by HVAS techniques.

Water pollution: Introduction, sources of pollutants, water pollutants, classification of inorganic, organic, thermal and radioactive pollutants.

Analysis of water pollution: Determination of pH, conductivity, TDS, acidity, alkalinity, chloride, iron, sulphate, sulphide, fluoride, ammonia, nitrate, nitrite, calcium, magnesium, DO,BOD, COD, etc.

Soil pollution: Origin and nature of soil, sources of soil pollution, purpose of analysis. Methods of soil analysis: pH, moisture, total nitrogen, lime potential, total sulphur, manganese, iron, Na, K, Ca, Mg, etc.

2. Green Chemistry

Introduction, importance and twelve principles of Green Chemistry. Designing a green synthesis using these principles. Green Chemistry in day to day life. Green solvents (alternatives of organic solvents).

Ionic liquids, supercritical fluids, CO_2 and H_2O and aqueous phase organic synthesis.

Non-traditional greener alternative approaches: Green reagents, catalysis, biocatalysts.

Applications of non-conventional energy sources: Microwave, ultrasonic assisted synthesis, electro-synthesis and sunlight (UV) radiation assisted synthesis.

3. Analytical Chemometrics

Propagation of measurement of uncertainties, useful statistical tests: Test of significance, F- test, t-test, chisquare-test, correlation coefficient, confidence limits of mean, comparison of mean with true values. Regression analysis (least square method for linear and nonlinear plots). Statistics of sampling and detection limit evaluation. Specific study for analytical method radiation by using validation parameters: (1) accuracy, (2) precision (repeatability and reproducibility), (3) linearity and range, (4) Limit of Detection (LOD) and Limit of quantification (LOQ),(5) selectivity/specificity, and (6) Robustness and Ruggedness.

Reference Books:

1. Fundamentals of Mathematical Statistics: by S.C. Chand and V.K. Kapoor: S. Chand and Co.
2. Practical Statistics (Vol 1 and 2) by Singh, Atlantic Publishers.2003.
3. V.K. Ahluwalia, Green Chemistry: Environmentally Benign Reactions. CRC, 2008.
4. Environmental Chemistry by H. Kaur, 3rd edition Pragati Prakashan, Meerut.
5. Environmental Chemistry 7th edition by A.K.De, New Age International Publishers; New Delhi.
6. Spectroscopy 6th edition by H. Kaur, Pragati Prakashan, Meerut.
7. Environmental Chemistry by V.K. Ahluwalia Ane Books India First Edition.

M. Sc. SEMESTER-II
C-205: PRACTICALS

6 CREDITS
150 MARKS

INORGANIC CHEMISTRY

1. Inorganic Qualitative Analysis

Analysis of a mixture containing six radicals including one less common metal ion:
W, Tl, Ti, Mo,Se, Zr, Th, Ce,V and Li.

Minimum 15 mixtures containing inorganic salts like $CuSO_4$, KBr , TiO_2 , KI, Na_2CrO_4, $CaCO_3$, $Zr(NO_3)_3$, $NaNO_3$, ZnS, Na_2SO_4, SeO_2, NaCl, K_2SO_4, $(NH_4)_2SO_4$, $(NH_4)_2MoO_4$, $BaCl_2$, $ZnCO_3$, $Al_2(SO_4)_3$, V_2O_5, ZnS, $Ni(NO_3)_2$, KNO_2, $Th(NO_3)_3$, KCl, $CdCO_3$, $CuCl_2$, $LiCO_3$, K_2SO_4, $AlPO_4$, H_3BO_3, $(NH_4)_2SO_4$, $CeSO_4$, $CdCl_2$, $Th(NO_3)_3$, $NaNO_3$, $ZnCO_3$, $AlPO_4$, $LiCO_3$, $Pb(NO_3)_2$, $NaNO_2$,$Zr(NO_3)_3$, Na_2WO_4, $MnSO_4$, $NaHSO_3$, SeO_2, K_2CrO_4, $FeSO_4$, $(NH_4)_2SO_4$, $(NH_4)_2MoO_4$, Na_3AsO_3, Na_3AsO_4, $(NH_4)_2SO_4$, K_2SO_4, $CeSO_4$, As_2O_3, NH_4Cl, $NiSO_4$, $LiCO_3$, $MgCO_3$, $NaNO_2$, $Mg_3(PO_4)_2$, V_2O_5, H_3BO_3, $SrCO_3$, $Th(NO_3)_3$, Na_3AsO_3, Na_3AsO_4, $BaCO_3$ and $LiCO_3$.

2. Inorganic Preparation Binuclear and Mono Nuclear Metal Complexes

Preparation of selected inorganic metal complexes and their estimation by volumetric/gravimetric/colorimetric techniques to determine the percentage purity of the complexes prepared.

a) Tetrammine cupric sulphate $[Cu(NH_3)_4]SO_4 \cdot H_2O$.

b) Tri (thiourea) cuprous sulphate [Cu $(NH_2CSNH_2)_3]_2$ SO_4 $2H_2O$].
c) Tri (thiourea) cuprous chloride [Cu $(NH_2CSNH_2)_3$] Cl.
d) Hexa ammine nickel(II) chloride [Ni $(NH_3)_6$] Cl_2.
e) Hexathiourea–plumbus nitrate [Pb $(NH_2CSNH_2)_6$] $(NO_3)_2$.
f) Potassium trioxalato chromate K_3 [Cr $(C_2O_4)_3$].
g) Potassium trioxalato aluminate K_3 [Al $(C_2O_4)_3$].
h) sodium trioxalate ferrrate(III) Na_3 [Fe $(C_2O_4)_3$] $9H_2O$.
i) Hexamminecobalt(III) chloride [Co $(NH_3)_6$] Cl_3.
j) Pentathioureadicuprous nitrate [Cu $(NH_2CSNH_2)_5$] $(NO_3)_2$.
k) Iron(III) acetylacetonate $Fe(acac)_3$ / $Fe(C_5H_7O_2)_3$

3. Quantitative Analysis

Estimation of the metal complexes by different techniques to determine the percentage purity quantitatively of the complexes.

a) Cu-EDTA (Volumetrically) and Cu-KCNS(Gravimetrically).
b) Ni- EDTA (Volumetrically) Ni- DMG (Gravimetrically.)
c) Co- EDTA (Volumetrically).
d) Cr- EDTA–$Pb(NO)_2$ (Volumetrically, Back Titration).
e) Al- EDTA –$ZnSO_4$ (Volumetrically, Back Titration).
f) Oxalate -$KMnO_4$(Volumetrically).

ORGANIC CHEMISTRY

1. Multistep Preparation

a) m-Nitro aniline from nitrobenzene.
b) Hydro quinone diacetate from hydroquinone.
c) p-Methyl acetanilide from p-toluidine.
d) p-,Bromo-aniline from aniline.
e) 7-Hydroxycoumarine from resorcinol.
f) Hippuric acid from glycine.
g) Aspirin from salicylic acid
h) Phthalamide from phthlic acid.
i) Magneson-II (4,(4' nitro benzene azo 1)naphthol) from p-nitroaniline.
j) Benzimdazol from o-nitroaniline.
k) Resacetophenone from resorcinol.

2. Qualitative Analysis of Bi-functional Compounds:

a) Anthranilic acid
b) p-Aminobenzoic acid
c) o-Chlorobenzoic acid
d) m-Nitrobenzoic acid
e) o/m/p-Nitroaniline
f) Bi-phenyl amine
g) N,N-Dimethyl aniline
h) Resorcinol
i) Ethyl acetoacetate
j) P-Dichlorobenzene
k) o/p-Cresol
l) o/m/p-Toluidine
m) Benzanilide
n) Acetamide
o) α/β-Naphthole,etc.

NOTE: Other bifunctional compounds may be asked in examination.

PHYSICAL CHEMISTRY

Conductometry

1. 1. To determine the concentration of HCl / CH3COOH / Oxalic acid/ HCl + CH_3COOH+ CuSO4/ Satd BA/ NH_4Cl/CH_3COONa/ mix of CH_3COONa + NH_4Cl.
2. To study the complexation of Ni^{+2} with EDTA.
3. To determine the equivalent conductance and dissociation constant of a weak electrolyte and to verify Oswald's dilution law.
4. To determine the equivalent conductance of a strong electrolyte and hence to verify the Ostwald's equation.
5. To determine the degree of hydrolysis and hydrolysis constant NH_4Cl/ CH_3COONa.

pHMetry

1. To determine the dissociation constant of benzoic/acetic / lactic acid.
2. To determine the concentration and amount of acid in a mixture of hydrochloric acid and acetic acid.
3. To determine the concentration and dissociation constants of a dibasic acid (oxalic acid).
4. To determine the dissociation constant of acetic acid (Buffer).

Potentiometry

1. To determine the normality and dissociation constant of the given acid (satd. BA).
2. To determine the normality and dissociation constants of the given dibasic acid (oxalic acid).
3. To determine the normality ofhydrochloric acid and acetic acid in the mixture.
4. To determine the standard redox potential and thermodynamic parameters of the Fe^{+2} ion.
5. To determine the concentration of KCl and the solubility product of AgCl.
6. To determine the normality of each halide in the mixture of halides.
7. To determine the standard oxidation potential of the quin hydroneelectrodel.

Spectrophotometry

1. To examine Lambert-Beer law in concentrated solution.
2. To study the rate of iodination.
3. To determine the composition of binary mixture containing potassium permanganate and potassium dichromate.

Ultrasonics

1. To determine the acoustical parameters of a given liquid.

Chemical kinetics

1. To determine the reaction velocity and reaction rate constant for the reaction between acetone and iodine.
2. To determine the heat and entropy of vaporization of a given liquid by kinetic approach.
3. To determine the kinetic parameters and temperature coefficient of reaction between $KBrO_3$ and KI.
4. To determine the kinetic parameters and the temperature coefficient of the reaction between $K_2S_2O_8$ and KI.

Thermodynamics

1. To determine the solubility and heat of solution of benzoic acid in toluene.
2. To determine the partial molar volume and the composition of unknown mixture of ethanol/methanol and water.

Partition function

1. To determine the distribution coefficient of benzoic acid between toluene and water at room temperature and hence to prove the dimerization of benzoic acid in toluene.
2. To determine the equilibrium constant for the reaction between iodide and iodine by the method of distribution.

Refractometer

1. To determine the molar refraction and refractive index of a given salt.
2. To study the variation of refractive index with composition of a given liquid and also to determine the composition of unknown mixture.

Polarimeter

1. 31. To determine the concentration of an unknown solution of optically active compound.
2. 32. To determine the specific and molecular rotation of cane sugar and hence intrinsic rotation.

ANALYTICAL CHEMISTRY

1. Preparation and standardization of 0.1N HCl, 0.1N H_2SO_4 and 0.1N HNO_3, against 0.1N NaOH solution as well as other strength of solutions. Find mean, standard deviation and other statistical parameters.
2. Preparation and standardization of 0.1N and 0.5N solution of NaOH and standardized against potassium hydrogen phthalate and succinic acid. Find mean, standard deviation, t-test and F-test.
3. Preparation and standardization of 0.1N or 0.1M I_2 solution and standardized against standard thiosulphate solution and other standardization solutions.
4. To determine the amount of iodine in iodized salt.
5. To determine the amount of vitamin-C (ascorbic acid) in a given sample.
6. To determine the percentage of reducing sugars in Honey sample.
7. To determine the saponification value of an oil or fat sample.
8. To determine the percentage of tannin in tea leaves.
9. To determine the percentage of calcium gluconate in the given commercial sample by complexometric titration.
10. To determine the amount of aspirin in a given sample.
11. To determine the iodine value of an oil or fat.
12. To estimate the amines using bromate-bromides solution (Bromination) method.
13. To estimate the calcium and magnesium in the given mixture solution of both by EDTA complexometric method. (50ml of mixture solution of Ca^{+2} and Mg^{+2} (25ml Ca^{+2} solution from $CaCO_3$ 10gm/L and 25ml Mg^{+2} solution ($MgCO_3$ 8.4 gm/L) use minimum quantity of dil. HCl (1ml) for Ca^{+2} and Mg^{+2} solution).
14. To determine chloride and bromide ion by precipitation titration method.
15. To determine barium gravimetrically and copper by volumetrically in a given mixture.
16. To determine the total protein content and solid content in sample of milk. (Formaldehyde method).
17. To determine the percentage of phthalic anhydride and maleic anhydride and find mean, and standard deviation.
18. To determine amount of iron (III) in solution by photometric titration (static) with EDTA.
19. To determine the amount of Cu^{+2} using DMG by spectrophotometric method.
20. To determine available chlorine in bleaching materials.

M. Sc. SEMESTER-II
C-206: VIVA VOCE

2 CREDITS
50 MARKS

Based on theory C-201 to C-204 and practicals

M. Sc. SEMESTER-III
PHYSICAL AND MATERIALS CHEMISTRY
C(PM)-301: ADVANCE CHROMATOGRAPHIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student will be Capable to understand the range and theories of instrumental methods available for separation.
- COs2: Able to select appropriate techniques for the separation of complex mixture into their individual components.
- COs3: Expand skills in the scientific methods of planning, developing, conducting, reviewing techniques for separation and identification of compound in complex mixture.

1. Introduction, revision of various chromatographic techniques and terminologies.
2. Principle, theory, instrumentation and applications of GC, HPLC, UPLC and super critical fluid chromatographic techniques.
3. **Ion Chromatography**: Principle, theory, instrumentation and applications.
4. **Exclusion Chromatography**: Theory and principle of size exclusion chromatography, experimental techniques for gel filtration chromatography(GFC) and gel-permeation chromatography(GPC).Column materials, factors governing column efficiency, methodology and applications.
5. Hyphenated techniques: Principle, theory, instrumentation and applications of GCMS, LC-MS, GC-IR, LC-NMR, etc.
6. **Planner chromatography**: Paper chromatography, thin layer chromatography, and high performance thin layer chromatography: Principle, theory, instrumentation and applications.

Reference Books:

1. Chromatography by E. Heftman, 5th edition, part-A and B, Elesvier Science Publisher, 1992.
2. Instrumental Methods of Analysis by B.K. Sharma, Goel Publisher, Meerut.
3. Analytical chemistry by Gary D. Christian, 6th edition (1994) John Wiley and sons Inc. New York.
4. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
5. Analytical Chemistry by H. Kaur, PragatiPrakashan, Meerut.
6. Instrumental Methods of Chemical Analysis by Chatwal and Anand.
7. Standard Methods of Chemical Analysis by F.J. Welcher.
8. Introduction to Modern Liquid Chromatography: 2nd edition L.R. Snyder and J.J. Kirkland- John Wiley & Sons Inc.
9. Analytical Methods in Chemistry by Y. R. Sharma.

10. Analytical chemistry by Open learning second edi. (Vol. 1-30) Wiley India Edi.
11. B. L. Karger, L.R. Snyder and C. Howarth, An Introduction to Separation Science, 2nd edition (1973), John Wiley, New York.

M. Sc. SEMESTER-III
PHYSICAL AND MATERIALS CHEMISTRY
C(PM)-302: ELECTRO ANALYTICAL TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student will be Capable to understand the range and theories of instrumental methods available for separation.
- COs2: Able to select appropriate techniques for the separation of complex mixture into their individual components.
- COs3: Expand skills in the scientific methods of planning, developing, conducting, reviewing techniques for separation and identification of compound in complex mixture.

1. **Polarography:** Introduction and classification of polarographic techniques. Principle, instrumentation and applications of DC polarography including stripping and cyclic voltammetry and numericals.
2. **Amperometry:** Introduction, theory and applications. Amperometric titrations.
3. **Electro Gravimetric and Coulometric Methods of Analysis:** Introduction, principle, theory, instrumentation and applications.
4. **Ion selective electrodes:** Introduction, classification, theory, types and construction of ion selective electrodes and their applications.
5. **Electrophoresis:** Introduction, principle, classification, theory, instrumentation, factors affecting and applications.
6. **Capillary Electrophoresis:** Principle, theory, instrumentation, capillary electro chromatography and applications.

Reference Books:

1. Instrumental Methods of Analysis by B.K. Sharma, Goel Ppublishing House, Meerut.
2. Analytical Chemistry by Gary D. Christian, 6th edition (1994) John Wiley and Sons Inc. New York.
3. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
4. Analytical chemistry by H. Kaur, Pragatiprakashan, Meerut.
5. Instrumental Methods of Chemical Analysis by Chatwal and Anand.
6. Standard Methods of Chemical Analysis by F.J. Welcher.
7. Vogel's Textbook of Quantitative Chemical Analysis, 6thEdn. Pearson Education Asia.
8. Modern Electrochemistry 2B (2ndedition) by John O'M Bockris and Amolya K. N. Reddy.

M.Sc. SEMESTER-III
PHYSICAL AND MATERIALS CHEMISTRY
C (PM)-303: MACROMOLECULER PHYSICAL CHEMISTRY-II

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Students to purify the synthesized polymers and to determine their molecular weights by different methods.
- COs2: Students will be able to process polymers by different techniques.
- COs3: The knowledge of composite helps to use them in different fields.

1. **Molecular Weight Determination**

End-group analysis, cryoscopy, ebulliometry, membrane osmometry, vapor pressure osmometry, light scattering (asymmetric and Zimm plot methods), GPC and ultracentrifugation (sedimentation velocity and equilibrium methods).

2. **Solution Viscosity and Molecular Size**

Determination of viscosity and types of viscosities. Determination of intrinsic viscosity, Huggin's constant and Kraemer's constant. Intrinsic viscosity and molecular weight, intrinsic viscosity and size, chain branching.

3. **Super Molecular Structure of Polymers**

Physical methods of investigation of molecular structure of polymers: Optical and electron microscopy, X-ray, electron and neutron diffraction techniques. Morphology of crystalline polymers: Lamellar single crystals, fibrillar and globular crystals; spherulites.

4. **Phase Transition in Polymers**

State of matter and phase state, First and second order phase transitions, Crystallization and glass transition, Factors affecting crystallizability and glass transition temperature, Effect of molecular weight and plasticizers on Tg, Glass transition of copolymers, The relation between Tg and Tm. and importance of Tg, Mechanism and kinetics of polymer crystallization, Thermodynamics of melting and crystallization, Melting temperatures of polymers, Free volume and packing density of polymers. Problems.

5. **Polymer Processing**

Types of plastics, elastomers and fibers andcompounding.Processing techniques: Calendaring, diecasting, rotational casting, film casting, compression molding, injection molding, blow molding, extrusion molding, thermo forming and foaming.

6. **Composite materials**

Definition and classification of composites.Types of matrix and fiber materials, applications of composites, laminates and hybrid composites. Reinforcements: Metallic, polymeric and ceramic fibers. Modification of fibers, properties of fiber reinforced (natural and synthetic fibers, advantages of natural fibers over synthetic fibers, polymer matrix composites and their production by hand layup, moulding, pultrusion and filament winding.

Reference Books:

1. Physical Chemistry of Polymers byATager, Mir Publishers, Moscow.
2. Text-book of Polymer Science by F. W. Billmeyer, Willey Interscience.
3. Polymer Science by V. R. Gowariker, N. V. Vishwanathan and J. Shreedhar, Willey Eastern Ltd., New Delhi.
4. Physical Chemistry of Macromolecules by D. D. Deshpande, IIT, Bombay

5. Analysis and Characterization of Polymers by Ed. SukumarMaity, AnusandhanPrakashan, Midnapore.
6. Composite Materials, Production, Properties, Testing and Applications by K. Srinivasan.
7. Macromolecular Physical Chemistry by P. H. Parsania.

M.Sc. SEMESTER-III
PHYSICAL AND MATERIALS CHEMISTRY
C (PM) - 304: NUCLEAR AND RADIO CHEMISTRY
ELECTIVE-I

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Students to understand the structure of nucleus and their properties.
- COs2: The concept of radioactivity, their types, detection and measurement will help to use different radioisotopes in different fields.
- COs3: Further, student will understand various different nuclear reactions.

1. Brief Introduction of Radioactivity

Nuclear particles, types of radiation, mass defect, binding energy, mean binding energy of stable nuclei, Disintegration theory: Nuclear stability and group displacement law. Synthesis of radioisotopes: ^{14}C, ^{3}H, ^{35}S, ^{36}Cl, ^{82}Br, ^{131}I, ^{32}P.

2. Detection and Measurement of Radioactivity

Ionization chamber, Geiger- Muller, proportional, scintillation counters, Wilson cloud chamber, health physics instrumentation: Film badges, pocket ion chambers, portable counters and survey meters. Accelerators: Van de Graff and cyclotron.

3. Nuclear Fission, Fusion and Nuclear Reactor

Characteristics of nuclear reactors and their applications, nuclear reactors in India, The four factor formula: The reproduction factor, reactor power, life and critical size of reactor, and breeder.

4. Isotope Effects and Isotopic Exchange Reactions

Isotope effect: Definition, physical and chemical isotope effects, generalities of isotope.
Isotopic exchange Basic concept, characteristics of isotopic exchange, mechanism of isotopic exchange, kinetics of homogenous and heterogeneous isotopic exchange reactions, self-diffusion, and surface measurements.

5. Primary Radiation Chemical Process

Direct interaction of radiation with matter, ionization, excitation, neutron impact, Basic reactions involving active species produced in the primary act and radiation dosimetry.

6. Tracer

Selection of radioisotopes as tracer, application of radioisotopes as tracers: Analytical, physicochemical, medical, agriculture and industrial applications, neutron activation analysis, radiometric titrations and isotope dilution techniques, radiopharmaceutical, radioimmunoassay and radiation sterilization.

Reference Books

1. Nuclear Chemistry and its applications byHaissionsky – Addison Wesley
2. Nuclear and Radio Chemistry by G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller, A Wiley – Interscince Publication, John Wiley and Sons, III rd Edition.
3. Radio Chemistry by An. N. Nesmeyanov, Mir Publishers.
4. Nuclear Chemistry by ShipraBaluja.
5. Artificial Radioactivity – By. K. Narayana Rao and H. J. Arnikar – Tata McGraw Hill Publishing Company Ltd. New Delhi
6. Radio Chemistryby Shipra Baluja.

M.Sc. SEMESTER-III PHYSICAL AND MATERIALS CHEMISTRY
(PM)-304: ELECTROCHEMISTRY
ELECTIVE-II

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Students to understand the concept of electrochemistry, various theories.
- COs2: Students will be able to determine various parameters / properties using different techniques, the knowledge of which helps them to use in different fields

1. **Fundamentals of Electrochemistry**
   Classification of conductors,the mechanism of electrolysis,electrolytic dissociation theory and evidences for the ionic theory.Influence of the solvent on dissociation.Faraday's laws of electrolysis.Problems.
2. **The Theory of Electrolytic Conductance**
   The degree of dissociation and inter ionic attraction.The ionic atmosphere and relaxation time.Mechanism of electrolytic conductance, Validity of Debye- Huckel - Onsager equation. Determination of degree of dissociation. Problems.
3. **Superconductor**
   Introduction, classification of superconductors,advancement in super conductors.Applications of superconductors in various fields.
4. **Semiconductors**
   Introduction, classification and applications.
5. **The Migration of Ions**
   Transference numbers and ionic velocities, Hittorf method, moving boundary method, Transference numbers in mixtures, abnormal transference numbers. Problems.
6. **Acids and Bases**
   Definitions, types of solvents, dissociation constants of acids and bases, Determination of dissociation constants, Acidity function, effect of solvent and temperature on dissociation constant and ionic product of water. Problems.
7. **Amphoteric Electrolytes**
   Dipolar ions and evidences for their existence. Dissociation of amino acids, isoelectric points and neutralization curves of ampholytes.
8. **Polarization and Over Voltage**
   Electrolytic polarization and concentration polarization. Decomposition voltages of aqueous solutions. Metal deposition over voltage, Hydrogen over voltage, Oxygen over voltage, Influence of current density, pH and temperature on over voltage, Electrolysis of water. Problems.

Reference Books:

1. An Introduction of Electrochemistry by S. Glasstone. Affiliated East West Press, New Delhi.
2. Electrochemistry by ShipraBaluja and FalguniKaria.
3. Electrochemistry by B. K. Sharma. Krishna Prakashan,Meerut.
4. Modern Electrochemistry byJO'MBockri's and A. K. N. Reddy, Vol. 2, Plenum Press, New York.,1992.
5. The Principles of Electrochemistry by Duncan A. Mac Innes Dover Publication Inc. N. Y.

M.Sc. SEMESTER-III
PHYSICAL AND MATERIALS CHEMISTRY
C(PM)-305: PRACTICALS

6 CREDITS
150 MARKS

Course Outcomes (COs):

- COs1: The knowledge will help students to develop skill to determine physicochemical properties of different compounds and for the synthesis of different polymers.
- COs2: To study various physicochemical properties by different methods and synthesis of different polymers by different types of polymerization.

1. **Physico-chemical exercises**
   Viscosity, thermodynamic excess properties, solubility, phase rule.
2. **Chromatography:**
   Paper, TLC and Column chromatography.
3. **Polymer Synthesis**
   Addition and condensation polymers: PS, PMA, PMMA, PAN, PVAc, UPE, Epoxy, PF, UF and MF resins.
4. **Characterization of Polymers:**
   Viscosity, molecular weight determination, epoxy equivalent, acid value, hydroxyl value, density, IR, NMR, UTM

M.Sc. SEMESTER-III
PHYSICAL AND MATERIALS CHEMISTRY
C(PM)-307: VIVA-VOCE

2CREDITS
50 MARKS

Theory based on C(PM)-301 to C(PM)-304 and practicals.

M.Sc. SEMESTER-IV
PHYSICAL AND MATERIALS CHEMISTRY
C(PM)-401: ADVANCE SPECTROSCOPIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: learners should be able to: Apply NMR, IR, MS, UV-Vis spectroscopic techniques in solving structure of organic molecules
- COs2: To determination of stereochemistry of unknown molecules.
- COs3: Interpret the above spectroscopic data of unknown compounds.
- COs4: Use these spectroscopic techniques in their research.

1. **Ultraviolet Photoelectron Spectroscopy:**
   An overview, theory and applications of UV-spectroscopy.
2. **Electron Paramagnetic Resonance Spectroscopy**
   Introduction, theory, instrumentation, spin-spin coupling, qualitative and quantitative analysis, multiple resonance, spin labelling, metallic complexes and other uses of EPR spectroscopy.
3. **^{1}HNMR Spectroscopy:**
   Overview of NMR spectroscopy, spin-spin interaction and nomenclature, non 1st order to 1storder spectrum, applications of coupling constants. 2D NMR technique .Multinuclear NMR spectroscopy and its applications.
4. **^{13}C NMR spectroscopy:**
   Comparison between 1H and 13C NMR spectroscopy, factors affecting 13C NMR chemical shifts and identification of various organic molecules with coupling, decoupling, off resonance, etc.
5. **Vibrational and Rotational Spectroscopy**
   a. NIR: Principle, instrumentation and applications.
   b. Raman spectroscopy: Principle, theory, instrumentation and applications.
6. **Mass spectroscopy:**
   Principle, theory, instrumentation, fragmentation and applications.

Reference Books:

1. Understanding NMR-Spectroscopy (2ndEdition), Wiley Publisher by James Keeler.
2. Spectroscopy by H. Kaur, PragatiPrakashan
3. Text book of spectroscopy by Jyotikumar, Sonali publication.
4. Analytical Spectroscopy by James Very, Pacific Book Int.
5. NMR Spectroscopy by Harald Gunther Wiley.
6. Handbook of Instrumental Techniques for Analytical Chemistry by F. Settle Pearso Edu.
7. Introduction to Spectroscopy (3rdEdition) by Pavia LampmanKriz: Cengage.
8. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal & Sham K. Anand, Hiamalaya Publishing House.
9. Spectroscopy of Organic Copmpounds, P.S. Kalsi, New Age International Ltd.
10. Analytical Spectroscopy by James Vergeese.
11. Organic Spectroscopy by William Kemp.
12. Spectrometric Identification of Organic Compounds. (6th Edition) by Robert M. Silverstein & Francis X. Webster, Wiley.
13. Organic Spectroscopy: Principles and Applications, 2ndEdition by Jag Mohan, Alpha Science International Ltd., Harrow U. K.

M. Sc. SEMESTER-IV
PHYSICAL AND MATERIALS CHEMISTRY
C(PM)-402:INSTRUMENTAL TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Students with the advanced technical skills and knowledge base that is required in the field.
- COs2: Apply the conceptual understanding of the principles and implementation modes of advance instrumental technique.

1. **X-ray diffractions**
   Introduction, origin of X-rays, monochromatization and diffraction methods. Crystal structure elucidation limited to cubic system. Applications of XRD and numericals.
2. **Thermal Methods Of Analysis**
   Principle, theory and instrumentation of TGA, DTA and DSC. Factors affecting thermal analysis. Applications of thermal methods in various field of science.Various theories of thermal analysis for evaluation of kinetic parameters and analysis of simple and polymeric compounds.
3. **Spectropolarimetry**
   Introduction, definition of polarized light, optical activity, specific rotation, ORD, CD, Cotton effect, etc. Instrumentation and applications.
4. **Scanning Electron and Transmission Electron Microscopy**
   Introduction, principle, theory, instrumentation and applications.
5. **Automated Analysis**
   Automated system an overview.Didistinction between automatic and automated systems, merits and demerits of automation, types of automated techniques. Discrete automatic system, C, H, and N elemental analyser, multilayer thin film analytical techniques. Flow injection analysis: Principle, instrumentation and applications.

Reference Books:

1. Chromatography by E. Heftman, 5th edition, part-A and B, ElsevierScience Publisher, 1992.
2. Instrumental Methods of Analysis by B.K. Sharma, Goel Publishing House, Meerut.
3. Analytical Chemistry by Gary D. Christian, 6th edition (1994) John Wiley and Sons Inc. New York.
4. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
5. Analytical chemistry by H. Kaur, Pragatiprakashan, Meerut.
6. Instrumental Methods of Chemical Analysis by Chatwal and Anand.
7. Standard Methods of Chemical Analysis by F.J. Welcher.

M. Sc. SEMESTER - IV
PHYSICAL AND MATERIALS CHEMISTRY
C (PM)-403: CHEMISTRY OF MATERIALS-I

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: To study different type of materials, their types, synthesis and applications, basics of some analysis related to biological properties of compounds, solar and fuel cells, ultrasonic technique and their applications.
- COs2: Knowledge of different materials will help student to understand their properties and uses in different fields.
- COs3: The knowledge of theories and different type of cells also help student to understand the significance of these modern approaches to older technology.

1. **Nanomaterials**
   Introduction of nano materials, their size, fundamental science behind nanotechnology. Applications of nanomaterials.
2. **Micelles**
   Surface active agents, classification of surface active agents, micellization, micelle structure and shape, shape transition, elongated micelles, vesicles, inverted structures, micelle aggregation number, hydrophobic interaction, critical micellar concentration(CMC), factors affecting the CMC of surfactants, counterion binding to micelles, thermodynamics of micellization, Gibbs free energy, enthalpy and entropy of micelle formation, phase separation and mass action models, solubilization, micro emulsion, reverse micelles.
3. **QSAR**
   Introduction, classification of QSAR parameters: hydrophobic, electronic, theoretical and steric. Advantages and disadvantages of QSAR.
4. **Ultrasonics**
   Introduction, applications and determination of thermodynamic parameters. Effect of concentration, temperature, nature of solvents and solutes on acoustical properties.
5. **Fuel cells**
   General chemistry of fuel cells, hydrogen-oxygen fuel cell, hydrocarbon-oxygen fuel cell, efficiency and advantages of fuel cells.
6. **Solar cells**
   Solar energy, conversion of solar energy into other forms of energy, solar technology, photo catalytic cells andsolar photovoltaic cells.Advantages of photo voltaics and applications of photovoltaic systems, PV street lighting system, other applications of solar energy, solar desalination, advantages of solar energy, environmental implications of solar energy.

Reference Books

1. Nanotechnology by M. Ratner and D. Ratner, Pearson.
2. Electrochemistry by B. K. Sharma, Goel Publishing House.
3. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania.
4. Surface active agents by M. J. Rosen

M. Sc. SEMESTER - IV
PHYSICAL AND MATERIALS CHEMISTRY
C(PM)-404: REACTION DYNAMICS AND MECHANISMS
ELECTIVE-I

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: To understand the basics of kinetics of fast reactions.

- COs2: Understanding of theories of reaction rates and reaction mechanisms.
- COs3: Knowledge of different types of reactions and catalysts used in reactions and their role in different reactions.
- COs4: student will acquire knowledge of different type of reactions, their mechanisms and theories.

1. **Fast Reactions**
   Introduction, methods of studying fast reactions: Flow methods, flash photolysis, relaxation methods.
2. **Theory of Reaction Rates**
   Collision and absolute reaction rate theory.Thermodynamical formulation of reactionrate.
3. **Reaction Mechanism**
   Reaction between NO_2 and F_2, NO_2 and CO at low temperature, NO and O_2 , H_2 and I_2 , hypochlorite and iodide,acetone and iodine, CO and Cl_2, ammonium cyanate and urea. decomposition of ozone, Acid catalyzed hydrolysis of methyl acetate. Thermal decomposition of nitrogen pentoxide.
4. **Chain Reactions**
   Definition, characteristics of chain reactions, mechanism of chain reactions, kinetics of chain reactions. Decomposition of ozone and nitrogen pentoxide, thermal reaction between hydrogen and bromine, photochemical reactions between hydrogen and bromine; hydrogen and chlorine, decomposition reaction of ethane (first order), acetaldehyde (one half and three half order) and butane (three half order).
5. **Acid-Base Catalysis**
   Types of acid-base catalysis, Mechanism of acid-base catalysis, catalytic coefficients.
6. **Photochemical Reactions**
   Laws of photochemistry, photolytic and photosensitized reactions, chemical actinometers.
7. **Reactions in Solution:**
   Transition state theory for liquid solutions, influence of ionicstrength of solution and nature of solvent on reaction rates,

Reference Books

1. Basic reaction Kinetics and Mechanisms by H.E. Avery, Macmillan
2. Chemical Kinetics byGurdeep Raj, Krishna Prakashan, Meerut
3. Chemical Kinetics by K. J. Laidler, MaGraw Hill New York.

M. Sc. SEMESTER - IV
PHYSICAL AND MATERIALS CHEMISTRY
C (PM) - 404: CHEMISTRY OF MATERIALS-II
ELECTIVE-II

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: To study different materials, their properties and applications.
- COs2: Understanding of applications of different materials in different fields.
- COs3: Student will acquire knowledge of different type of materials and their applications.

1. **Phase Transfer Catalysts**
   Definition, principle, types, examples, applications, scope, benefits and barriers of commercial phase-transfer catalysis applications.
2. **Liquid Crystals**
   Definition and classification of liquid crystals. Synthesis of simple and polymeric liquid crystals. Effect of chemical constituents and lateral substituents on liquid crystal behaviour. Applications of liquid crystals.
3. **High Performance Thermoplastics**
   Polyimides and copolymers, polyether sulfones, polyether ketones, aromatic polyamides and other polymers, application of highperformance polymers.
4. **Mechanical andOptical Properties**
   Introduction, linear visco-elastic behavior: Maxwell and Kelvin-Voigt models and creep behavior. Stress relaxation and dynamic mechanical behavior, Mechanical spectra. Effect of molecular weight, cross link density, crystallinity, tacticity, plasticizers, blending and
   copolymerization on mechanical properties.
   Mechanical tests: Stress-strain properties in tension,fatigue test, tear resistance, abrasion resistance, hardness,transparent, opaque and translucent materials, color, gloss, haze and
   transparency.
5. **Paints**
   Introduction, classification of paints, pigments, classification of pigments, particles, organic and inorganic pigments, toxicity of pigments.
6. **Water BorneCoatings**
   Polymer emulsions, formation of emulsions, surfactants, vinyl emulsion paints: materials and manufacture. Acrylic emulsions and paints, water soluble binders.

Reference Books

1. Physical Chemistry by P. C. Rakshit.
2. Physical Chemistry by Danial Alberty, Mc Graw-Hill.
3. Text-book of Polymer Science, F. W. Billmeyer, Willey Interscience.
4. Outlines of Paint Technology by W. M. Morgans, CBS Publishers and Distributors.
5. Phase Transfer Catalysis by Charles M. Starks, Charles L. Liotta and Marc
6. Halpern. Springer International Edition
7. Physical Chemistry of Macromolecules, D. D. Deshpande, IIT, Bombay
8. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania.
9. Liquid Crystals and Plastic Crystals by W. Gray and P. A. Windsor, Vol. 1.

M. Sc. SEMESTER - IV
PHYSICAL AND MATERIALS CHEMISTRY
C (PM)–405: PRACTICALS/DISSERTATION

6 CREDITS
150 MARKS

1. Kinetic study by polarimetry and conductometry,
2. Conductometry: Mixture of mono and biprotic acids, very weak acid and very weak base, relative acid strength, amount of aspirin tablet, dissociation constant of copper sulphate.

3. Potentiometry: Iodide- permanganate, K_{sp} of AgCl, activity coefficient and transport number determination, thermodynamic parameter determination of zinc-copper cell and equilibrium constant of silver-ammonia complex.
4. pHmetry: Mixture of mono and biprotic acids, amount of aspirin tablet,, mixture of carbonate and bicarbonate, solubility and dissociation constant of salicylic acid, Hammet constant of substituted benzoic acids.
5. Spectrophtometry:Indicator constants, paracetamol in a tablet, complexometric titrations and molecular compositions of complexes.
6. Ultrasonics. Determination of excess acoustical parameters of various binary mixtures.
7. Polarographic and amperometric experiments by various methods.

M. Sc. SEMESTER - IV
PHYSICAL AND MATERIALS CHEMISTRY
C (PM)- 406: VIVA-VOCE

2 CREDITS
50 MARKS

Theory based on C(PM)-301 to C(PM)-304 and practicals.

M. Sc. SEMESTER-III
PHARMA-ANALYTICAL CHEMISTRY
C(PA)-301: ADVANCE CHROMATOGRAPHIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: student will be Capable to understand the range and theories of instrumental methods available for separation.
- COs2: Able to select appropriate techniques for the separation of complex mixture into their individual components.
- COs3: Expand skills in the scientific methods of planning, developing, conducting, reviewing techniques for separation and identification of compound in complex mixture.

1. Introduction, revision of various chromatographic techniques and terminologies.
2. Principle, theory, instrumentation and applications of GC, HPLC, UPLC and super critical fluid chromatographic techniques.
3. **Ion Chromatography:** Principle, theory, instrumentation and applications.
4. **Exclusion Chromatography:** Theory and principle of size exclusion chromatography, experimental techniques for gel filtration chromatography(GFC) and gel-permeation chromatography(GPC).Column materials, factors governing column efficiency, methodology and applications.
5. **Hyphenated techniques:** Principle, theory, instrumentation and applications of GCMS, LC-MS, GC-IR, LC-NMR, etc.
6. **Planner chromatography:** Paper chromatography, thin layer chromatography, and high performance thin layer chromatography: Principle, theory, instrumentation and applications.

Reference Books:

1. Chromatography by E. Heftman, 5th edition, part-A and B, ElesvierScience Publisher, 1992.
2. Instrumental Methods of Analysis by B.K. Sharma, Goel Publisher, Meerut.
3. Analytical chemistry by Gary D. Christian, 6thedition (1994) John Wiley and sons Inc. New York.
4. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
5. Analytical Chemistry by H. Kaur, PragatiPrakashan, Meerut.
6. Instrumental Methods of Chemical Analysis by Chatwal and Anand.
7. Standard Methods of Chemical Analysis by F.J. Welcher.
8. Introduction to Modern Liquid Chromatography: 2nd edition L.R. Snyder and J.J. Kirkland- John Wiley & Sons Inc.
9. Analytical Methods in Chemistry by Y.R. Sharma.
10. Analytical chemistry by Open learning second edi. (Vol. 1-30) Wiley India Edi.
11. B. L. Karger, L.R. Snyder and C. Howarth, An Introduction to Separation Science, 2nd edition (1973), John Wiley, New York.

M. Sc. SEMESTER-III
PHARMA-ANALYTICAL CHEMISTRY
C(PA)-302: ELECTRO ANALYTICAL TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: student will be Capable to understand the range and theories of instrumental methods available for separation.
- COs1: Should be able to: Write equations representing electrochemical cell, explain various over potential involved during the operation of the cell. Students can learn different types of electro-analytical techniques.
- COs2: Apply theories in electrochemistry to analyze electrode kinetics. Students should be able to understand principle instrumentation and application of various electro-analytical techniques.

1. **Polarography**
   Introduction and classification of polarographic techniques. Principle, instrumentation and applications of DC polarography including stripping and cyclic voltammetry and numerical.
2. **Amperometry**
   Introduction, theory and applications. Amperometric titrations.
3. **Electro Gravimetric and Coulometric Methods of Analysis**
   Introduction, principle, theory, instrumentation and applications.
4. **Ion selective electrodes**
   Introduction, classification, theory, types and construction of ion selective electrodes and their applications.
5. **Electrophoresis**
   Introduction, principle, classification, theory, instrumentation, factors affecting and applications.

6. **Capillary Electrophoresis**
   Principle, theory, instrumentation, capillary electro chromatography and applications.

Reference Books

1. Instrumental Methods of Analysis by B. K. Sharma, Goel Ppublishing House, Meerut.
2. Analytical Chemistry by Gary D. Christian, 6th edition (1994) John Wiley and Sons Inc. New York.
3. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
4. Analytical chemistry by H. Kaur, Pragatiprakashan, Meerut.
5. Instrumental Methods of Chemical Analysis by Chatwal and Anand.
6. Standard Methods of Chemical Analysis by F.J. Welcher.
7. Vogel's Textbook of Quantitative Chemical Analysis, 6thEdn. Pearson Education asia.

M. Sc. SEMESTER-III
PHARMA-ANALYTICAL CHEMISTRY
303: ADAVANNCES IN ENVIRNOMENTAL CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student can learn different types of water Pollution and their effects on nature, physical & biological characteristics of water pollution, specific & non-specific characterization of water, typical water treatment & waste water treatment.
- COs2: Treatment of industrial pollution Treatment of Industrial wastes like electroplating industry, fertilizer industry and pharmaceuticals industries. Carbon and Nitrogen cycles on nature.
- COs3: The students will learn what is toxic, and most importantly, will become an expert on what we can do to find solutions to the challenges of toxic substances in the environment.

1. **Types of Water Pollution**
   Introduction, ground water, surface water, river water and marine pollution.
2. **Water Pollutants and their effect**
   Inorganic and toxic metals and their detrimental effect.Organic pollutants, eutrophication, esticide pollutants.
3. **Industrial Pollution and treatment options**
   Effluents from some typical industries, sources, characteristics and their effect, textiles, paper and pulp, fertilizer, dairy, drug, electroplating, leather industries. Tanning and drug, general methods of treatment and treatment option.
4. Treatment and purification of water.
5. Domestic effluent treatment and control of water pollution.
6. Solid waste treatment and disposal methods.
7. Control of soil pollution
8. Environmental toxicology.
9. Air pollution control methods.
10. Radioactive pollution and disposal of radioactive waste.
11. Carbon credit and EIA study.

Reference Books:

1. Environmental Chemistry by A. K. De.

2. An Introduction to air pollution by R. K. Trivedi and P. K. Goel.
3. Principles of Environmental Chemistry by H. Kolhandaraman and Geetha Swaminathan.
4. Atmospheric Pollu8tion By Black. W. (McGrow Hill Company) New York. 67
5. A Textbook of Environmental Chemistry and Pollution Control by S. S. Dara (S. Chand & Company) New Delhi.
6. Ecology of Polluted waters and Toxicology by K. D. Mishra.
7. Environmental Guidelines and Standards in Indian by P. K. Goel & K. P. Sharma.
8. Enzyme Biotechnology by G. Tripathi.
9. Industry, Environment and Pollution by Arvind Kumar and P. K. Goel.
10. Manual on water & waste water analysis by Neeri.
11. Water Pollution by Dr. V. P. Kudesia.
12. Basic concepts of Environmental Chemistry by Des W. Connell.
13. Manual on Water and Wastewater analysis by Dr. B. B. Sundarsan.
14. Liquid waste of Industry: Theories Practices and Treatment by Nelson L. Nemerow.
15. Green chemistry (V.K. Ahluwalia)
16. Perspective in Enviromentalstidies (A. Kaushik & C.P. Kaushik)
17. Vogels qualitative Inorganic Analysis (Seventh Edition by G. svehla)
18. Air pollution & Water Pollution.

M.Sc. SEMESTER-III
PHARMA-ANALYTICAL CHEMISTRY
304: SELECTED TOPICS IN ANALYTICAL CHEMISTRY
ELECTIVE-I

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Students with the advanced technical skills and knowledge base that is required in the field of industrial product.
- COs2: Students in the area of different types of qualitative and quantitative analysis in various industrial product.
- COs3: To provide overview of the applications of these concepts in applied field.

1. **Natural Product Analysis**
   Introduction, sources, classification, isolation techniques qualitative and quantitative analysis of phytochemicals.Characterization and elucidation of structure by various instrumental techniques.
2. **Pharmaceutical Analysis**
   Pharmacopoeias at glance, limit test for impurities, introduction to drugs, classification, contamination and drug product analysis.
3. **Fertilizer Analysis**
   Sampling, sample preparation, nitrogen, phosphorous, and potassium analysis in fertilizers.
4. **Pesticide Analysis**
   Introduction, classification, DDT, endosulphan, malathion, dichlorovos, etc.
5. **Cement Analysis**

Introduction, loss on ignition, insoluble residue, R_2O_3 and other elements of cement, air and dust pollution treatment plant, atmoshpheric dispersion of pollutants in cement industries.

6. **Cosmetic Analysis**

Composition of creams and lotions, determination of water, propylene glycol, non-volatile matter and ash determination, qualitative and quantitative analysis of borates, carbonates, sulphates, phosphate, titanium and zinc oxide. Analysis of face powder, deodorants and antiperspirants.

Reference Books

1. Treatise on Analytical Chemistry vol. I&II by I. M. Kolthoff.
2. Encyclopaedia of industrial chemical analysis vol. 1to20 (John Wiley Publishers)
3. Cosmetics by W. D. Poucher (three volumes)
4. Pharmacopeia of India vol. I and II.
5. Practical Pharmaceutical Chemistry IIIrd Edition Vol.I by A. H. Beckett and J. B. Sterlake.
6. Practical Pharmaceutical Analysis by AshutoshKar.
7. Official Method of Analysis 11th edition (1970), W. Horwitz (editor), Association of Official Analytical chemists, Washington DC.
8. Vogel's textbook of quantitative inorganic analysis, L. Borrt et al. ELBS.
9. Chemistry of natural products by V. K. Ahluwalia, Lalita S. Kumar.

M. Sc. SEMESTER-III
PHARMA-ANALYTICAL CHEMISTRY
C(PA)-304: PATENT LAWS ANS CASE STUDIES
ELECTIVE-II

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student able to use various parameter of pharma regulatory affairs to make proper documentation as per standard protocol.
- COs2: To learn various topics like SOP, ICH guidelines, GMP, GLP, Calibration and validation used in pharma regulatory affairs.
- COs3: To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques followed by ICH guidelines.

1. **Patent Laws:** Indian and international.
2. IPRs and other related laws.
3. Patents search tools and their usages.
4. Selected topics of chemo and bio informatics tools and their applications.
5. Agreements, confidential, nondisclosure agreements.

Reference Book

1. Patents for future by N. B. Zaveri, Vakils, Feffer and Simons Ltd. Mumbai (1st edition 2001)

M. Sc. SEMESTER-III
PHARMA-ANALYTICAL CHEMISTRY
C(PA)-305: PRACTICALS

6 CREDITS
150 MARKS

1. To determine the % purity of a given sample of isoniazid.
2. To determine the amount of benzyl penicillin in the given sample.
3. To determine the amount of paracetamol in the given sample by colorimetric method.
4. To determine the amount of salicylic acid by colorimetric method.
5. To determine the amount of acetyl salicylic acid in the aspirin tablet.
6. To determine the amount of ascorbic acid in the given sample.
7. To determine the amount of cephalexin.
8. To determine the concentration of the given sample of adrenaline tartrate using spectrophotometric method.
9. To determine the amount of KI in KIO_3.
10. To determine the amount of $KBrO_3$ in the given commercial sample.
11. To determine the iron (Fe) content in the given sample.
12. To determine the composition of Fe (III)- EDTA/ Fe (III)-Oxalate complex form in acidic medium by Job's method using SSA as an oxaillary ligand.
13. To determine the amount of copper in the given sample by spectrophotometric method.
14. To determine the amount $KMnO_4$ and $K_2Cr_2O_7$ present in the given sample by column chromatography.
15. To determine the sulphate amount in the given water sample.
16. To determine the amount of free chlorine in the given sample of bleaching liquid.
17. To determine the amount of sulphites in the given sample.
18. To determine the amount of sodium nitrite ($NaNO_2$) in the given commercial sample.
19. To determine aluminium using by complexometric titration method.
20. To determine Rf values of the amino acids in a given mixture by circular paper chromatography.
21. To determine Rf values amino acids in a given mixture by ascending chromatography.
22. To determine Rfvalues of the metal ions in a given mixture by circular paper chromatography.
23. To determine Rfvalues of metal ions in a given mixture by ascending paper chromatography.
24. Qualitative and quantitative analysis by gas chromatographic technique.
25. Qualitative and quantitative analysis by HPLC method.
26. Separation of metal ions by ion exchange chromatography.
27. Estimation of COD in a given water sample.
28. Other relevant experiments based on theory.

M.Sc. SEMESTER-III
PHARMA-ANALYTICAL CHEMISTRY
C(PA)-306: VIVA VOCE

2 CREDITS
50 MARKS

Theory based on C(PA)-301 to C(PA)-304 and practicals

M. Sc. SEMESTER-IV
PHARMA-ANALYTICAL CHEMISTRY
C(PA)-401: ADVANCE SPECTROSCOPIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: the learners should be able to: Apply NMR, IR, MS, UV-Vis spectroscopic techniques in solving structure of organic molecules.
- COs2: To determination of stereochemistry of unknown molecules.
- COs3: Interpret the above spectroscopic data of unknown compounds.
- COs4: Use these spectroscopic techniques in their research.

1. Ultraviolet Photoelectron Spectroscopy: An overview, theory and applications of UV-spectroscopy.
2. Electron Paramagnetic Resonance Spectroscopy: Introduction, theory, instrumentation, spin-spin coupling, qualitative and quantitative analysis, multiple resonance, spin labelling, metallic complexes and other uses of EPR spectroscopy.
3. ^{1}HNMR Spectroscopy: Overview of NMR spectroscopy, spin-spin interaction and nomenclature, non 1 st order to 1st order spectrum, applications of coupling constants. 2D NMR technique. Multinuclear NMR spectroscopy and its applications.
4. ^{13}C NMR spectroscopy: Comparison between 1H and ^{13}C NMR spectroscopy, factors affecting ^{13}C NMR chemical shifts and identification of various organic molecules with coupling, decoupling, off resonance, etc.
5. Vibrational and Rotational Spectroscopy c. NIR: Principle, instrumentation and applications. d. Raman spectroscopy: Principle, theory, instrumentation and applications.
6. Mass spectroscopy: Principle, theory, instrumentation, fragmentation and applications.

Reference Books

1. Understanding NMR-Spectroscopy (2ndEdition), Wiley Publisher by James Keeler.
2. Spectroscopy by H. Kaur, PragatiPrakashan
3. Text book of spectroscopy by Jyotikumar, Sonali publication.
4. Analytical Spectroscopy by James Very, Pacific Book Int.
5. NMR Spectroscopy by Harald Gunther Wiley.
6. Handbook of Instrumental Techniques for Analytical Chemistry by F. Settle Pearson Edu.
7. Introduction to Spectroscopy (3rd Edition) by Pavia LampmanKriz: Cengage.
8. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal & Sham K. Anand, Hiamalaya Publishing House.
9. Spectroscopy of Organic Copmpounds, P.S. Kalsi, New Age International Ltd.
10. Analytical Spectroscopy by James Vergeese.
11. Organic Spectroscopy by William Kemp. 25. Spectrometric Identification of Organic Compounds. (6th Edition) by Robert M. Silverstein & Francis X. Webster, Wiley.
12. Organic Spectroscopy: Principles and Applications, 2nd Edition by Jag Mohan, Alpha Science International Ltd., Harrow U. K.

M. Sc. SEMESTER-IV
PHARMA-ANALYTICAL CHEMISTRY
C(PA)-402: INSTRUMENTAL TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Students with the advanced technical skills and knowledge base that is required in the field of instrumental analysis and which will enable them to pursue careers as analysts in the chemical and/or pharmaceutical industry.
- COs2: The learners should be able to apply the conceptual understanding of the principles and implementation modes of advance instrumental technique.

1. X-ray Diffractions

Introduction, origin of X-rays, monochromatization and diffraction methods. Crystal structure elucidation limited to cubic system. Applications of XRD and numericals.

2. Thermal Methods of Analysis

Principle, theory and instrumentation of TGA, DTA and DSC. Factors affecting thermal analysis. Applications of thermal methods in various field of science. Various theories of thermal analysis for evaluation of kinetic parameters and analysis of simple and polymeric compounds.

3. Spectropolarimetry

Introduction, definition of polarized light, optical activity, specific rotation, ORD, CD, Cotton effect, etc. Instrumentation and applications.

4. Scanning Electron and Transmission Electron Microscopy

Introduction, principle, theory, instrumentation and applications.

5. Automated Analysis

Automated system an overview. Didistinction between automatic and automated systems, merits and demerits of automation, types of automated techniques. Discrete automatic system, C, H, and N elemental analyser, multilayer thin film analytical techniques. Flow injection analysis: Principle, instrumentation and applications.

Reference Books

1. Chromatography by E. Heftman, 5th edition, part-A and B, Elsevier Science Publisher, 1992.
2. Instrumental Methods of Analysis by B. K. Sharma, Goel Publishing House, Meerut.
3. Analytical Chemistry by Gary D. Christian, 6th edition (1994) John Wiley and Sons Inc. New York.
4. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
5. Analytical chemistry by H. Kaur, Pragatiprakashan, Meerut.
6. Instrumental Methods of Chemical Analysis by Chatwal and Anand.
7. Standard Methods of Chemical Analysis by F.J. Welcher.

M. Sc. SEMESTER-IV
PHARMA ANALYTICAL CHEMISTRY C (PA)-403:
PHARMA REGULATORY AFFAIRES

4 Credits
100 Marks

Course Outcomes (COs):

- COs1: Student should be able to use various parameter of pharma regulatory affairs to make proper documentation as per standard protocol.
- COs2: To learn various topics like SOP, ICH guidelines, GMP, GLP, Calibration and validation used in pharma regulatory affairs.
- COs3: To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques followed by ICH guidelines.

1. Introduction of regulatory affairs.
2. Standard operating procedures and documentation.
3. ICH guidelines.
4. GMP, GLP, C-GMP and other practices.
5. Calibration, validation and quantifications.
6. Analytical method validation protocols.
7. Selected topics on updates regulation aspects.

Reference Books

1. Guidelines on GMP/GLP BY S. Lyer.
2. US pharmacopeia and its Revised books.
3. Indian Pharmacopoeia(JP).
4. British Pharmacopoeia(BP).
5. Japanese Pharmacopoeia(JP).
6. Analytical method validation and instrumental performance verification(by chung chow chan, Y.C. Lee ana Lam).
7. Quality assurance in Analytical Chemistry (by B. W. Wenclawiak, M. Koch ,E. Hadjicostas).
8. Development & validation of analytical methods.(by Christopher Riley, ThomsRasanske).
9. SOP guidelines(by D. H. Shah).
10. Regulation of clinical trials (by Rakesh Kumar Rishi).
11. ICH guidelines (QQ1A, Q1B, Q1C,Q1D, Q1E, Q1F, Q2A, Q2A, Q3A(R), Q3B(R), Q3C, Q3C(M), Q4 Q4A, Q4B, Q5A, Q5B,Q5C,Q5D, Q5E, Q6, Q6A,Q6A,Q7,Q7A, Q8,Q9, Q10,).
12. Laboratory QS,QA, Standardization, Accreditation(by Pamposhkumar& V.P.S. Tomar).

M.Sc. SEMESTER-IV
PHARMA-ANALYTICAL CHEMISTRY
404: APPLIED ANALYTICAL CHEMISTRY
ELECTIVE-I

4 Credits
100 Marks

Course Outcomes (COs):

- COs1: Students with the advance analytical techniques and knowledge base that is required in the field of analysis.
- COs2: Understand the essential concept used in various analytical technique.
- COs3: To study in detail the basic concept of classical and instrumental technique of analysis of various industrial product.
- COs4: To understand the principle of various analytical techniques.

1. **Solvent Extraction Method in Analysis:**
   Principle, classification of extraction system, mechanisms of extraction, theory and applications solid phase extraction and applications.
2. **Food Analysis**
   Food additives, food preservatives, milk and milk products, honey, beverages, jam, catch up, etc. Tocopherol and other food product analysis.
3. **Clinical Analysis**
   Biological significance, assay of enzymes, vitamins and clinical chemical analysis.
4. **Green Analytical Chemistry**
   Introduction, principle and applications.
5. **Process analytical chemistry**
   Introduction, theory and applications.
6. **Analysis of Minerals, Ores and Alloys**
   Dolomite, bauxite, limestone, hematite, pyrolusites, gypsum and uranium ores, steel, Cu-Ni alloy, solder, bronze, brass, tenoallous of silicon, chromium, titanium, etc.

Reference Books

1. Analytical chemistry of Food by Ceiwyns James Blackie Academic and Professional Chapman and Hill Publisher, 1stEdn. Madras.
2. Chemical analysis of food by Pearson.
3. Practical Biochemistry in clinical medicine by R.L. Nath, Academic Publisher 2nd Edn. (1990)
4. Introduction to Food Science and Technology of Food Science and Technology series by G. F. Stewart and M. A. Amerine, Academic Press.
5. Handbook of Industrial Chemistry by Davis Berner.
6. Solvent Extraction in Analytical Chemistry by G. H. Morrison and H. Freiter John Wiley New York 1958.
7. Basic Concept of Analytical Chemistry by S.M. Khopkar.
8. Quantitative Inorganic Analysis by A. I. Vogel 5th edition.
9. Encyclopaedia of Industrial Methods of Chemical Analysis by F. D. Snil.

M.Sc. SEMESTES-IV
PHARMA-ANALYTICAL CHEMISTRY
404: SELECTED TOPICS IN ANALYTICAL CHEMISTRY ELECTIVE-II
4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: The learners should be able to identify the basic principles of analysis related to quality and quantity of the various substances.
- COs2: To provide basic understanding of the principles, instrumentation and application of chemical analysis techniques.

1. Analysis of Paints and Pigments

Preliminary inspection of sample. Test on the total coating. Separation of pigments, binder and thinner of latex paints.Separation of pigments, binder and thinner of solvent type coating.Modification of binder.Identification and analysis of thinner.

2. Analysis of Coal and Coke

Types, composition of sample, proximate and ultimate analysis calorific value by bomb calorimetry.

3. Analysis of Gaseous Fuels

Composition of fuel gases, collection of gas and analysis of fuel gases (coal gas, producer gas, water gas and flue gas).

4. Analysis of Explosives

General methods, heat of explosion, hygroscopicity, moisture by Karl Fischer titration, qualitative tests of explosives, qualitative analysis of explosive mixture dynamites. Blasting caps and electric detonators, primers, liquid propellants and solid propellants.

5. Glass and Glass-Ceramics

Introduction, composition, method of analysis sampling and sample preparation, composition analysis preliminary testing, decomposition, chemical methods for the individual constituents of Si, B, Pb, Zn, Al, Cl, Ca, Mg, Ti.

6. **Body Fluid Analysis**

Composition and detection of abnormal level of certain constituents leading to diagnosis of diseases. Sample collection and preservation of physiological fluids, analytical methods to the constituents of physiological fluids (blood, urine and serum). Blood estimation of lucose, cholesterol, urea, haemoglobin and bilirubin. Urine-urea, uric acid, creatinine, calcium, phosphate, sodium, potassium and chloride.

7. Forensic Analysis

Special features of forensic analysis, sampling, sample storage, sample dissolution, classification of poisons, lethal dose, significance of LD-50 and LC-50. General discussion of poisons with special reference to mode of action of cyanide, organophosphate and snake venom. Estimation of poisonous material such as lead, mercury and arsenic ion biological sample.

Introduction to Forensic Science:

Profile of a forensic laboratory, forensic scientist role and quality control, crime scene investigation, collation and preserving physical evidences and evidentiary documentation, future prospects of forensic analysis.

8. Real case Analysis

Liquor analysis, trap-case analysis, petroleum product analysis, fire and debris analysis, injuries, firearm wounds, asphyxia and stress analysis (only analytical identification).

Reference Books

1. Handbook of Industrial Chemistry by Davis Berner.
2. Quantitative Inorganic Analysis by A. I. Vogel. 5th edition.
3. Encyclopaedia of Industrial Methods of Chemical Analysis by F. D. Snil.
4. Textbook of Forensic Pharmacy by B. M. Mithal 9th edition 1993, National Centre Calcutta.
5. Forensic Pharmacy by B. S. Kuchekar and A. M. KhadatareNiraliPrakashan.

M. Sc. SEMESTES-IV
PHARMA-ANALYTICAL CHEMISTRY
405: PRACTICALS/ DISSERTATION

6 CREDITS
150 MARKS

Course Outcomes (COs):

- COs1: Students should be in a position to use standardized material to determine an unknown concentration.
- COs2: To gain experience with some statistics to analyse data in laboratory.
- COs3: Students should be in position to use different techniques for qualitative and quantitative estimation

1. To determine the active ingredient of a given sample of dichlorovos.
2. To determine the active content of phosphamidon in the given sample.
3. To determine the active content of endosulphan in a given sample.
4. Determination of nitrite (NO_2^-) in the given sample.
5. Determine the percentage of tin (Sn) and lead (Pb) in the given sample of solder wire.
6. To determine calcium and calcium carbonate in Ca-ore.
7. To estimate copper and tin in the given sample of bronze.
8. To determine sulphite (SO_3^-) in sulphurous acid (H_2SO_3) by back titration.
9. To determine copper, nickel and zinc composition in the given sample of germen silver alloy.
10. To analyse the given dolomite ore sample for its various elements.
11. To determine iron in ore.
12. To determine the available phosphorous in the soil.
13. To determine copper and zinc content in brass.
14. To determine of barium by preparing barium thiosulphate monohydrate.
15. To determine the lead by volumetric titration.
16. To determine zinc as ammonium phosphate or pyrophosphate.
17. To determination of Mg as a 8-hydroxy phenolate.
18. To determine the H_2O_2 in the given commercial sample.
19. To determine amount of organic carbon in soil.
20. Solvent extraction of organic/metal ion and their quantitative analysis.
21. Flame photometric determination of Na, K, Li and Ca.
22. Any other relevant experiment may be added.

M. Sc. SEMESTES-IV
PHARMA-ANALYTICAL CHEMISTRY
406: VIVA VOCE

2 CREDITS
50 MARKS

Theory based on C(PA)-401 to C(PA)-404 and practicals.

M. Sc. SEMESTER-III
ORGANIC PHARMACEUTICAL CHEMISTRY
C(OP)-301: ADVANCE CHROMATOGRAPHIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student will be Capable to understand the range and theories of instrumental methods available for separation.
- COs2: Able to select appropriate techniques for the separation of complex mixture into their individual components.
- COs3: Expand skills in the scientific methods of planning, developing, conducting, reviewing techniques for separation and identification of compound in complex mixture.

1. Introduction, revision of various chromatographic techniques and terminologies.
2. Principle, theory, instrumentation and applications of GC, HPLC, UPLC and super critical fluid chromatographic techniques.
3. **Ion Chromatography**: Principle, theory, instrumentation and applications.
4. Exclusion Chromatography:
   Theory and principle of size exclusion chromatography, experimental techniques for gel filtration chromatography (GFC) and gel-permeation chromatography(GPC). Column materials, factors governing column efficiency, methodology and applications.
5. **Hyphenated techniques:**
   Principle, theory, instrumentation and applications of GCMS, LC-MS, GC-IR, LC-NMR, etc.
6. Planner chromatography: Paper chromatography, thin layer chromatography, and high performance thin layer chromatography: Principle, theory, instrumentation and applications

Reference Books

1. Chromatography by E. Heftman, 5th edition, part-A and B, Elesvier Science Publisher, 1992.
2. Instrumental Methods of Analysis by B. K. Sharma, Goel Publisher, Meerut.
3. Analytical chemistry by Gary D. Christian, 6th edition (1994) John Wiley and sons Inc. New York.
4. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
5. Analytical Chemistry by H. Kaur, PragatiPrakashan, Meerut.
6. Instrumental Methods of Chemical Analysis by Chatwal and Anand.

7. Standard Methods of Chemical Analysis by F. J. Welcher.
8. Introduction to Modern Liquid Chromatography: 2nd edition L. R. Snyder and J. J. Kirkland- John Wiley & Sons Inc.
9. Analytical Methods in Chemistry by Y. R. Sharma.
10. Analytical chemistry by Open learning second edi. (Vol. 1-30) Wiley India Edi.
11. B. L. Karger, L. R. Snyder and C. Howarth, An Introduction to Separation Science, 2 nd edition (1973), John Wiley, New York.

M. Sc. SEMESTER-III
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-302: ORGANIC SYNTHESIS-A DISCONNECTION APPROACH

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: The learners should be able to: Use various reagents and organic reactions in organic synthesis.
- COs2: Use retrosynthetic method for the logical dissection of complex organic molecules and devise synthetic methods.
- COs3: To learn various organic reactions and reagents used in them as tools applied in the art of organic synthesis. To learn retrosynthetic approach towards organic synthesis.

1. Disconnection fundamentals, explanation of synthons, synthetic equivalents considering various examples, concept and design of synthesis for molecules, criteria for good disconnection.
2. Explanation of one group disconnection and two group disconnection considering various examples.
3. Disconnections considering use of Diels-Alder reaction concept and its use in synthesizing organic molecules.
4. Reversal of polarity meaning, explanation (Unpolung) various examples in which polarity of carbon is reversed.
5. Protection and deprotection of various functional groups, various reagents for and examples.
6. Ring synthesis: three and four membered cyclic compounds.
7. Disconnection of acyclic and cyclic heterocompounds, synthesis of ethers, amines, nitrogen and oxygen containing five and six membered heterocyclic compounds.
8. Illogical two disconnection and synthesis of 2-hydroxy carbonyl compounds, 1,2-diols,1,4-diols and 1,6-carbonyl compounds.

Reference Books

1. Designing Organic Synthesis – S. Warren, Wiley.
2. Some Modern Methods for Organic Synthesis – W. Carruthers.
3. Principles of Organic Synthesis – R. Norman and J. M. Coxon.
4. Advanced Organic Chemistry Part B – F. A. Carey and R. J. Sundberg.
5. Organic Synthesis –Concept, Methods, Starting Materials – J. Fuhrhop.
6. Modern Synthetic Reactions – H. O. House, W. A. Benjamin.
7. Disconnection Approach – Warren.

M. Sc. SEMESTER-III
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-303 : HETEROCYCLIC CHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: The learners should be able to: Name and structure of heterocycles Design the root for synthesis of heterocyclic compounds.
- COs2: The application of reagents and other heterocycles for the synthesis of other heterocycles.
- COs3: To learn the synthetic strategies, stability and physic chemical properties of heterocyclic compounds. The application of hetero cyclic compounds in various fields.

1. **Nomenclature of Heterocyclic Compounds**
   Introduction, Hanzch-Widman nomenclature for monocyclic, fused and bridged heterocycles.
2. **Three and four membered heterocycles**
   Preparation and properties of aziridine, azirine, oxiran, thiirane.
   Preparation and properties of diazirine and oxaziridine.
   Preparation and properties of azetidine, oxetane, thietane.
3. **Five-membered Heterocycles**
   Preparation and properties of pyrazole, imidazole, oxazole, thiazole.
   Preparation of isoxazole, oxazole, isothiazole, isothiazole.
   Preparation and properties of indole, benzofuran, thianaphthene.
   Preparation of isoindole, indolizine, dibenzofuran, isobenzofurans, carbazole.
   Preparation and properties of triazole and tetrazole.
4. **Six-membered Heterocycles**
   Preparation and properties of pyridine, pyran, pyrimidine, pyridazine and pyrazine.
   Preparation of 2-pyrones and 4-pyrones.
   Preparation and properties of quinoline, isoquinoline, acridine,phenanthridine, quinazoline, quinoxaline and cinnoline.
   Preparation of benzopyran, benzo-2-pyrones and benzo-4-pyrone.
5. **Seven and Eight Membered Heterocycle**
   Synthesis of azepine, thiepine, diazepine.
   Synthesis of azocine, 1,4-diazocine,1,4-dioxocin,1,4-dithicine.

Reference Books

1. Heterocyclic Chemistry-R.K. Bansal.
2. An introduction to the Chemistry of Heterocyclic Compounds - R.H.Acheson.
3. Chemistry of Heterocyclic compounds-J.J. Trivedi
4. Heterocyclic Chemistry-R.R. Gupta, M.Kumar and V. Gupta, Springer.
5. The Chemistry of Heterocycles - T. Eicherand S. Hauptmann.
6. Heterocyclic chemistry - J.A. Joule, K. Mills & G.F. Smith.
7. Comprehensive Heterocyclic Chemistry - A. R. Katritzky and C. W. Rees
8. Heterocyclic Chemistry - T. L. Gilchrist.
9. The Essence of Heterocyclic Chemistry, New Age International Publications,2013

M.Sc. SEMESTER-III
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-304 : CHEMISTRTY OF NATURAL PRODUCTS
ELECTIVE-I

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: the learners should be able to know the colour properties of chemicals. Structure of Chromophore and Auxochrome and dying process.
- COs2: Student learn preparation of dyes, Identify the structure of pigments
- COs3: To know the chemical properties and application of naturally occurring pigments. Unit operation for dying process.

1. **Alkaloids**
   Introduction and classification, Chemistry of atropine, coniine, and reserpine.Synthesis of morphine, colchinine, strychnine, sceletium A4.
2. **Vitamins**
   Introduction and Chemistry of Vitamin A, E and K. Synthesis of riboflavin, pyridoxine vitamin C, niacin, pantothenic acid, folic acid,vitamin-H.
3. **Nucleic acid**
   Structure of nucleoside, nucleotide, and protein.
4. **Terpenoids**
   Introduction, classification, Chemistry of eudesmol, zingiberene and α-pinene.Synthesisof farnesol, santonine and longifolene.
5. **Steroids and Hormones**
   Constitution of cholesterol (no synthesis), Chemistry of progesterone and testosterone. Synthesis of hormones:Hexosterol and stilbosterol, ACTH.
6. **Prostaglandins**

Reference Books

1. Natural products: Chemistry and Biological Significance – J. Madd, R. S. Davidson,
J. B. Hobbs, D.V. Banthrope.
2. Organic Chemistry, Vol 2., - I..L. Finar.
3. StereoselectiveSynthesis: A Practical Approach - M. Nogradi.
4. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas - Ed. Kurt, M. P. Gupta and A. Marston.
5. New trends in Natural Product Chemistry – Alta – Ur- Rahman and M.I. choudhary.
6. Chemistry of Natural Products. By S. V. Bhat, B. A. Nagasampagi and M. Sivakumar,Springer-Berlin Heidelberg (2005).
7. Organic Chemistry of Natural Products by O.P. Agarwal, Goel Publishing House, Meerut(1997).

M. Sc. SEMESTER-III
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-304: SYNTHETIC DYES AND PIGMENTS
ELECTIVE-II

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: The learners should be able to know thee complexity of the natural products.
- COs2: Design for the synthesis of natural products and their application.
- COs3: Student learns extraction and isolation of natural product.
- COs4: To know the chemical properties and application of naturally available compounds.

1. **Color and Chemical Constitution**

   Introduction of dyes and pigments, prerequisites for a dye. Nomenclature of dyesintermediates, nomenclature of dyes.Bathochromic and hypsochromic effects.Colour, relation between colour and chemical constitution: Witt's theory, Armstrong's theory, Nietzki's theory, Valence bond theory, Molecular orbital theory. Classification of dyes based on chemical constitution and method of applications and examples.

2. **Natural Pigments and Porphyrins Derivatives**

   General structures, synthesis and spectral properties.Structural determination of haemoglobin, chlorophyll and bilirubin.Synthesis of cryptopyrrole, phytopyrrole, opsopyrrole and haemopyrrole and their carboxylic acid derivatives.

3. **General Introduction**

   Diazotization, mechanism and different methods of diazotization and laws of coupling, General introduction, classification and synthesis of monoazo dyes, bisazo dyes and azoic dyes. Evaluation of dyes.

   Synthesis of the following dyes: Disperse Red 13, Acid Blue 92, Mordant Black 11, Acid Black 1, Acid Blue 113, Direct Blue 15, Direct Violet 1, Direct Red 28, Naphthol AS-BR, Fast Orange GGD.

4. **Heterocyclic Dyes**

   Pyrazolone dyes, cyanine dyes, dyes containing azine, oxazine and thiazine ring systems. Thiazole dyes.

   Pigments: Different classes of organic pigments and synthesis. Synthesis of basic Yellow 11, Basic Orange 21, Safranine B, Rosinduline GG, Sirius Supra Blue FFRL, Brilliant Alizarin Blue 3R, Sirius Supra Yellow RT, Acid Yellow 19, Copper Phthalocyanine, Sirius Supra Light Green FFGL.

Reference Books

1. The Chemistry of Synthetic Dyes, Vol. I to VII by Venkataraman, Academic Press, New York.
2. Chemistry of Synthetic Dyes & Pigments by Lubs.
3. Dyes and their intermediates by E. N. Abrahart.
4. Handbook of Synthetic Dyes and Pigments, Vol. I & II by K. M. Shah.
5. Industrial Dyes by Klans Hunger, Germany by Wiley-VCH

M. Sc. SEMESTER-III
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-305: PRACTICALS

6 CREDITS
150 MARKS

Course Outcomes (COs):

- COs1: The learners should be able to know Safety point in Laboratory.
- COs2: Handle of Hazardous chemicals and precautions.
- COs3: General process for synthesis, characterization and identification of the products.
- COs4: Students; to know practical approach for the synthesis, optimization of reaction condition.
- COs5: Stoichiometric calculation for reagents, Separation of mixture and identification of unknown compounds by comparative study

1. Multicomponent reactions
2. Fries reaction
3. Friedel-Craft reaction
4. Mannich reaction
5. Beckmann reaction
6. Fischer indole synthesis
7. Hoffmann Degradation
8. Benzil-benzilic acid reaction
9. Ullmann reaction (Nascent Copper preparation and use)
10. Cyclocondensation reaction
11. Formylation reaction
12. Pechmann condensation

M. Sc. SEMESTER-III
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-306: VIVA VOCE

2 CREDITS
50 MARKS

Theory based on C(OP)-3-1 to C(OP)-304 and practicals.

M. Sc. SEMESTER-IV
ORGANIC PHARMACEUTICAL CHEMISTRY
C(OP)-401: ADVANCE SPECTROSCOPIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: To determination of stereochemistry of unknown molecules.
- COs2: Interpret the above spectroscopic data of unknown compounds.
- COs3: Use these spectroscopic techniques in their research.
- COs4: To learn basic principles of NMR, IR, UV-Vis spectroscopy and mass spectrometry

1. Ultraviolet Photoelectron Spectroscopy: An overview, theory and applications of UV-spectroscopy.
2. Electron Paramagnetic Resonance Spectroscopy: Introduction, theory, instrumentation, spin-spin coupling, qualitative and quantitative analysis, multiple resonance, spin labelling, metallic complexes and other uses of EPR spectroscopy.
3. 1HNMR Spectroscopy: Overview of NMR spectroscopy, spin-spin interaction and nomenclature, non 1st order to 1storder spectrum, applications of coupling constants. 2D NMR technique.Multinuclear NMR spectroscopy and its applications.
4. 13C NMR spectroscopy: Comparison between 1H and 13C NMR spectroscopy, factors affecting 13C NMR chemical shifts and identification of various organic molecules with coupling, decoupling, off resonance, etc.
5. Vibrational and Rotational Spectroscopy.
    a) NIR: Principle, instrumentation and applications.
    b) Raman spectroscopy: Principle, theory, instrumentation and applications..
6. Mass spectroscopy: Principle, theory, instrumentation, fragmentation and applications

Reference Books

1. Understanding NMR-Spectroscopy (2ndEdition), Wiley Publisher by James Keeler.
2. Spectroscopy by H. Kaur, PragatiPrakashan
3. Text book of spectroscopy by Jyotikumar, Sonali publication.
4. Analytical Spectroscopy by James Very, Pacific Book Int.
5. NMR Spectroscopy by Harald Gunther Wiley.
6. Handbook of Instrumental Techniques for Analytical Chemistry by F. Settle Pearson Edu.
7. Introduction to Spectroscopy (3rdEdition) by Pavia LampmanKriz: Cengage.
8. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal & Sham K. Anand, Hiamalaya Publishing House.
9. Spectroscopy of Organic Copmpounds, P.S. Kalsi, New Age International Ltd.
10. Analytical Spectroscopy by James Vergeese.
11. Organic Spectroscopy by William Kemp.
12. Spectrometric Identification of Organic Compounds. (6th Edition) by Robert M. Silverstein & Francis X. Webster, Wiley.
13. Organic Spectroscopy: Principles and Applications, 2ndEdition by Jag Mohan, Alpha Science International Ltd., Harrow U. K.

M. Sc. SEMESTER-IV
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-402: CHEMISTRY OF SYNTHETIC DRUGS

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Recognize and comment on different synthetic strategies and methods for stereo cotrol when faced with synthetic drugs.
- COs2: Understood different system of human body. Application of drug molecules.
- COs3: To understood the drug metabolism and its action in human body.
- COs4: To learn various nucleophilic, substitution and electrophilic reaction in organic

chemistry for drug synthesis. To create an interest of students to learn medicinal chemistry.

1. General introduction, nomenclature and classification of drugs.
2. Cardiovascular drugs: Antiarrhythmic agent, antihypertensive, vasodilators (peripheral and coronary), coagulants and anticoagulants, antithrombotic and antiplatelet drugs.
3. Central Nervous system: Anaesthetic (local & general), analgesics, antipyretics, steroidal and nonsteroidal antiinflammatory drugs), sedative and hypnotic ranquilizers (major and minor), antiepileptics, anticonvulsants, antidepressants and antimaniacs. Drugs used in movement disorder, antiemetics ,CNS stimulants and activators.
4. Musculoskeletal Disordor Drugs: NSAIDS, antiarthritic drugs, neuromuscular drugs, muscle relaxants, topical analgesics.
5. Respiratory System Drugs: Antitussives, expectorants and mucolytics, respiratory stimulants, and antiasthematics.
6. Gastrointestinal Tract Drugs: Antacids, antiulcer, anti-spasmodics, anti-diarrheals, laxatives and lubricants.
7. Genito urinary system Drugs: Urinary infectives, diuretics and anti-diuretics, analgsics , spermicidal, contraceptives
8. Allergy & immunology Antiallergic and antihistamin, immuno-suppressants.
9. Hormones: Anebolic and androgenic steroids, conticosteroids, oestrogen, progeslogers and contracoptrus, thyroids and antithyroid drugs, antidiabetic and hyper glycemics, fertility agents, antiobesity drugs, hypolipidaemic agents.
10. Antiinfections and Antiinfestation Anticancer introduction to chemotherapeutic agents Antimalarials, antiprotogoals, antileprosy, antitubercular, antifungal, antianaerobicsanthelminticsand antiinfestive drugs and antiviral. Antibiotics and antibacterial Pencillins, cophelosphorins, fluroquinolones, aminoglycosides, macrolides and other antibiotics, chloramphenicol, tetracycline, oxazolidinediones, and sulfonamides.

M.Sc. SEMESTER-IV
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-403: STEREOCHEMISTRY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: student will be able to generalize the concept of stereochemistry and reaction pathway.
- COs2: Describe the stereo chemical and conformational structure of molecules.
- COs3: Chemical reactivity and on the mechanism of organic reaction.
- COs4: students familiar with the basic concept of stereo chemistry, which will be used for further studies.
- COs5: Providing the knowledge and in depth understanding stereochemistry, its effect in synthesis, behavior of chiral compounds and properties.

1. **Fundamental of Stereochemistry**

Important terminology of stereochemistry andnomenclature. Chiral properties of Organic compounds: ORD, CD and rules for optical properties.Chemical and stereo chemical aspects of DNA, andenzymes.

2. **Conformational Analysis**
   Acyclic, cyclic, fused and bridged cyclic ring system. Dynamicstereo chemistry, conformation and reactivity.
3. **Diastereosilectivity**
   Stereospecific and stereo selective reactions, prochirality, Crame's rule, Newman projection and Felkin-Anh model. Stereo selective and stereo regulator polymerization. Stereo chemistry of fused ring and bridge ring and spirans.
4. **Determination of Stereochemistry by Spectroscopic Methods**
   Dihedral angle and coupling constant.3j Coupling and Karplus equation and its modification. Geminal coupling in six-membered, five-membered and four-membered ring, Nuclear over houser effect, etc. Geometrical isomer and coupling constants.

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Reference Books

1. Organic Chemistry - I.L. Finar.
2. Stereochemistry - J.P. Trivedi
3. Stereochemistry of Organic Compounds by- D. Nasipuri,2nd Edition, New Age International(P) Ltd.(1994).
4. Stereochemistry of Organic Compounds - P.S. Kalsi.
5. StereoselectiveSynthesis : A Practical Approach, - M. Nogradi, VCH.
6. Organic Chemistry, By, J. Clayden,N. Greeves, S.Warren and P.Worthers, Oxford, University Press, (2001).
7. Stereochemistry of Carbon CompoundsBy E.L. Eliel,Tata McGrawn-Hill Pub. Co. Ltd.(1962).

M. Sc. SEMESTER-IV
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-404:ADVANCED STEREO CHEMISTRY
ELECTIVE-I

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student will be able to Generalize the concept of stereo-chemistry and reaction pathway.
- COs2: Describe the stereo chemical and conformational structure of molecules.
- COs3: Chemical reactivity and on the mechanism of organic reaction.
- COs4: Students familiar with the basic concept of stereo chemistry, which will be used for further studies.
- COs5: Providing the knowledge and in depth understanding stereochemistry, it,s effect in synthesis, behaviour of chiral compounds and properties

1. **Isomerism of Organic Compounds**
   General introduction and classification of isomerism, entiomerism, measurement of optical activity, elements of symmetry and chirality of molecule, asymmetric and dissymmetric molecules.
2. **Aliphatic Nucleophilic Substitution**

Introduction of aliphatic nucleophilic substitution reaction.SN2 reaction mechanism and evidence.SN1 eaction, nucleophilic substitution of allylicsystems.SN1 and SN2 eactions. Rearrangement in allylic systems. Nucleophilic displacements at allylic Halides tosylates. Nucleophilic substitution at the benzylic position. Nucleophilic substitution of vinylic and aryl halides. The SNimechanism,mixed SN1and SN2 reactions. Ambidentnucleophiles, Regioselectivity, set mechanisms, neighboring group participation-Anchimer icassistance and others.

3. **Stereo Chemistry of Fused ring, bridge ring and Spirans**
   Introduction, trans-fused ring system, cis-fused ring system, spirocyclic ring system. Reactions with cyclic transition states.
4. **Stereo Selective and Stereo Regulator Polymerization.**
5. **Stereo Chemistry of N, S, P, As and B compounds.**

Reference Books

1. Organic Chemistry by I.L Finar.
2. Stereochemistry by J.P.Trivedi.
3. Stereochemistry by D.Nasipuri.
4. Stereochemistry of Organic Compounds by P.S.Kalsi (7th edition).
5. Stereochemistry of Organic Compounds byE.L.Elieil and S.H.Wilen(1994).
6. Principle of Asymmetric Synthesis by J.Aube and R.E.Gawely.
7. Stereochemistry by Dacid G. Morris (2001).
8. StereoselectiveSynthesis: A Practical Apporch by M.Nogardi, VCH.
9. Organic Chemistry Clayden, Graves, Warren, Wothers Edition 2001 Oxford University.

M. Sc. SEMESTER-IV
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-404:ADVANCED MEDICINAL CHEMISTRY
ELECTIVE-II

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Understand Drug metabolism and mechanism pathway.
- COs2: Recognize and comment on different synthetic strategies and methods for stereocontrol when faced with synthetic drugs.
- COs3: Understood different system of human body. Application of drug molecules.
- COs4: To learn theories and principle related to medicinal chemistry.
- COs5: To learn various nucleophilic, substitution and electrophilic reaction in organic chemistry for drug synthesis.

1. Introduction and Important terminology
2. Drug Design
   Fundamentals, techniques, concept of lead identification and lead modification SAR. Factors affecting biological activity. Resonance, inductive effect, Isosterism, bioisosterism and spatial consideration.
3. Pharmacokinetics
   ADME, prodrugs and polymorphism.

4. Pharmacodynamics
   Fundamentals, treatment of diseases by enzymes stimulation and inhibition, LDSO, MIC and MEC, etc.Theories of drug activity relationship.
5. Patents and IPR in drug discovery and development.
6. Combinatorial Chemistry
   Fundamentals methods, preparation study of targeted or focused libraries.
7. Recent updates in drug discovery (New Drugs).

Reference Books

1. Introducion to Medicinal Chemistry, AGringuage, Wiley-VCH.
2. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed Robert F. Dorge.
3. An Introduction of Drug Design, S,S. Pandey and J.R. Dimoock, New Age International
4. Burgers Medicinal and Drug Discovery, Sixth Edition, Ed. M. E. Wolff, John Wiley.
5. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill
6. The Organic Chemistry of Drug Design Action, R. B. Silverman, Academic Press.
7. Strategies for Organic Drug synthesis and Design, D. Ladnicer, John Wiley
8. Pharmaceutical Substances, Kleemann, Vol-I and II, Fourth edition, Thieme
9. Principles of Medicinal Chemistry, William Foye, Fourth edition, Lippincott,William and Wilkins.
10. Analytical Profile of Drug Substances (Series), Florey.
11. Erck Index, Thirteen edition, Merck and Co.
12. Total Synthesis of Natural Products, Apsimon (series).
13. Principles of Medicinal Chemistry by S. S. Kadam, Mahadik, Bothera, Nirali Publication, 11th edition.
14. Pharmacology and Pharmacotherapeutics by R. S. Satqskar, Bhandarkar, Popular Prakashan.
15. Bio Pharmaceutics and Pharmakinatics by Bhramankar, VallabhPrakashan

M. Sc. SEMESTER-IV
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-405:PRACTICALS/DISSERTATION

6 CREDITS
150 MARKS

Course Outcomes (COs):

- COs1: Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments.
- COs2: Students should be able to demonstrate considerable improvement in the following areas: In-depth knowledge of the chosen area of research.
- COs3: Competence in research design and planning.
- COs4: Capability to create, analyse and critically evaluate different technical solutions.
- COs5: Ability to conduct research independently. Ability to perform analytical techniques/ experimental methods.

1. Multistep preparations with TLC monitoring of following

a. Reduction
b. Partial Reduction
c. Oxidation
d. Nitration
e. Diazotization
f. Sulphonation
g. Methylation
h. Etherification
i. Use of PTC in organic synthesis
j. New reagents
2. Drug Analysis
3. Spectral analysis of synthesized compounds

M. Sc. SEMESTER-IV
ORGANIC-PHARMACEUTICAL CHEMISTRY
C(OP)-406:VIVA VOCE

2 CREDITS
50 MARKS

Theory based on C(OP)-401 to C(OP)-404 and practicals

M. Sc. SEMESTER-III
INORGANIC CHEMISTRY

C (I)-301: ADVANCE CHROMATOGRAPHIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student will be Capable to understand the range and theories of instrumental methods available for separation.

- COs2: Able to select appropriate techniques for the separation of complex mixture into their individual components.

- COs3: Expand skills in the scientific methods of planning, developing, conducting, reviewing techniques for separation and identification of compound in complex mixture.

- COs4: To study in detail the fundamental aspects of various Separation experimental and instrumental methods in chemistry.

1. Introduction, revision of various chromatographic techniques and terminologies.
2. Principle, theory, instrumentation and applications of GC, HPLC, UPLC and super critical fluid chromatographic techniques.
3. **Ion Chromatography:** Principle, theory, instrumentation and applications.

4. **Exclusion Chromatography:**

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

5. **Hyphenated techniques:** Principle, theory, instrumentation and applications of GC- MS, LC-MS, GC-IR, LC-NMR, etc.
6. **Planner chromatography:**

Paper chromatography, thin layer chromatography, and high performance thin layer chromatography: Principle, theory, instrumentation and applications.

Reference Books:

1. Chromatography by E. Heftman, 5th edition, part-A and B, Elsevier Science Publisher, 1992.
2. Instrumental Methods of Analysis by B. K. Sharma, Goel Publisher, Meerut.
3. Analytical chemistry by Gary D. Christian, 6th edition (1994) John Wiley and sons Inc. New York.
4. Fundamental of Analytical Chemistry 8thEdn. Saunders College Pub. 2001.
5. Analytical Chemistry by H. Kaur, PragatiPrakashan, Meerut.
6. Instrumental Methods of Chemical Analysis by Chatwal and Anand.
7. Standard Methods of Chemical Analysis by F. J. Welcher.
8. Introduction to Modern Liquid Chromatography: 2nd edition L. R. Snyder and J. J. Kirkland- John Wiley & Sons Inc.
9. Analytical Methods in Chemistry by Y. R. Sharma.
10. Analytical chemistry by Open learning second edi. (Vol. 1-30) Wiley India Edi.
11. B. L. Karger, L. R. Snyder and C. Howarth, An Introduction to Separation Science, 2nd edition (1973), John Wiley, New York.

M. Sc. SEMESTER-III
INORGANIC CHEMISTRY

C (I)-302: MOLECULAR SYMMETRY AND GROUP THEORY

4 CREDITS

100 MARKS

Course Outcomes (COs):

- COs1: Symmetry and point group is essential part of inorganic chemistry for determination of molecular structure, stereochemistry of molecule, chemical bond determination, and isomerism.

- COs2: Strong field and weak filed determination for co-ordination chemistry and practical application pH metry and spectrophotometer and also for determination of energy of molecule.

➢ COs3: The fundamental and advanced concepts of molecular shape of molecule and symmetry, and symmetry element and operation as well as concept of group theory.

1. Molecular Symmetry

Concept of Symmetry in Molecules

Symmetry elements and symmetry operations.

Group Theory

Molecular Point Groups: Definitions of group, subgroups, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group. **Matrix Methods in Symmetry:** Representations of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, D_{nh} etc. groups to be worked out explicitly). Character of a representation. The great orthogonality theorem and its importance. Character tables and their use in chemical bonding, Molecular orbital theory and hybridization.

IR and Raman Spectroscopy of Molecules: Application of group theory to Vibrational spectroscopy, symmetry and shapes of AB_2, AB_3, AB_4, AB_5, and AB_6. Applications of resonance to Raman and IR spectroscopy.

2. Strong field and Weak Field Approximation

Derivation of sine formula.

Weak Field Approximation: Splitting of the free ion terms of d^2 in an octahedral field, calculation of the energy of various terms in weak field approximation: $^3A_{2g}$, $^3T_{2g}$ and $^3T_{1g}$ derived from $^3F(d^2)$ and ^1E_g and $^1T_{2g}$ derived from ^1D in an Oh field. **Strong Field Approximation:** Determining multiplicities by the method of descending symmetry. Calculation of energy of various terms within the frame-work of strong field approximation.

Reference Books

1. Chemical Application Of Group Theory, F. A. Cotton,W E S Wiely.
2. Introduction to Ligand Field, B.N.Figgis, Inc. New York.
3. Coordination Compounds, S. F. A. Kettle, ELBS.
4. Introduction to Ligand Field Theory, Bell Hausen, McGraw Hill.
5. Group Theory and Its Application to Chemistry, K. V. Raman, Tata McGraw Hill.

M. Sc. SEMESTER-III
INORGANIC CHEMISTRY

C (I)-303: ADVANCE BIOINORGANIC CHEMISTRY

4 CREDITS

100 MARKS

Course Outcomes (COs):

- COs1: Student teaches about metal ion role in human biological system of calcium channel and sodium channel pump.

- COs2: Metalloenzymes role in metabolic function with enzyme base process.

- COs3: Redox Metalloenzymes for cytochrome system and their role in photo synthesis process, and coordination compound and their function and their application in inorganic medicinal drugs for different medical

- COs4: Metal ion role in transportation and storage and metal base enzyme and their role in biological system. Photosynthesis process in plant.

- COs5: Coordination Compound and their role in medicinal filed.

1. **Metal ion Transport and Storage:** Storage and transport of alkali and alkaline earth metals, ionophores, Na/K (sodium/potassium) pump, calcium pump. Scheme for (Ca^{2+}, Mg^{2+})-ATPase.

Storage and Transport of Iron

Ferritin and transferrin. Transport and storage of iron in plants, storage of iron in microbes.

2. **Metalloenzymes**

Mechanism of enzyme action, role of metal ions in catalysis.Kinetics of enzyme catalysis. The chemistry of vitamin B12: Adenosylcobalmin and cynocobalmin (Vitamin -B12), absorption, transport and metabolic function of vitamin B12.

Nitrogen Fixation and Iron-sulphur Proteins: Nitrogen cycle and its fixation, iron-sulphur, 1Fe-S, 2Fe-2S, 4fe-4S proteins.

3. **Redox Metalloenzymes**

Cytochromes electron carriers, classification of cytochromes, cytochromes *c*, Cytochromes *b*, cytochromes P-450.

4. **Photosynthesis**

Photoredox and non-protein metallobiomolecules: Chlorophyll, photosynthesis, light reaction, dark reaction: The Calvin cycle.

5. **Coordination Compounds in Medicine**

Metals and its Complexes as Therapeutic Agents: General Remarks, anticancer drugs (platinum complexes) antiarthritis drugs (gold, copper and their complexes).

Reference Books

1. The Inorganic Chemistry of Biological Processes, M. N. Hughes, John Wiley & Sons.
2. Bioinorganic Chemistry, G. R. Chatwal and A. K. Bhagi, Himalaya Publishing House.
3. Advance Inorganic Chemistry, Cotton & Wilkinson, Weily Elsevier.
4. Principle of Bioinorganic Chemistry, S. J. Lippard and J. M. Berg, Uni. Science Books.
5. Inorganic Biochemistry Vols. I and II ed., G. L. Eichhorn, Elsevier.

M. Sc. SEMESTER-III
INORGANIC CHEMISTRY

C (I)-304: ORGANOMETALLIC COMPOUNDS AND CATALYSIS (ELECTIVE-I)

4 CREDITS

100 MARKS

Course Outcomes (COs):

- COs1: Introduction of organometallic type of compound and their synthesis and application in different filed of chemical synthesis.
- COs2: Student learns catalyst synthesis and their type and industrial application and uses in hydro formylation reactions.
- COs3: Oxidative addition, reductive elimination, insertion and des-insertion reactions. And help full for new route of targeted and efficient synthesis with minimum time and maximum yield.

1. Organometallic Compounds

Introduction and nature of bonding in organometallic compounds of transition metals. π -bonded organ metallic compounds. Introduction and classification of π bonded organometallic compounds of transition metals. Preparative methods, typical Reactions and applications of η4-cyclobutadyne complexes, η5-cyclpentadynyl d-block Metal complexes, fluxional organometallic compounds.

2. Catalysis

Homogeneous and heterogeneous catalysis involving metal complexes and organometallic compounds. Hydrogenation and hydro formylation reactions. Oxidative Addition, reductive elimination, insertion and des-insertion reactions.

Metal complexes in enantioselective synthesis

Asymmetric hydrogenation and oxidation of alkenes, catalyst characterization, Kinetics and application of these reactions. Catalyst development and mechanistic Aspects of Zeigler –

Natta catalysis, Fischer–Tropsch synthesis, water–gas shift Reaction, Wacker process, monsanto process. Phase transfer and micellar catalysis. Principles of Green Chemistry and role of catalysis – concept of atom economy, E Factors and atom efficiency, typical examples of atom economic reactions and atom Un-economic reactions, some specific examples of chemical routes developed using Catalysts.

Reference Books

1. Advance Inorganic Chemistry, Cotton & Wilkinson, Weily Elsevier.
2. Inorganic Polymers, Chatwal, Himalya Publishing.
3. Organometallic Chemistry, R. C. Mehrotra and A. Singh, New Age International.
4. Principle and Application OfOrganotransition Metal Chemistry, Collman, Uni. Sci. Book.
5. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley.
6. Metallo-Organic Chemistry, A. J. Pearson, Wiley.

M. Sc. SEMESTER-III
INORGANIC CHEMISTRY
C (I)-304: SELECTED TOPICS IN INORGANIC CHEMISTRY
(ELECTIVE-II)

4 CREDITS

100 MARKS

Course Outcomes (COs):

- COs1: Student learns about inorganic polymer and their synthesis and industrial application.
- COs2: Human body and metal base enzyme and their function.
- COs3: Organometallic Compounds in radiopharmaceuticals, tracers, ionphorse and sensors with application.

1. Inorganic Chemistry of Chains, Rings and Cages

Chains: Catenation, heterocatenation, zeolites, inseralation chemistry, one- dimensional conductors.

Rings: Borazines, phosphazenes (synthesis, bonding and reaction). Phosphazene polymers and homocyclic inorganic systems.

Cage compounds having phosphorus oxygen, nitrogen and sulphur (structure and bonding). Borane cages, boranes, $B_{12}H_{12}$ and other boranes derived from $B_{12}H_{12}$, structure relationship of closo, nido, archano and hypo boranes, carboranes, metallacarboranes, structure prediction of heterocarboranes.

2. Inorganic Chemistry of Biological system

Introduction, energy sources for life, non-photosynthetic processes, metalloporphyrins, cytochromes, iron porphyrins biomolecules. Structure and function of hemoglobin, Function of chlorophyll, structure and function of hemoglobin. Other iron-porphyrin biomolecules, peroxides and catalases, cytochrome P450 enzymes, other natural oxygen carriers, hemerythrins, electro transfer, respiration and photosynthesis; ferridoxins, and subredonim carboxypeptidase, carbonic anhydrase, metallathioneins. Blue copper proteins, superoxide dismutase hemocyanines photosynthesis, chlorophyll and photosynthetic reaction center.

3. Enzymes

Structure and function, inhibition and poisoning Vitamin B12 and B12 coenzymes metallothioneins, nitrogen fixation, in-vitro and in vivo nitrogen fixation, bio- inorganic chemistry of Mo and W, nitrogenases: other elements V, Cr, Ni (essential and trace elements in biological systems). Correnoid dependent enzymetic reaction, Vitamin B12 model compounds.

4. Organometallic CompoundS in Pharmaceuticals: Organometallic compounds as radiopharmaceuticals, tracers, ionphorse and sensors

Reference Books

1. J. E. Huheey, E. A. Keiter and R. L. Kieter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edition, Haper Collins.
2. B. Douglas, D. McDaniel and J. Alexzander, Concepts and Model of Inorganic Chemistry, 3rd Edition, John Wiley and Sons.
3. F.A.Cotton and G. Wilkinson, Advanced Inorganic Chemistry: A Comprehensive Text, 5th Edition, John Wiely.
4. Ch, Elschenbroich and A. Salzer, Organimetallics, A Concise Introduction, Second Edition, Wiley-VCH.
5. D.F.Shriver and P.W. Atkins, Inorganic Chemistry, 3rd Edition Oxford University, Press.
6. J.A.Cowan, Inorganic Biochemistry, 2nd Edition, Wiley – VCH.
7. G.Wulfsberg, Inorganic Chemistry, University Science Books.

M. Sc. SEMESTER-III
INORGANIC CHEMISTRY

C (I)-305: PRACTICALS

6 CREDITS
150 MARKS

Course Outcomes (COs):

- COs1: Student learned about metal determination with percentage and composition with other metal with Quantitative, Qualitative Spectrophotometric analysis and water contain cations and anion and hardness of water.

➢ COs2: Introduction of different inorganic analysis procedure for metal and metal composition analysis by Quantitative and Qualitative as well as Spectrophotometric analysis method, water analysis of cations and Anion.

1. **Ore and Alloy Analysis**
    a. Dolomite
    b. Magnesite
    c. Calcite
    d. Brass
    e. Bronze
    f. Steel
    g. German Silver
    h. Steel
    i. Hematite
2. **Determination of composition and stability constant by various methods:**
    a. Job's method of continuous variations.
    b. Mole-ratio method.
    c. Slope-ratio method
3. **Water Analysis**

Identification and determination of some cations and anions like

Chloride
Sulphate
3-Nitrate
Carbonate
Bicarbonate
Calciam
Magnesium
COD
Total hardness
pH measurement
Conductivity measurement

Reference Books

1. Vogel's Qualitative Inorganic Analysis, G. Svehla ,Orient Longman.
2. Advance Inorganic Analysis, Subhash-Satish, Pragati-Prakashan.
3. Text book of Quantitative Inorganic Analysis, Vogel's, ELBS.
4. Inorganic Preparation, J. Palmar, Willy.
5. Fundamental of Analytical Chemistry, Skoog and West, Holt,Rinehart And Winston Inc.
6. Environmental Chemistry, A. K. De , Wiley Eastern.

M. Sc. SEMESTER-III
INORGANIC CHEMISTRY

C (I)-306: VIVA VOCE

2 CREDITS
50 MARKS

Based on theory (C-101 to C104) and practicals

M. Sc. SEMESTER-IV
INORGANIC CHEMISTRY

C (I)-401: ADVANCE SPECTROSCOPIC TECHNIQUES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Apply NMR, IR, MS, UV-Vis spectroscopic techniques in solving structure of organic molecules to determination of stereochemistry of unknown molecules.
- COs2: Interpret the above spectroscopic data of unknown compounds.
- COs3: Use these spectroscopic techniques in their research.

1. **Ultraviolet Photoelectron Spectroscopy**: An overview, theory and applications of UV-spectroscopy.
2. **Electron Paramagnetic Resonance Spectroscopy:** Introduction, theory, instrumentation, spin-spin coupling, qualitative and quantitative analysis, multiple resonance, spin labelling, metallic complexes and other uses of EPR spectroscopy.
3. **^{1}HNMR Spectroscopy:** Overview of NMR spectroscopy, spin-spin interaction and nomenclature, non 1^{st} order to 1^{st}order spectrum, applications of coupling constants. 2D NMR technique.Multinuclear NMR spectroscopy and its applications.
4. **^{13}C NMR spectroscopy:** Comparison between ^{1}H and ^{13}C NMR spectroscopy, factors affecting ^{13}C NMR chemical shifts and identification of various organic molecules with coupling, decoupling, off resonance, etc.
5. **Vibrational and Rotational Spectroscopy**
   g. NIR: Principle, instrumentation and applications.
   h. Raman spectroscopy: Principle, theory, instrumentation and applications.
6. **Mass spectroscopy:** Principle, theory, instrumentation, fragmentation and applications.

Reference Books

1. Understanding NMR-Spectroscopy (2nd Edition), Wiley Publisher by James Keeler.
2. Spectroscopy by H. Kaur, PragatiPrakashan
3. Text book of spectroscopy by Jyotikumar, Sonali publication.
4. Analytical Spectroscopy by James Very, Pacific Book Int.
5. NMR Spectroscopy by Harald Gunther Wiley.
6. Handbook of Instrumental Techniques for Analytical Chemistry by F. Settle Pearson Edu.
7. Introduction to Spectroscopy (3rd Edition) by Pavia LampmanKriz: Cengage.
8. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal & Sham K. Anand, Hiamalaya Publishing House.
9. Spectroscopy of Organic Copmpounds, P.S. Kalsi, New Age International Ltd.
10. Analytical Spectroscopy by James Vergeese.
11. Organic Spectroscopy by William Kemp.
12. Spectrometric Identification of Organic Compounds. (6th Edition) by Robert M. Silverstein & Francis X. Webster, Wiley.
13. Organic Spectroscopy: Principles and Applications, 2nd Edition by Jag Mohan, Alpha Science International Ltd., Harrow U. K.

M. Sc. SEMESTER-IV
INORGANIC CHEMISTRY

C (I)-402: INORGANIC SPECTROSCOPY

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student learned about spectral analysis of inorganic compound especially metal complexes. Application of Inorganic spectroscopy for determination of their structure.

- COs2: Inorganic spectroscopy is powerful tool for various analysis of metallic compound and their structure determination.

1. Nuclear-Quadrupole Resonance

Introduction, origin of transition and experimental techniques. Towne's and Dailey's formula, structural information from NQR illustrated by suitable examples.

2. Nuclear Magnetic Resonance

NMR studies of nuclei such as ^{19}F , ^{11}B and ^{31}P applications in inorganic complexes and shift reagents.

3. Electron Spin Resonance

Interaction between electron and spin and magnetic field, ESR technique, relaxation process and line width in ESR transition, hyperfine structure in ESR, zero field splitting, Kramer's degeneracy. Determination of 'g' and factors affecting it. Isotropic and anisotropic 'g' values, measurement techniques and applications of ESR measurements.

4. Photoelectron Spectroscopy

Basic principles, experimental method, ionisation process and Koopman's Theorem.Photoelectric spectra and their interpretation for simple molecules.Ultraviolate photoelectron spectra of atoms, Ultraviolate photoelectron spectra of molecules.Basic idea of Auger electron spectroscopy.

Reference Books

1. Physical Methods in Chemistry, R. S. Drago, Saunders College.
2. Introduction to Molecular Spectroscopy, G. M. Barrow, McGraw Hill.
3. Introduction to Magnetic Resonance, Carrington and Maclachalan, Harper &Row
4. Modern Spectroscopy, J.M.Hollas,John Wiley
5. Introduction to Molecular Spectroscopy, G.M.Barrow, McGraw Hill.
6. Structural Methods in Inorganic Chemistry, Ebsworth& Rankin, ELBS.
7. Introduction to Photoelectron Spectroscopy, P. K.Ghosh, John Wiley

M. Sc. SEMESTER-IV
INORGANIC CHEMISTRY

C (I)-403: BONDING IN COMPLEXES

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student learned about Crystal Field Theory (CFT) is a model for

the bonding interaction between transition metals and ligands.

➢ COs2: The electrons in the d orbitals of the central metal ion and those in the ligand repel each other due to repulsion between like charges.

➢ COs3: To impart concept of Crystal Field Theory.

1. **Theoretical Principles of Crystal Field Theory**
   Brief introduction to spherical harmonics. The shape of d-orbitals, Derivation of crystal field potential for the tetragonal, cubic and square planar arrangement of ligands around metal ion.Transformation of these potential from Cartesian to spherical harmonics.

2. **Effect of V(oct) and d^1 System**
   (i) Evaluation of the various integral involved.
   (ii) Solution of the secular determinant to obtain energies and corresponding wave functions.
   (iii) Crystal field splitting diagram for Oh, Td, square planar systems. Simple applications of CFSE.

3. **Electronic Spectra and Magnetic Properties of Transition Metal Complexes** Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states),calculations of Dq, B and β parameters, charge transfer spectra. Spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereo chemical information. Anomalous magnetic moments, magnetic exchange coupling and spin crossover. Determination of the function (L, M_ℓ, S, M_S) corresponding to the terms ^3F, ^3P, ^1G, ^1P and ^1S obtained from d^2 system by R. S. coupling.

Reference Books

1. Chemical Application of Group Theory, F. A. Cotton, W E S Wiely.
2. Advanced Inorganic Chemistry, Cotton Wilkinson, W S E Wiley.
3. Introduction to Ligand Field, B. N. Figgis, Inc. New York.
4. Coordination Compounds, S. F. A. Kettle, ELBS.
5. Introduction to Ligand Field Theory, BellHausen, McGraw Hill.
6. Inorganic Reaction Mechanism, J.O. Edwards, Benjamin.
7. Mechanism of Inorganic Reactions, F. Basolo and R. G. Pearson, Wiley New York.

M. Sc. SEMESTER-IV
INORGANIC CHEMISTRY
C(I)-404:COORDINATION CHEMISTRY

ECTIVE-I

4 CREDITS

100 MARKS

Course Outcomes (COs):

- COs1: Student learned about concept of Coordination Chemistry and Metal Ligands interaction their coordination and application of Coordination bonding to design and synthesis of new ligands and new metal complexes.

- COs2: Student learned about shape and some geometrical information by coordination chemistry and their application toward in industrial approach and some synthesis of catalyst.

- COs3: To impart knowledge of transition metal complexes and its application for synthetic area in inorganic and organic chemistry

1. **Reaction Mechanism of Transition Metal Complexes**

Substitution reaction of octahedral complexes: The nature of substitution reaction, Theoretical approach to substitution mechanism. Nucleophilic reactivity and nature of central atom.Kinetic application of crystal field theory. Substitution reaction of Co(III) complexes, replacement of co-ordinated water. Acid catalysis.

2. **Stereochemical changes in Octahedral Complexes**

Molecular rearrangement in complexes.Reactions of geometrical and optical isomers.Isomerization and racemization of octahedral complex.Ligand stereospecificity.

3. **Substitution Reaction of Square-Planar Complexes**

Trans effect and its theories. Mechanism of substitution reaction of Platinum (II) complexes.

4. **Oxidation-Reduction Reaction**

Outer sphere mechanism, inner sphere mechanism, and two electron transfer. Application to synthesis of coordination compounds.

5. **Complex Equilibria**

Introduction, computation of stability constant from equilibrium data.Basic principle, Mathematical functions and their interrelationships.

6. **Method of Computing Stability Constant**

Method based on half integral n values, correction method, graphical method and numerical method.. Experimental determination of composition and stability: Spectroscopic methods, methods of continuous variations, pH-metric Irving-Rossotti method.

Reference Books

1. Coordination Chemistry, D. Benerjia, Tata McGraw Hill.
2. Mechanism of Inorganic Reactions, F.Basolo and R. G. Pearson, Wiley New York.
3. Determination of Stability constants, Rossotti and Rassotti.
4. The Mechanisms of Reactions at Transition Metal Sites, Richard A.. Henderson, Oxford
5. Inorganic Reaction Mechanism, J.O. Edwards, Benjamin.
6. Chemistry of Complex Equilibria, T. M. Beck.
7. Chemistry of Metal Chelate Compounds, Martell and Calvin, John Wiley & Sons

M. Sc. SEMESTER-IV
INORGANIC CHEMISTRY

C (I)-404: CATALYSIS ELECTIVE-II

4 CREDITS
100 MARKS

Course Outcomes (COs):

- COs1: Student learned about concept of organometallic chemistry and their application in industrial approach and some synthesis of organic compound using organometallic compound as catalyst.

- COs2: To impart concepts in organometallic chemistry, and their application, and type of catalyst and catalysis process in chemistry synthesis of organic compound using organometallic complexes as catalyst.

1. Application of Organometallic Complex to Catalysis

a. Fundamental processes in reaction of organo-transition metal complex
Ligand coordination and dissociation, oxidative addition/reductive elimination including cyclometallation reaction. Insertion/Extrision, reaction of coordination ligands.

b. Characteristics of transition metal complexes catalyst
Mild condition and high selectivity homogeneous and heterogeneous catalysis. Polymerization and oligomerization of olefins and dienes.

c. Synthesis using carbon monoxide
Hydroformylation reaction, carboxylation of olefins, carbonylation of methanol, synthesis of oxalates, reaction, of synthesis gas.

d. Oxidation of reaction
Oxidation of olefins by Wacker process, acetoxlation of olefins, synthesis of arcylates and related derivatives, olefins epoxidation, olefin metathesis.

2. Organic Synthesis Using Transition Metal Complexes

a. Hydrogenation and related reactions, basic concept of olefin hydrogenation, asymmetric hydrogenation, hydro-silyation, hydrocyanation, isomerisation of olefins.
b. C-C bond formation: C-C coupling combing oxidation addition, alkylation and reductive elimination, C-C coupling utilizing oxidative addition combined with CO insertion, combination, of olefin insertion, hydrogen transfer and oxidative addition of organic halides.
c. Synthesis utilizing nucleophilic attack on coordinated ligands: reaction of coordinated olefins, synthesis and reactivity of coordinated allyl ligands, synthesis using C-H bond activation, synthesis utilizing oxidation addition and decarbonylate synthesis utilizing inseration and alkyl transfer, cyclopropanation reaction.
d. Electrophilic attack on the coordinated ligands, electrophilic cleavage of M-C organocobalt complex.
e. Stoichiometric reactions utilizing transition metal complexes: organocopper, organocobalt complexes.

Reference Books

1. F.A.Cotton and G. Wilkinson, Advanced Inorganic Chemistry, John Wiley and sons.
2. J.E.Huheey, Inorganic Chemistry, Harper International.
3. M.N. Greenwood and A. Earnshaw, chemistry of the Elements, Pergramon Press.
4. Ch, Elschenbroich A. Salzer, Organometallic; A concise Introduction Chemistry: VCH.
5. D.F.Shriver, Inorganic Chemistry, Oxford Press

M. Sc. SEMESTER-IV
INORGANIC CHEMISTRY

C (I)-405: PRACTICALS/DISSERTATION

6 CREDITS
150 MARKS

Course Outcomes (COs):

- COs1: Student learned about concept of inorganic qualitative analysis and synthetic approach for preparation of some inorganic compound and their separation by chromatographic technique and flame photometric determination and pH metry analysis for inorganic compound.

- COs2: To impart concepts of Qualitative analysis as well as Preparation of

metal complexes and various chromatographic separation technique.

1. **Inorganic Qualitative Analysis**

Analysis of a mixture containing Eight radicals including one less common metal ions: W, Tl, Ti, Mo, Se, Zr, Th, Ce, V, Li.

Minimum 15 mixtures containing inorganic salts like $CuSO_4$, KBr , TiO_2 , KI, Na_2CrO_4, $CaCO_3$, $Zr(NO_3)_3$, $NaNO_3$, ZnS, Na_2SO_4, SeO_2, NaCl, K_2SO_4 , $(NH_4)_2SO_4$, $(NH_4)_2MoO_4$, $BaCl_2$, $ZnCO_3$, $Al_2(SO_4)_3$, V_2O_5, ZnS, $Ni(NO_3)_2$, KNO_2, $Th(NO_3)_3$, KCl, $CdCO_3$, $CuCl_2$, $LiCO_3$, K_2SO_4, $AlPO_4$, H_3BO_3, $(NH_4)_2SO_4$, $CeSO_4$, $CdCl_2$, $Th(NO_3)_3$, $NaNO_3$, $ZnCO_3$, $AlPO_4$, $LiCO_3$, $Pb(NO_3)_2$, $NaNO_2$, $Zr(NO_3)_3$, Na_2WO_4, $MnSO_4$, $NaHSO_3$, SeO_2, K_2CrO_4, $FeSO_4$, $(NH_4)_2SO_4$, $(NH_4)_2MoO_4$, Na_3AsO_3, Na_3AsO_4, $(NH_4)_2SO_4$, K_2SO_4, $CeSO_4$, As_2O_3, NH_4Cl, $NiSO_4$, $LiCO_3$, $MgCO_3$, $NaNO_2$, $Mg_3(PO_4)_2$, V_2O_5, H_3BO_3, $SrCO_3$, $Th(NO_3)_3$, Na_3AsO_3, Na_3AsO_4, $BaCO_3$, $LiCO_3$.

2. **Preparations and Characterization of Inorganic Compounds**

Preparation of selected inorganic compounds, their estimation and characterization by usual methods.

a. Cu (α – Benzoin oxime)

b. $Ni(DMG)_2$

c. Fe (Cupfferon)

d. Prussian Blue-$Fe_4[Fe(CN)_6]_3$

3. **Chromatographic Separation**

a. Paper Chromatography-circular and ascending

1. Zn^{++}, Mn^{++} and Co^{++}
2. Ag^{++}, Hg^{++} and Pb^{++}
3. Ni^{++}, Cu^{++}, and Co^{++}

b. Column Chromatography- Ion exchange

1. Zn^{++} and Mg^{++}
2. Co^{++} and Ni^{++}
3. Cl^- and Br^-
4. Zn^{++} and Cd^{++}

c. Thin-layer chromatography –

1. Fe^{++} and Al^{++}
2. Cu^{++} and Ni^{++}

4. **Flame Photometric Determination**
   1. Sodium and potassium when present together,
   2. Lithium/ Calcium

5. **pH metry**

Determination of stability constant of complexes by pH-metry method

1. Cu(II)- salicylaldehyde

2. Ni(II) – salicylaldehyde

Reference Books

1. Inorganic Reaction Mechanism, J. O. Edwards, Benjamin.
2. Mechanism of Inorganic Reactions, F. Basolo and R. G. Pearson, Wiley New York.
3. Fundamental of Analytical Chemistry, Skoog and West, Holt, Rinehart and Winston Inc.
4. Text Book of Quantitative Inorganic Analysis, Vogel's, ELBS.

M. Sc. SEMESTER-IV
INORGANIC CHEMISTRY

C (I)-406: VIVA VOCE

2 CREDITS
50 MARKS

Theory based on C (I)-402 to C(I)-404 and practicals