

CURRICULUM OF CHEMISTRY

MSc Program (2-Year, 4-Semester)



Department of Chemistry
Shaheed Benazir Bhutto Women University
Peshawar

SCHEME OF STUDIES
(Session 2019 onward)

	Course Code	Course Title	Credit Hours
Semester-I	CHM-511	Analytical Chemistry-I	3 (2 + 1)
	CHM-512	Inorganic Chemistry-I	3 (2 + 1)
	CHM-513	Organic Chemistry-I	4 (3 + 1)
	CHM-514	Physical Chemistry-I	4 (3 + 1)
	MTH-506	Basic Mathematics for Chemistry	2 (2 + 0)
	FENG-510	Functional English-I	2 (2 + 0)
Total:			18
Semester-II	CHM-515	Analytical Chemistry-II	3 (2 + 1)
	CHM-516	Inorganic Chemistry-II	3 (2 + 1)
	CHM-517	Organic Chemistry-II	4 (3 + 1)
	CHM-518	Physical Chemistry-II	4 (3 + 1)
	CHM-519	Industrial Chemistry	2 (2 + 0)
	FENG-520	Functional English-II	2 (2 + 0)
Total:			18

Specialization
(Analytical/Inorganic/Organic/Physical
Chemistry)

Analytical Chemistry

Semester – III & IV		
CHM-610	Environmental Chemistry (compulsory)	3
CHMA-611	Atomic Spectroscopy	3
CHMA-612	Electroanalytical Techniques	3
CHMA-613	Advanced Separation Techniques	3
CHMA-614	Thermal Methods of Analysis	2
CHMA-615	Nuclear Analytical Techniques	2
CHMA-616	Food and Drug Analysis	2
CHMA-617	Principles and Applications of Molecular Spectrophotometry	3
CHMA-618	Luminescence Spectroscopy	2
CHMA-619	Advanced Spectroscopy	2
CHMA-620	Bioanalytical Chemistry	2
*CHMA-621 Or *CHMA-699	Analytical Chemistry Laboratory-III Or Thesis/Research Project in Analytical Chemistry	3

*CHMA-622 Or *CHMA-699	Advanced Analytical Chemistry Laboratory Or Thesis/Research Project in Analytical Chemistry	3
Total:		33

Note:- Five (05) courses containing 12 credits will be offered in each semester that consist of three (03) theory courses of 2 credits each and two (02) theory courses of 3 credits each. One (01) practical course of 3 credits or thesis/research project of 3 credits will also be offered in each semester. One (01) compulsory theory course CHM-600 (Environmental Chemistry) of 3 credits will be offered only in the third semester in addition to five (05) other theory courses. Total 18 credit hours will be taught in the third semester and 15 credit hours in the fourth semester.

**Thesis/Research Project, if chosen, will be of 06 credit hours i.e., 03 credit hours in each semester (semester III and semester IV).*

Inorganic Chemistry

Semester – III & IV		
CHM-610	Environmental Chemistry (compulsory)	3
CHMI-611	Molecular Spectroscopy	3
CHMI-612	Organometallic Chemistry	2
CHMI-613	Crystallography	3
CHMI-614	Inorganic Polymers	2
CHMI-615	Elementary Group Theory	2
CHMI-616	Separation Techniques	2
CHMI-617	Nuclear and Radiochemistry	2
CHMI-618	Coordination Chemistry	3
CHMI-619	Bio-coordination Chemistry	2
CHMI-620	Aqueous and Non-aqueous Solvents	2
CHMI-621	Physical Methods in Inorganic Chemistry	3
CHMI-622 Or CHMI-699	Inorganic Chemistry Laboratory-III Or Thesis/Research Project in Inorganic Chemistry	3
CHMI-623 Or CHMI-699	Advanced Inorganic Chemistry Laboratory Or Thesis/Research Project in Inorganic Chemistry	3
Total:		35

Note:- Five (05) courses containing 12 credits will be offered in each semester that consist of three (03) theory courses of 2 credits each and two (02) theory courses of 3 credits each. One (01) practical course of 3 credits or thesis/research project of 3 credits will also be offered in each semester. One (01) compulsory theory course CHM-600 (Environmental Chemistry) of 3 credits will be offered only in the third semester in addition to five (05) other theory courses. Total 18 credit hours will be taught in the third semester and 15 credit hours in the fourth semester.

**Thesis/Research Project, if chosen, will be of 06 credit hours i.e., 03 credit hours in each semester (semester III and semester IV).*

Organic Chemistry

Semester – III & IV		
CHM-610	Environmental Chemistry (compulsory)	3
CHMO-611	Chemistry of Heterocycles	2
CHMO-612	Reaction Mechanism-I	3
CHMO-613	Spectroscopic Methods in Organic Chemistry-I	2
CHMO-614	Chemistry of Natural Products	3
CHMO-615	Name Reactions	2
CHMO-616	Introduction to Polymer Chemistry	3
CHMO-617	Reaction Mechanism-II	3
CHMO-618	Stereochemistry	3
CHMO-619	Retrosynthesis	2
CHMO-620	Quantum Organic Chemistry	2
CHMO-621	Spectroscopic Methods in Organic Chemistry-II	3
CHMO-622	Extraction and Separation Methods in Organic Chemistry	2
*CHMO-623 Or *CHMO-699	Organic Chemistry Laboratory-III Or Thesis/Research Project in Organic Chemistry	3
*CHMO-624 Or *CHMO-699	Advanced Organic Chemistry Laboratory Or Thesis/Research Project in Organic Chemistry	3
Total:		39

Note:- Five (05) courses containing 12 credits will be offered in each semester that consist of three (03) theory courses of 2 credits each and two (02) theory courses of 3 credits each. One (01) practical course of 3 credits or thesis/research project of 3 credits will also be offered in each semester. One (01) compulsory theory course CHM-600 (Environmental Chemistry) of 3 credits will be offered only in the third semester in addition to five (05) other theory courses. Total 18 credit hours will be taught in the third semester and 15 credit hours in the fourth semester.

**Thesis/Research Project, if chosen, will be of 06 credit hours i.e., 03 credit hours in each semester (semester III and semester IV).*

Physical Chemistry

Semester – III & IV		
CHM-610	Environmental Chemistry (compulsory)	3
CHMP-611	Polymer Chemistry	2
CHMP-612	Molecular Spectroscopy	3
CHMP-613	Chemical Kinetics	3
CHMP-614	Solid State Chemistry	2
CHMP-615	Electrochemistry	2
CHMP-616	Surface Chemistry	2
CHMP-617	Chemical Thermodynamics	3
CHMP-618	Solution Chemistry	2

CHMP-619	Colloids and Surfactants	2
CHMP-620	Quantum Chemistry	3
CHMP-621	Statistical Mechanics	2
*CHMP-622 Or *CHMP-699	Physical Chemistry Laboratory-III Or Thesis/Research Project in Physical Chemistry	3
*CHMP-623 Or *CHMP-699	Advanced Physical Chemistry Laboratory Or Thesis/Research Project in Physical Chemistry	3
Total:		35

Note:- Five (05) courses containing 12 credits will be offered in each semester that consist of three (03) theory courses of 2 credits each and two (02) theory courses of 3 credits each. One (01) practical course of 3 credits or thesis/research project of 3 credits will also be offered in each semester. One (01) compulsory theory course CHM-600 (Environmental Chemistry) of 3 credits will be offered only in the third semester in addition to five (05) other theory courses. Total 18 credit hours will be taught in the third semester and 15 credit hours in the fourth semester.

****Thesis/Research Project, if chosen, will be of 06 credit hours i.e., 03 credit hours in each semester (semester III and semester IV).***

Details of M.Sc. Courses (Chemistry)

MSc-1st Semester

CHM-511 Analytical Chemistry-I (Cr. 2)

Introduction: Importance, application, growth of analytical chemistry. **Analytical Sampling:** Analytical data, data handling, statistical treatment of data. **Stoichiometry:** Stoichiometric calculations, chemical reactions. Concept of mole. **Chemical Equilibrium:** Law of mass action, degree of dissociations, theoretical principles, acid-base equilibria, solubility equilibria, complexation equilibria. **Quantitative Analytical Methods:** Potentiometry, Conductometry, instrumentation, application.

Recommended Books

1. G.D. Christian, *Analytical Chemistry*, 6th ed., John Wiley & Sons Ltd., Singapore (2003).
2. D. Harvey, *Modern Analytical Chemistry*, McGraw-Hill Companies Inc. (2000).
3. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Thomson Books/Cole, Belmont, USA (2004).

Supplementary Books

1. D.C. Harris, *Quantitative Chemical Analysis*, 5th ed., W.H. Freeman Company, New York (1999).
2. R. Kellner, J.M. Mermet, M. Otto, M. Valcarcel and H.M. Widmer, *Analytical Chemistry*, 2nd ed., Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2004).
3. J. Mendham, R.C. Denney, J.D. Barnes, and M. Thomas, *Vogel's Textbook of Quantitative Analysis*, 6th ed., Pearson Education Ltd. (2000).
4. R.B. Fischer, D.C. Peters, *Basic theory and concepts of Quantitative Chemical Analysis*, W.B. Saunders Company (1986).

CHM-511 Analytical Chemistry Laboratory-I (Cr. 1)

Note:- Out of thirteen any ten experiments would be conducted.

1. To determine the exact weights of materials and to analyze replicate measurements statistically.
2. To calibrate volumetric apparatus and to investigate errors in delivered volume.

3. To determine the concentration of a strong acid solution by conductometric titration.
4. To determine the individual concentration of the acids in the given binary mixture of a strong/weak acid conductometrically.
5. To evaluate K_{sp} for lead iodate by conductance method.
6. To determine solubility product of cadmium iodate titrimetrically.
7. To establish the constancy of the solubility product.
8. To estimate Ca^{2+} and Mg^{2+} concentration in drinking water by EDTA complexometric titration method.
9. To determine concentration of a strong acid potentiometrically using first and second derivative methods.
10. To determine pK_a for the given set of weak acids by the potentiometric method.
11. To show independence of solubility on amount of undissolved species.
12. To establish the stoichiometric relation for the precipitation of silver chloride.
13. To prepare a buffer solution and study its buffering capacity.

Recommended Books

1. G.D. Christian, *Analytical Chemistry*, 6th ed., John Wiley & Sons Ltd., Singapore (2003).
2. R. Kellner, J.M. Mermet, M. Otto, M. Valcarcel and H.M. Widmer, *Analytical Chemistry*, 2nd ed., Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2004).

CHM-512 Inorganic Chemistry-I (Cr. 2)

Periodic table: Periodic classification and periodic properties of the elements. **Theories of bonding:** Chemical bonding – valence bond and molecular orbital theories; shapes of inorganic molecules – VSEPR theory. **Theories of acids and bases:** Bronsted Lowry, solvent systems definition, Lewis acid-base concept, hard soft acids and basis. **Zero-group elements:** Their isolation, properties, and uses. **Interhalogen compounds:** Chemistry of interhalogens, pseudohalogens and polyhalides.

Recommended Books

1. F.A. Cotton, et al., *Advanced Inorganic Chemistry*, 6th ed., John Wiley, New York (1999).

2. J.E. Huheey, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Addison-Wesley, Reading (1993).
3. M.C. Day Jr. and Jod Selbin, *Theoretical Inorganic Chemistry* by Reinhold Publishing Corporation, New York (1962)

Supplementary Books

1. A.J. Emeleus and A.G. Sharp, *Modern Aspects of Inorganic Chemistry*, Read K. Paul, London (1983).
2. T. Moeller, *The Chemistry of the Lanthanides*, Chapman and Hall Ltd. London (1965).
3. J.D. Lee, *Concise Inorganic Chemistry*, Chapman and Hall London (1996).

CHM-512 Inorganic Chemistry Laboratory-I (Cr. 1)

Separation of metal ions by paper chromatography, estimation of pair of metal ions like $\text{Cu}^{2+}/\text{Ni}^{2+}$, $\text{Al}^{3+}/\text{Fe}^{3+}$, $\text{Ca}^{2+}/\text{Ba}^{2+}$, $\text{Zn}^{2+}/\text{Pb}^{2+}$, estimation of halide ions.

Recommended Book

1. A.I. Vogel, *A Textbook of Quantitative Inorganic Analysis: Theory and Practice*, Green and Co. Ltd., London (2000).

CHM-513 Organic Chemistry-I (Cr. 3)

Nomenclature of organic compounds: Aliphatic and alicyclic hydrocarbons, oxygen, and nitrogen containing compounds, monocyclic and bicyclic ring systems. **Literature of organic chemistry:** Primary sources, secondary sources, literature searching. **Introduction to stereochemistry:** Symmetry elements, chirality and stereoisomerism, nomenclature of chiral compounds, drawing Fischer projections, resolution of racemic mixtures. **Structure-reactivity relationship:** Changes in chemical reactivity with change in molecular structure in terms of acid base strength. **Reactive intermediates:** Types, structure, stability, methods of generation, and their reactivity.

Recommended Books

1. J. McMurry, *Organic Chemistry*, 5th ed., Brooks/Cole, Boston (2007).
2. J.G. Smith, *Organic Chemistry*, McGraw-Hill, New York/Boston (2006).
3. L.G. Wade, *Organic Chemistry*, 5th ed., Pearson Education, Delhi (2003).

Supplementary Books

1. M.B. Smith and J. March, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, John Wiley & Sons (2007).

2. F.A. Carey, *Organic Chemistry*, McGraw-Hill, Higher Education, New York (2006).

CHM-513 Organic Chemistry Laboratory-I (Cr. 1)

Experiments based on different techniques like re-crystallization, distillation, steam distillation, fractional distillation, vacuum distillation, and different types of chromatography. Some one-step preparations of organic compounds.

Recommended Books

1. B.S. Furniss, *Vogel's Textbook of Practical Organic Chemistry Including Qualitative Organic*, Longman Group, London (1978)
2. R. Adams, J.R. Johnson and Wilcox Jr., *Laboratory Experiments in Organic Chemistry*, 6 Ed., Collier-M London (1970).

Supplementary Books

1. A.M. Schoffstall, and B.A. Gaddis, *Microscale and Miniscale Organic Chemistry Laboratory Experiments*, (Druelinger, Melvin L.), McGraw-Hill, Boston (2004).
2. H. Becker and I. Hazzard, *Organicum: Practical Handbook of Organic Chemistry*, Reading, Masachuse Addison-Wesley Publishing Co. (1973).

CHM-514 Physical Chemistry-I (Cr. 3)

Gases: Ideal and real gases; Virial coefficients; van der Waals equation; transport properties; distribution of energies and speeds; molecular collisions and collision theory. **Thermodynamics:** Laws of thermodynamics. Concepts of enthalpy, entropy, heat capacity, free energy and process reversibility. Applications of thermodynamics to chemical systems. **Chemical kinetics:** Reactions and reaction rate laws, order of reaction, experimental determination of reaction orders, factors influencing reaction rates, elementary reactions, and reaction mechanism. Reactions with simple kinetic form; 0th-order, 1st-order, 2nd-order, complex reactions. **Electrochemistry and solutions:** Ideal and non-ideal solutions; electrolyte solutions and types of interactions. Ionic activity; ionic equilibria; electrode potentials. Redox reactions; electrochemical cells, Nernst equation.

Recommended Books

1. P.W. Atkins, *Physical Chemistry*, 7th ed., Freeman & Co., New York (2005).
2. R.A. Alberty and R.J. Silby, *Physical Chemistry*, John Wiley, New York (1995).
3. I.N. Levine, *Physical Chemistry*, McGraw Hill, New York (2002).

Supplementary Books

1. J.H. Espenson, *Chemical Kinetics and Reaction Mechanisms*, 2nd ed., McGraw-Hill, Singapore (1995).
2. J.L. Latham and A.E. Burgess, *Elementary Reaction Kinetics*, 3rd ed., John Wiley, New York (1981).
3. P.W. Atkins, *Elements of Physical Chemistry*, W.H. Freeman and Company, New York (1996).

CHM-514 Physical Chemistry Laboratory-I (Cr. 1)

1. Handling of chemicals and preparation of standard solutions.
2. To determine the rate constant for the acid catalyzed reaction of hydrolysis of an ester.
3. Determination of molar refraction of different pure liquids and binary mixtures. (H₂O, CH₃OH, C₂H₅OH, C₃H₇OH)
4. Determination of equivalence point in acid-base titration using pH meter.
5. Determination of molar mass of a given compound using cryoscopic method.
6. Adsorption study of an organic acid on charcoal using adsorption isotherm.
7. Determination of distribution constant for heterogeneous equilibrium using Nernst's distribution law.
8. Determination of activation energy of a chemical reaction.
9. Calorimetric determination of the heat of neutralization of a strong acid and a strong base.
10. Spectroscopic characterization and study of Beer's law.

Recommended Books

1. C.W. Garland, J.W. Nibler and D.P. Shoemaker, *Experiments in Physical Chemistry*, McGraw Hill, 7th ed. (1996).
2. A Findlay, *Findlay's Practical Physical Chemistry*, Longman, London (1972).

Supplementary Book

1. D.A. Skoog, *Principles of Instrumental Analysis*, 3rd ed., Harcourt Brace College Pub., New York (1998).

MTH-506 Basic Mathematics for Chemistry (Cr. 2)

Review of basic algebra: Constants and variables; complex numbers. **Equations:** Linear, quadratic, and higher order; roots of equations. **Functions:** Linear, polynomial, exponential, logarithmic, trigonometric. **Coordinate systems:** Cartesian, polar, their relationship; graphs, axes, scale, straight line, curves. **Differentiation:** Single variable problems, concept of maxima and minima, partial differentiation. **Integration:** indefinite and definite, determination of unknown constant; problems of multiple variables. **Matrices and determinants:** Vectors. The above contents with specific applications to chemical problems.

Recommended Books

1. G. Doggett and B.T. Sutcliff, *Mathematics for Chemistry*, Longman Scientific & Technical, New York (1995).
2. P. Abbott, *New Calculus*, Teach Yourself Books, Hodder and Stoughton (1984).
3. F. Daniels, *Mathematical Preparation for Elementary Physical Chemistry*, McGraw-Hill, New York (1986).
4. K.J. Smith, *Algebra and Trigonometry*, Brooks/Cole Publishing Company, California (1987).
5. K.J. Smith, *Calculus with Applications*, Brooks/Cole Publishing Company, California (1988).
6. J. Barrante, *Applied Mathematics for Physical Chemistry*, Prentice Hall, Inc. (1974).

2nd Semester

CHM-515 Analytical Chemistry-II (Cr. 2)

Spectrometry: Basic concepts, classification, theoretical concepts. **UV/visible spectrophotometry:** Introduction, Lambert-Beer Law, deviations, applications. **Solvent Extraction:** Distribution coefficient, distribution ratio, percent extraction, solvent extraction of metal complexes. **Chromatography:** Principles and theory, types of chromatography, paper chromatography, thin layer chromatography, column, and gas chromatography. **Electrogravimetry:** Theory and principles, instrumentation, separation of metal ions, applications. **Voltammetry:** Introduction, instrumentation and applications of voltammetry and polarography.

Recommended Books

1. D.C. Harris, *Quantitative Chemical Analysis*, 5th ed., W.H. Freeman Company, New York (1999).

2. D.A. Skoog and J.J. Leary, *Principles of Instrumental Analysis*, 4th ed., Saunders College Publishing, USA (1992).
3. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, *Instrumental Methods of Analysis*, Wiley, New York (2003).

Supplementary Books

1. G.D. Christian, *Analytical Chemistry*, 6th ed., John Wiley & Sons Ltd., Singapore (2003).
2. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Thomson Books/Cole, Belmont, USA (2004).
3. D. Harvey, *Modern Analytical Chemistry*, McGraw-Hill Companies Inc. (2000).
4. R. Kellner, J.M. Mermet, M. Otto, M. Valcarcel and H.M. Widmer, *Analytical Chemistry*, 2nd ed., Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2004).
5. J. Mendham, R.C. Denney, J.D. Barnes, and M. Thomas, *Vogel's Textbook of Quantitative Analysis*, 6th ed., Pearson Education Ltd. (2000).
6. R. de Levie, *Principles of Quantitative Chemical Analysis*, McGraw-Hill Companies, Inc. (1997).

CHM-515 Analytical Chemistry Laboratory-II (Cr. 1)

Electrogravimetry:

- To determine Copper(II) in solution by electrogravimetric method.
- To separate and quantify copper in brass using constant-current electrolysis.

Spectrophotometry:

- To estimate Nickel(II) in solution spectrophotometrically.
- Spectrophotometric determination of ammonia.
- To determine Iron(II) by spectrophotometric method using o-phenanthroline.
- Colorimetric determination of Iron(III) with potassium thiocyanate.
- To verify Beer's law and to evaluate molar extinction coefficient.

Chromatography:

- To separate Fe(III), Co(II), Ni(II) and Cu(II) from solution using paper chromatography.

Distribution Coefficient:

- To determine distribution coefficient of a given solute between an aqueous/non-aqueous system.

Amperometry:

- To estimate lead amperometrically through titration with potassium dichromate.

Titrimetry:

- To determine Calcium by the indirect titration with EDTA.
- To determine Zinc by direct titration with EDTA.

Recommended Books

1. G.D. Christian, *Analytical Chemistry*, 6th ed., John Wiley & Sons Ltd., Singapore (2003).
2. R. Kellner, J.M. Mermet, M. Otto, M. Valcarcel and H.M. Widmer, *Analytical Chemistry*, 2nd ed., Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2004).

CHM-516 Inorganic Chemistry-II (Cr. 2)

Chemistry of transition and inner transition elements: Periodic trends, oxidation states, shapes of orbitals, metal-metal bonding, crystal field theory, magnetic properties, 3d, 4d and 5d transition series, 4f and 5f inner transition series, their coordination behavior etc. **Crystalline state:** ABAB- - - and ABCABC- - - packing, MX and MX₂ systems, **structure and energetics of inorganic molecules**, theory of metals and intermetallic compounds. **Redox reactions:** Balancing of redox reactions, mechanisms of electron transfer processes – outer sphere and inner sphere mechanism.

Recommended Books

1. F.A. Cotton, et al., *Advanced Inorganic Chemistry*, 6th ed., John Wiley, New York (1999).
2. J.E. Huheey, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Addison-Wesley, Reading (1993).

3. M.C. Day Jr. and Jod Selbin, *Theoretical Inorganic Chemistry* by Reinhold Publishing Corporation, New York (1962).

Supplementary Books

1. A.J. Emeleus and A.G. Sharp, *Modern Aspects of Inorganic Chemistry*, Read K. Paul, London (1983).
2. T. Moeller, *The Chemistry of the Lanthanides*, Chapman and Hall Ltd. London (1965).
3. J.D. Lee, *Concise Inorganic Chemistry*, Chapman and Hall London (1996).

CHM-516 Inorganic Chemistry Laboratory-II (Cr. 1)

Synthesis of selected coordination/organometallic compounds such as:

- | | |
|------------------------|--------------------------|
| i) $K_3[Cr(C_2O_4)_3]$ | ii) $[Co(NH_3)_5Cl]Cl_2$ |
| iii) $C_6H_4(OH)HgCl$ | vi) $(C_6H_4CH_2)_3SnCl$ |

Titrimetric and spectrophotometric determination of di and trivalent metal ions in complexes. Kinetics of inorganic chemical reactions such as reaction of iodine with persulphate.

Recommended Books

1. A.I. Vogel, *A Textbook of Quantitative Inorganic Analysis: Theory and Practice*, Green and Co. Ltd., London (2000).
2. W.J. Jolly, *The Synthesis and Characterization of Inorganic Compounds*, Prentice Hall, Englewood Cliffs, New York (1970).

CHM-517 Organic Chemistry-II (Cr-3)

Functional Groups Chemistry: Synthesis and reactions with mechanisms and stereochemical aspects. Hydrocarbons (Saturated, unsaturated, aromatic) alkyl halides, alcohols, phenols, ethers, amines, carbonyl compounds, carboxylic acids and their derivatives.

Recommended Books

1. F.A. Carey, *Organic Chemistry*, 6th ed., McGraw-Hill, Higher Education, Boston (2006).
2. J.G. Smith, *Organic Chemistry*, McGraw-Hill, Boston (2006).

Supplementary Books

1. T.W.G. Solomon and C.B. Fryhle, *Organic Chemistry*, 8th ed., John-Wiley, New York (2004).
2. L.G. Wade, *Organic Chemistry*, 5th ed., Pearson Education, New Delhi (2003).
3. M.A. Fox and J.K. Whitesell, *Organic Chemistry*, 3rd ed., Jones and Bartlett, Boston (2003).

CHM-517 Organic Chemistry Laboratory-II (Cr. 1)

One and two-step preparations of different types of organic compounds and their identification by physical and chemical methods

Recommended Books

1. A.M. Schoffstall and B.A. Gaddis, *Microscale and Miniscale Organic Chemistry Laboratory Experiments*, (Drueling, Melvin L.), McGraw-Hill, Boston (2004).
2. R. Adams, JR. Johnson and Wilcox Jr., *Laboratory Experiments in Organic Chemistry*, 6th ed., Collier-M, London (1970).

Supplementary Books

1. B.S. Furniss, *Vogel's Textbook of Practical Organic Chemistry Including Qualitative Organic*, Longman Group, London (1978).
2. H. Becker and I. Hazzard, *Organicum: Practical Handbook of Organic Chemistry*, Reading, Masachuse Addison-Wesley Publishing Co. (1973).
3. J.C. Gilbert, and S.F. Martin, *Experimental Organic Chemistry: A Miniscale and Microscale Approach*, Saunders College Publishing, Fort Worth (1998).

CHM-518 Physical Chemistry-II (Cr. 3)

Quantum mechanics: Historical background of the development in atomic structure; basic concepts of quantum mechanisms; wave functions; vectors; operators; eigen values. Schrödinger's equation and its application to simple system: particle in one- and three dimensional box; rigid rotor; hydrogen atom and hydrogen-like ions; quantum numbers. **Chemical bonding:** Molecular systems: H₂-molecule. Molecular orbital (MO) and Valence bond (VB) theories; hybridization. **Molecular spectroscopy:** Rotational, vibrational and electronic spectroscopy of diatomic molecules; basic nuclear magnetic resonance spectroscopy.

Recommended Books

1. I.N. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill (2002).

2. P.W. Atkins and J. de Paula, *Physical Chemistry*, 7th ed., Oxford University Press (2002).

Supplementary Books

1. H. Kuhn and H.D. Fosterlings, *Principles of Physical Chemistry*, John Wiley & Sons, Ltd. (2000).
2. D.O. Hayward, *Quantum Mechanics for Chemists*, Royal Society for Chemistry (2002).

CHM-518 Physical Chemistry Laboratory-II (Cr. 1)

1. Conductometric determination of degree of dissociation and dissociation constant of a weak acid.
2. Determination of the equilibrium constant for the reversible reaction, $I_2 + I^- \leftrightarrow I_3^-$.
3. Determination of heat of solution of oxalic acid by solubility method using van't Hoff equation.
4. Determination of the specific rate constant for the saponification of ethylacetate conductometrically.
5. Spectrophotometric determination of dissociation constant and pK_a value of an indicator.
6. Determination of specific angle of rotation of sucrose using a polarimeter.
7. To determine the degree of hydrolysis, hydrolysis constant and dissociation constant for acetic acid from the hydrolysis of sodium acetate in aqueous solution.
8. Determination of molar volumes of the given liquids and investigation of solvent-solvent interaction from the density measurements of their mixtures.
9. Determination of equivalence point in acid-base titration using conductivity meter.
10. Comparison of molar conductivity for 1:1 electrolytes and verification of Debye-Huckel-Onsager equation.

Recommended Books

1. C.W. Garland, J.W. Nibler and D.P. Shoemaker, *Experiments in Physical Chemistry*, McGraw Hill, 7th ed. (1996).

2. A. Findlay, *Findlay's Practical Physical Chemistry*, Longman, London (1972).

Supplementary Books

1. D.A. Skoog, *Principles of Instrumental Analysis*, 3rd ed., New York (1998).
2. L.P. Gold, L. Gold, *Physical Chemistry Laboratory*, Primis Publishers (1997). ISBN: 0072902698.

CHM-519 Industrial Chemistry (Cr. 2)

Industrial units: Basic data for the development of the industrial unit e.g. basic chemical data, chemical control, raw materials etc. Chemical processes i.e. unit operations, unit process. **Chemistry and technology of industries:** Water conditioning, cement, glass, ceramic, leather, fertilizers, sugar and starch, oil, fats and waxes, soap and detergent, pulp and paper etc.

Recommended Books

1. D.D.L. Chung, *Composite Materials: Functional Material of Modern Technologies*, Springer-Verlag, London (2003).
2. F.L. Mathews and R.D. Rawlings, *Composite Materials: Engineering and Science*, Chapman and Hall, London (1994).
3. T.L. Vigo and B.J. Kinzig, *Composite Applications: The role of Matrix, Fiber and Interface*, VCH, New York (1992).

3rd and 4th Semester

3rd Semester (Compulsory Course)

Note: CHM-600 in 3rd semester is a compulsory course for all specializations.

CHM-610 Environmental Chemistry (Cr. 3)

Introduction: Environmental Chemistry, Environmental segments, Species present in Environment, Types of Pollution, Environmental radioactivity. **Atmospheric pollution:** The atmosphere, composition, temperature and pressure profile, role of free radicals in the atmosphere, temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, atmospheric aerosols, acid-rain major sources, mechanism, control measures and effects on buildings and vegetation, global warming, major greenhouse gases, mechanism, control measures and global impact, the stratospheric ozone–the ozone hole, CFCs, ozone protection, biological consequences of ozone depletion. **Water Pollution:** Water pollution and waste water treatment, municipal, industrial and agricultural sources of pollution, heavy metals contamination of water, eutrophication, detergents and phosphates in water, water quality criteria, water

purification: primary, secondary and advanced treatment, removal of nitrogen and phosphorous compounds from polluted water, organic matter in water and its decomposition. **Land pollution:** Soil and mineral resources, general principles of metal extraction, heavy metals contamination of soil, toxicity of heavy metals, bio-accumulation of heavy metals, organic matter in soil, macro and micro-nutrients in soil, ion- exchange in soil, soil pH and nutrients availability. **Solid pollutants:** Classification and origin of solid wastes, Characteristics of solid wastes, Solid waste treatment and methods of disposal. **Toxic and Hazardous Waste:** Types of toxic and hazardous waste, Radioactive waste, Nuclear waste management, Toxic chemicals, Treatment and disposal of hazardous waste, Control and treatment of trace elements. **Green Chemistry:** Atom economy, integrated pests management control (IPMC), ionic liquids, super critical extraction technology, green synthesis, recycling, carbon dioxide sequestering, water based paints.

Recommended Books

1. C. Baird, M. Cann, *Environmental Chemistry*, 5th ed., W.H. Freeman & Company, (2012).
2. S.S. Dara and D.D. Mishra, *A Text Book of Environmental Chemistry and Pollution Control*, 9th ed., S. Chand & Co. Ltd., (2004).
3. R. Singhi and V. Singh, *Green Chemistry for Environmental Remediation*, John-Willey & Sons, Inc., (2011).
4. A.M. Holloway and R.P. Wayne, *Atmospheric Chemistry*, 1st ed., Royal Society of Chemistry, (2010).
5. M. Vaclavikova, K. Vitale, G.P. Gallios and L. Ivanicova, *Water Treatment Technologies for Removal of High Toxicity Pollutants*, Springerlink, UK, (2010).
6. S.E. Manahan, *Environmental Chemistry*, 9th ed., CRC press, Taylor & Francis group, USA, (2009).
7. J.E. Girard, *Principles of Environmental Chemistry*, 2nd ed., Jones and Bartlett publishers, (2010).
8. R.M. Harrison, P. Monks, J.G. Farmer, M.C. Graham, S.J. Mora, I. Pulford, and C. Hulsal, *Principles of Environmental Chemistry*, 1st ed., Royal Society of Chemistry, (2007).
9. A. Matalack, *Introduction to Green Chemistry*, 2nd ed., CRC press, Taylor & Francis group, USA, (2010).
10. J. Wright, *Environmental Chemistry*, Routledge, (2003).

11. P. O'Neill, *Environmental Chemistry*, 3rd ed., Blackie Academic & Professional, (1998).
12. D.M. Elsom, *Atmospheric Pollution: A Global Problem*, 2nd ed., Wiley-Blackwell, (1992).

I. Analytical Chemistry (3rd & 4th Semesters)

CHMA-611 Atomic Spectroscopy (Cr. 3)

Origin of spectral transitions in atoms: Atomic spectra and spectral notations, intensities and line widths of gas-phase atomic spectra and its variations with temperature and pressure. **Absorption & emission spectra:** Boltzman distribution, spectral line broadening, background correction, factors affecting atomization/ionization. **Atomic absorption and emission methodologies:** Optimization of analytical conditions, concentration ranges in atomic spectroscopy. **Interferences:** Spectral, physical, chemical and instrumental and their elimination. **Optical components of atomic absorption/emission spectrophotometers:** Radiation sources, atomizers, monochromators and detectors, modulation in atomic spectroscopy. **Flame Vs. Electrothermal atomic absorption spectroscopy:** Qualitative and quantitative applications of absorption and emission measurements. **Flame photometry:** Flame characteristics and spectral interferences, components of flame photometer, non-metals and flame photometry. **Sampling:** Sample and standard preparation methods for atomic spectroscopy.

Recommended Books

1. F. Rouessac and A. Rouessac, *Chemical Analysis – Modern Instrumental Methods and Techniques*, John Wiley & Sons, Ltd., UK (2000).
2. K.A. Rubinson and J.F. Rubinson, *Contemporary Instrumental Analysis*, Prentice-Hall, Inc., USA (2000).
3. R. Kellner, J.M. Mermet, M. Otto, M. Valcarcel and H.M. Widmer, *Analytical Chemistry*, 2nd ed., Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2004).

Supplementary Books

1. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Thomson Books/Cole, Belmont, USA (2004).
2. D. Harvey, *Modern Analytical Chemistry*, McGraw-Hill Companies Inc. (2000).
3. R.D. Braun, *Introduction to Instrumental Analysis*, McGraw-Hill Book Company (1987).

4. E.H. Evans, *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons Ltd., New York (1998).
5. D.A. Skoog and J.J. Leary, *Principles of Instrumental Analysis*, 4th ed., Saunders College Publishing, USA (1992).
6. G.D. Christian, *Analytical Chemistry*, 6th ed., John Wiley & Sons Ltd., Singapore (2003).
7. J. Mendham, R.C. Denney, J.D. Barnes, and M. Thomas, *Vogel's Textbook of Quantitative Analysis*, 6th ed., Pearson Education Ltd. (2000).

CHMA-612 Electroanalytical Techniques (Cr. 3)

Potentiometry: Electrode potential, Nernst equation and its use for measuring half-cell potential, different kinds of electrodes including glass and calomel electrodes, working of potentiometer and its applications including pH measurements, Ion selective electrode systems, Ion exchange membrane electrode, solid state membrane electrodes, and bio-membrane electrodes, Potentiometric titrations. **Coulometry and Electrogravimetry:** Basic electrochemistry, principle, instrumentation of coulometry, principle, instrumentation of electrogravimetry, consequences of electrogravimetry, Ohmic drop, activation over potential, concentration and gas polarization, basic difference and merits/demerits of coulometry and electrogravimetry. **Voltammetry and Polarography:** Basic principle, voltammogram, polarizable and non-polarizable electrodes, solid electrodes, their scope and limitations, cyclic voltammetry, anodicstripping voltammetry. voltammetric equation, basic concept of polarography and interpretation of various polarographic curves, measurement of decomposition potential, diffusion and limiting currents, derivation of Ilkovic equation, logarithmic analysis of polarographic wave, advantages and limitation of dropping mercury electrode.

Recommended Books

1. G. D. Christian, *Analytical Chemistry*, 6thed., John-Wiley & Sons, (2006).
2. D. C.Harris, *Quantitative Chemical Analysis*, 8thed.,W.H. Freeman andCompany, (2009).
3. D. Kealey, and P. J. Haines, *BIOS Instant Notes in Analytical Chemistry*,Bios Scientific Publishers Limited, (2002).
4. B. K., Sharma, *Instrumental Methods of Chemical Analysis*, 24thed., GoelPublishing House, (2005).
5. D. A. Skoog, and D. M. West, *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., (2008).

6. Fritz, Schulz, *Electroanalytical Methods: Guide to Experiments and Applications*, 2nd revised, Springer-Verlag Berlin, (2010).
7. P. M. S. Monk, *Fundamentals of Electroanalytical Chemistry*, John-Wiley & Sons Ltd, (2001).

CHMA-613 Advanced Separation Techniques (Cr. 3)

Introduction: Classifications of chromatographic techniques, the chromatographic processes, rate theory of chromatography, Van-Deemter equation and its significance in evaluating column efficiency. **Gas Liquid Chromatography:** General principle, sample preparation/derivatization, separation process, and instrumental aspects and its applications. **HPLC:** General principle, sample preparation, separation process (normal phase and reverse phase separation), instrumentation, method development and applications. **Capillary electrophoresis:** Theory and principle of CE, mobility, electro osmotic flow separation by CE, instrumentation, modes of operation, applications.

Recommended Books

1. D. A. Skoog, P. M. West, F. J. Holler, and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 9th ed., Cengage Learning, (2013).
2. G. D. Christian, *Analytical Chemistry*, 6th ed., John-Wiley & Sons, (2004).
3. D. Kealey, and P. J. Haines, *BIOS Instant Notes in Analytical Chemistry*, 1st ed., Taylor & Francis, (2002).
4. B.K. Sharma, *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, (2005).
5. R. L. Grob, F. Eugene, Barry, *Modern Practice of Gas Chromatography*, 4th ed., John-Wiley & Sons, (2004).
6. R. Kellner, J. M. Mermet, M. Otto, M. Valcarcel, and H. M. Widmer, *Analytical Chemistry: A Modern Approach to Analytical Science*, Wiley-VCH, (2004).
7. V. R. Meyer, *Practical High-Performance Liquid Chromatography*, 5th ed., John-Wiley & Sons, Ltd., (2010).
8. S. Lindsay, *High Performance Liquid Chromatography*, 2nd ed., John Wiley & Sons, Ltd., (1992).
9. A. Braitwaite, and F. J. Smith, *Chromatographic Methods*, 5th ed., Kluwer Academic Publishers, (1999).

10. J. M. Miller, *Chromatography: Concepts and Contrasts*, 2nded., JohnWiley & Sons, Inc., (2005).
11. P. Camilleri, *Capillary Electrophoresis: Theory and Practice*, 2nded., CRCPress, (1998).

CHMA-614 Thermal Methods of Analysis (Cr. 2)

Thermal Methods of Analysis: General introduction, principles, instrumentation, sources of errors, interpretation of data, factors affecting curve, thermogravimetry, differential thermal analysis and differential scanning calorimetry, evolved gas detection, evolved gas analysis. **Applications:** Applications of thermal techniques in analysis of different materials such as TGA, DTA and DSC.

Recommended Books

1. T. Hatakeyama and F.X. Quinn, *Thermal Analysis: Fundamentals and Applications to Polymer Science*, Chichester, John Wiley & Sons (1999).
2. M.E. Brown, *Introduction to Thermal Analysis: Techniques and Applications*, Chapman and Hall, London (1988).
3. P.J. Haines, *Thermal Methods of Analysis: Principles, Applications and Problems*, Blackie Academic and Professional, London (1995).

Supplementary Books

1. B. Wunderlich, *Thermal Analysis*, Academic Press, Boston (1990).
2. W.W.M. Wendlandt, *Thermal Methods of Analysis*, 3rd ed., John Wiley and Sons, New York (1986).
3. J.W. Dodd and K.H. Tonge, *Thermal Methods: Analytical Chemistry by Open Learning*, Chichester, John Wiley and Sons (1987).

CHMA-615 Nuclear Analytical Techniques (Cr. 2)

Radiotracer techniques, choice of radiotracers, factors affecting choice of radiotracers, isotope dilution analysis (IDA), principle and equation, instrumentation, applications, advantages and limitations, sub-stoichiometric isotope dilution analysis (SIDA), activation analysis (AA), principle of NAA, neutron sources, interferences, sensitivity and detection limits, classification, instrumentation, applications, advantages and limitations, comparison of NAA and IDA with other methods, radiometric titrations (RT), procedure, advantages and limitations, radio chromatography and radioimmunoassay.

Recommended Books

1. G. Friedlander, J. W. Kennedy, E. S. Macias, and M. J. Miller. *Nuclear and Radiochemistry*, 3rd ed., Wiley, (1981).
2. H. J. Arnikan, *Essentials of Nuclear Chemistry*, 4th ed., New Age International Pvt. Ltd. (1995).
3. B. G. Harvey, *Nuclear Physics and Chemistry*, 2nd ed., Prentice Hall Inc., (1969).
4. I. I., Naqvi, M. A, Farrukh, *Radiotracers in Chemical Applications: Radiochemistry*, VDM Verlag Dr. Muller, (2010).

CHMA-616 Food and Drug Analysis (Cr. 2)

Food Products: Introduction to food analysis, sampling of food, general methods of analysis. Analysis of milk, butter, wheat flour, meat, beverages, tea, coca, honey and soft drinks. **Pharmaceuticals:** Classification of drugs, tests for analysis of different pharmaceuticals, introduction to US and British pharmacopeia. **Forensics:** History and scope of Forensic Science, Forensic Ethics, Forensic Toxicology. Classification and analysis of narcotics & dangerous drugs, examination of crime scene evidences, fingerprinting, skeletal material to provide scientific opinion for legal.

Recommended Books

1. D. A. Skoog, D. M. West, and F. J. Holler, *Fundamentals of Analytical Chemistry*, 7th ed., Saunders College Publishing, (1995).
2. G. D. Christian, *Analytical Chemistry*, John-Wiley & Sons, Inc., 6th ed., (2004).
3. W. G. Eckert, *Introduction to Forensic Science*, 2nd ed., CRC Press, (1997).
4. S. S. Nielsen, *Food Analysis*, 4th ed., Springer, (2010).
5. G., Thomas, *Medicinal Chemistry: An Introduction*, 2nd ed., John-Wiley & Sons, (2007).
6. L. F. Kobilinsky, *Forensic Chemistry Handbook*, 1st ed., John-Wiley & Sons, USA, (2012).
7. D. G. Watson, *Pharmaceutical Analysis: A Textbook for Pharmacy Students and Pharmaceutical Chemists*, Elsevier, (2012).
8. S. H. Barbara, *Forensic Analytical Techniques*, 1st ed., John-Wiley & Sons, (2013).
9. A. R. W. Jackson, and J. M. Jackson, *Forensic Science*, 2nd ed., Pearson Education, (2008).

CHMA-617 Principles and Applications of Molecular Spectrophotometry (Cr. 3)

Molecular structure and spectral transitions: Measurement of spectra, light scattering-elastic and inelastic, absorption and emission spectroscopy. **Absorption spectroscopy in UV-Visible region:** Absorbance and transmittance, applications and deviations of Beer-Lambert law, spectral resolution and errors in concentration measurements, applications and comparison of fluorescence and phosphorescence spectroscopy, spectral interferences and spectra of mixtures, chemical interferences, instrumental interferences. **Instrumentation:** Wavelength separations, sources and detectors for electromagnetic radiations. **Derivative spectroscopy:** Theory and applications. **IR and Raman spectroscopy:** Vibrational frequencies, qualitative analysis, IR spectra and Raman spectra, samples for IR and Raman spectroscopy, band intensities, quantitation, IR and Raman spectrophotometers, correlation charts and tables. **NMR Spectroscopy:** Introduction, principles and applications of NMR.

Recommended Books

1. D. Harvey, *Modern Analytical Chemistry*, McGraw-Hill Companies Inc. (2000).
2. R. Kellner, J.M. Mermet, M. Otto, M. Valcarcel and H.M. Widmer, *Analytical Chemistry*, 2nd ed., Wiley-VCH, Verlag GmbH & Co. KGaA, Weinheim (2004).
3. D.L. Pavia, G.M. Lampman, and G.S. Kriz, *Introduction to Spectroscopy*, 3rd ed., Thomson Learning Inc. (2001).

Supplementary Books

1. K.A. Rubinson and J.F. Rubinson, *Contemporary Instrumental Analysis*, Prentice-Hall, Inc., USA (2000).
2. J. Mendham, R.C. Denney, J.D. Barnes, and M. Thomas, *Vogel's Textbook of Quantitative Analysis*, 6th ed., Pearson Education Ltd. (2000).
3. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Thomson Books/Cole, Belmont, USA (2004).
4. F. Rouessac and A. Rouessac, *Chemical Analysis – Modern Instrumental Methods and Techniques*, John Wiley & Sons, Ltd., UK (2000).
5. G.D. Christian, *Analytical Chemistry*, 6th ed., John Wiley & Sons Ltd., Singapore (2003).
6. D.A. Skoog and J.J. Leary, *Principles of Instrumental Analysis*, 4th ed., Saunders College Publishing, USA (1992).
7. D.C. Harris, *Quantitative Chemical Analysis*, 5th ed., W.H. Freeman Company, New York (1999).

CHMA-618 Luminescence Spectroscopy (Cr. 2)

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Recommended Books

1. G. D. Christian, *Analytical Chemistry*, 6th ed., John-Wiley & Sons, (2006).
2. D. C. Harris, *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, (2011).
3. R. D. Braun, *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. J. R. Lakowicz, *Principles of Fluorescence Spectroscopy*, 3rd ed., Springer (2006).
5. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., (Int.), Cengage Learning, (2004).
6. C. Burgess, and D. G., Jones, *Spectrophotometry, Luminescence and Colour; Science and Compliance*, Vol. 6, Elsevier Science, (1995).

CHMA-619 Advanced Spectroscopy (Cr. 2)

Mass Spectroscopy: Principle of Mass spectroscopy, Instrumentation in details, Quantitative and Qualitative application in analytical chemistry. X-rays Spectroscopy: Nature and production of X-rays, X-rays absorption, X-rays emission, Instrumentation, X-rays fluorescence analysis, Diffraction studies single crystal analysis. Electron spin resonance spectroscopy: Instrumentation, Samples and sample holder, ESR spectra and Hyperfine interaction, Applications, Spin labels and spin traps. Surface Analysis: Introduction, Electron spectroscopy techniques, X-Rays photoelectron spectroscopy, Instrumentation for XPS, Sample introduction and handling for surface analysis, Analytical applications of XPS.

Recommended Books

1. R. Ekman, J. Silberring and A. M. W. Brinkmalm *Mass Spectrometry Instrumentation, Interpretation and Applications*, John Wiley & Sons, (2009).

2. C. Dass, *Fundamentals of Contemporary Mass Spectrometry*, John Wiley & Sons, (2007).
3. C. Barshick, D. Dackworth, and D. Smith, *Inorganic Mass Spectrometry: Fundamentals and Applications*, Taylor & Francis (2000).
4. B.D. Culity and S.R. Stock, *Elements of X-ray Diffraction*, 3rd ed., Prentice Hall (2003).
5. L. Smart and M. Gagan, *The Molecular World: The Third Dimensions*, RSC, UK (2002).
6. A. Lund, M. Shiotani and S. Shimada, *Principles and Applications of ESR Spectroscopy*, Springer (2011).
7. P.V.D. Heide, *X-Ray Photoelectron Spectroscopy: An Introduction to Principles and Practices*, Wiley (2011).

CHMA-620 Bioanalytical Chemistry (Cr. 2)

Introduction: History of Bioanalytical Chemistry. **Characterization, separation, detection and quantitative analysis:** biomolecules, metabolites, biopharmaceuticals, biomarkers, biosensors, biotherapeutics, toxins, environmental contaminants, and consumer products. **Applications of Bioanalytical Chemistry:** Toxicology, forensics, pharmacokinetics, metabolism, clinical chemistry, and biotechnology.

Recommended Books

1. A. Manz, P.S. Dittrich, N. Pamme and D. Lossifidis. *Bioanalytical Chemistry*, Imperial College Press, London WC2H 9HE (2015).
2. S.R. Mikkelsen and E. Cortón. *Bioanalytical Chemistry*, John Wiley & Sons, Inc., Hoboken, New Jersey (2016).
3. V.A. Gault and N. H. McClenaghan. *Understanding Bioanalytical Chemistry; Principles and Applications*, Wiley-Blackwell (2009).

Note:- In accordance with the policy of the department one of the following two courses (CHMA-611 and CHMA-699) will be offered in the third semester:

CHMA-621 Analytical Chemistry Laboratory-III (Cr. 3)

The course teacher(s) shall offer practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

Note:- In accordance with the policy of the department one of the following two courses (CHMA-612 and CHMA-699) will be offered in the fourth semester:

CHMA-622 Advanced Analytical Chemistry Laboratory (Cr. 3)

The course teacher(s) shall offer advanced level practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

CHMA-699 Thesis/Research Project in Analytical Chemistry (Cr. 3)

The student shall undertake and complete short research project under the supervision of a teacher. The evaluation shall be based on its oral presentation or oral examination (viva) and written report.

II. Inorganic Chemistry (3rd & 4th Semesters)

CHMI-611 Molecular Spectroscopy (Cr. 3)

UV/VIS Spectroscopy: Basic principle, instrumentation & sample handling, Woodward Fieser rule for conjugated dienes and unsaturated carbonyl systems. Absorption by aromatic compounds. Applications of UV-Visible spectroscopy. **IR Spectroscopy:** Basic Principle, Instrumentation and sample handling, Interpretation of IR spectra, Applications of IR spectroscopy. **Mass Spectrometry:** Basic Principle, Instrumentation, Modes of fragmentation of various organic molecules, Determination of molecular mass, molecular formula and molecular structure, Interpretation of Mass spectrum. **NMR Spectroscopy:** Basic Principle, Spin flipping, Spin relaxation, The Chemical shift, Instrumentation and Sample handling, Spin-spin splitting and coupling constant, Interpretation of NMR spectra. Structure elucidation of inorganic compounds by joint applications of IR, UV, NMR spectroscopy and Mass spectrometry.

Recommended Books

1. A.K. Brisdon, *Inorganic Spectroscopic Methods*, 1st ed., Oxford University Press (1998).
2. C.N.R. Rao, *Spectroscopy in Inorganic Chemistry VI*, 1st ed, Academic Press (1970).
3. D.C. Harris, *Symmetry and spectroscopy*, new ed., Dover Publications (1989).
4. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. A. Vyvyan, *Introduction to spectroscopy*, 4th ed., Cengage Learning (2008).

CHMI-612 Organometallic Chemistry (Cr. 2)

Introduction: historical background and current trends. 18-Electron rule: rationalization, limitations. Types of ligands. Chemistry and bonding of metal-sigma and pi-complexes: metal carbonyls and related compounds, metal alkyls, metal hydrides, complexes of

molecular nitrogen, oxygen and hydrogen, metal phosphines and complexes of pi-bond ligands. Applications of organometallic chemistry. Metal cluster and rationalization of their structures: electron counting schemes in clusters.

Recommended Books

1. R.H. Crabtree, *The Organometallic Chemistry of the Transition Metals*, John Wiley & Sons (2014).
2. M. Bockmann, *Organometallic Chemistry 1 & 2*, Oxford Chemistry Primers (1994).
3. A. Yamamoto, *Organotransition Metal Chemistry: Fundamental Concepts and Applications*, John Wiley & Sons (1986).

CHMI-613 Crystallography (Cr. 3)

Introduction: Techniques involving X-rays, historical background, the eye and microscope analogy, interatomic on intermolecular forces, solid-crystalline, amorphous. **X-rays:** Production, X-ray tubes, absorption and filtering, selection of radiation, detection of X-rays. **Geometry of the crystal:** Introduction, unit cells, lattices, crystal systems, crystal classes, space groups. **Symmetry:** Macroscopic and microscopic symmetry elements, crystal symmetry and properties. **Diffraction of X-rays:** Bragg's equation and Bragg's law, reciprocal lattice, Bragg's law in reciprocal lattice. **Diffractional methods:** Powder methods – camera and diffractometer, single crystal methods – camera (Rotation, Oscillation, Weissenberg and Precession) and diffractometer. Intensities of the diffracted beam; measurement, data reduction. Solution of the structure, refinement and interpretation of the result.

Recommended Books

1. B.D. Cullity and S.R. Stock, *Elements of X-ray Diffraction*, 3rd ed., Prentice Hall (2003).
2. L. Smart and M. Gagan, *The Molecular World: The Third Dimensions*, RSC, UK (2002).
3. M.M. Woolfon, *An Introduction to X-ray Crystallography*, Cambridge University Press (1970).

CHMI-614 Inorganic Polymers (Cr. 2)

Inorganic Polymers: Introduction to polymeric materials. Preparation of polyorganosiloxanes and various systems containing P-N; S-N and transition-metal polymers. **Characterization:** Characterization of polymeric materials (infrared, NMR, molecular weight determination, thermogravimetry, scanning electron microscopy). **Applications.**

Recommended Books

1. F.G.A. Stone and W.A.G. Graham, *Inorganic Polymers*, Academic Press, Inc., London (1962).
2. F.G.R. Gimblett, *Inorganic Polymer Chemistry*, Butterworths, London (1963).
3. C.E. Carraher, Jr., J.E. Sheads and C.U. Pittman, Jr., *Advances in Organometallic and Inorganic Polymer Science*, Marcel Dekker, Inc., New York (1982).

Supplementary Book

1. C.E. Carraher, Jr., *Polymer Chemistry*, 5th ed., Marcel Dekker, Inc., New York (2000).

CHMI-615 Elementary Group Theory (Cr. 2)

Symmetry: Symmetry, symmetry operations, point groups, **Groups and representations:** Groups, transformation, matrices, representations of groups, character tables. **Application:** Application of group theory to valence bond, molecular orbital, crystal field theories and IR spectra.

Recommended Books

1. K.C. Molloy, *Group Theory for Chemists*, Harward Publishing Ltd. (2007)
2. F.A. Cotton, *Chemical Applications of Group Theory*, 3rd ed., John Wiley, New York (1990).
3. A.B.P. Lever, *Introduction to Electronic Spectroscopy*, Elsevier, Amsterdam (1968).
4. J.P. Facer, *Symmetry in Coordination Chemistry*, Academic Press, New York (1971).

Supplementary Books

1. Alan and Vincent, *Molecular Symmetry and Group Theory*, John Wiley, London (1977).
2. J. Huheey, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Addison-Wesley, Reading/Singapore (1993).

CHMI-616 Separation Techniques (Cr. 2)

Chromatographic Techniques: Gas chromatography mass spectroscopy (GC-MS), **Liquid Chromatography:** High performance liquid chromatography (HPLC), Ultra performance liquid chromatography (UPLC), Liquid chromatography-mass spectrometry (LC-MS). Thin-Layer Chromatography (TLC), Paper Chromatography (PC), Column Chromatography (CC), ion-exchange, electrophoresis.

Recommended Books

1. R.D. Braun, *Introduction to Instrumental Analysis*, McGraw-Hill Ryerson, Limited (1987).

CHMI-617 Nuclear and Radiochemistry (Cr. 2)

Radioactivity: Nuclear structure and properties. Radioactive decay. **Nuclear reactions.** Effect of radiation on biological systems. **Instrumentation:** Sources of nuclear bombarding particles. Detection and measurement of nuclear radiation. **Applications:** Application of radioactivity in various fields.

Recommended Books

1. K.H. Lieser, *Nuclear and Radiochemistry: Fundamentals and Applications*, 2nd rev. ed., Wiley-VCH, Berlin (2001).
2. G. Choppin, J.O. Liljenzin and J. Rydberg, *Radiochemistry and Nuclear Chemistry*, 3rd ed., Butterworth-Heinemann (2002).
3. Y. Hido and M. Satake, *An Introduction to Nuclear Chemistry*, Discovery Publishing House, New Delhi (2003).

Supplementary Book

1. G. Friedlander and J.W. Kennedy, *Nuclear Radiochemistry*, 3rd ed., John Wiley and Sons, New York (1981).

CHMI-618 Coordination Chemistry (Cr. 3)

Introduction and historical development: Introduction, Werner's coordination theory, nomenclature of the coordination complexes. **Bonding:** The electron pair bond, effective atomic number, electronic structure, bonding theories, magnetic properties. **Stereochemistry:** Geometry of coordination compounds, Jahn-Teller distortions, isomerism in metal complexes. **Preparation and reactions of coordination compounds:** Reactions in aqueous solution, in non-aqueous solvents, in the absence of solvent, thermal dissociation of solid complexes, oxidation-reduction reactions, catalysis, synthesis of cis-trans isomers, preparation of optically active compounds, carbonyls and organometallic compounds. **Complex ion stability:** Stability constant, factors that

influence complex stability, determination of stability constants. **Kinetics and mechanisms of reactions of coordination compounds:** Rate of reaction, the rate law, effective collisions, inert and labile complexes, mechanisms of substitution reactions, octahedral substitution, square planar substitution, mechanisms of redox reactions. Applications of coordination complexes in various fields.

Recommended Books

1. F. Basolo and R.C. Johnson, *Coordination Chemistry*, NBF Pakistan (1988).
2. J.E. Huheey, *Inorganic Chemistry, Principles of Structure and Reactivity*, 4th ed., Addison-Wesley, Reading/Singapore (1993).
3. F.A. Cotton, et al., *Advanced Inorganic Chemistry*, 6th ed., John Wiley, New York (1999).

CHMI-619 Bio-coordination Chemistry (Cr.2)

Introduction: Elements and their role: Essential and trace elements in biological systems, Roles of some individual elements in biological systems. **Cell and various elements:** Structure of cell and role of different metal ions in the cell. **Metals in biological molecules:** Metal containing biological molecules and their function (hemes, Vit. B₁₂, different enzymes, etc.)

Recommended Books

1. R.W. Hay, *Bioinorganic Chemistry*, Ellis, Harwood, London (1991).
2. D.F. Fenton, *Bio-coordination Chemistry*, Oxford Primer Series (No.25), Oxford University Press (1995).
3. P.C. Wilkins and R.G. Wilkins, *Inorganic Chemistry in Biology*, Oxford Primer Series (No.46), Oxford University Press (1997).

Supplementary Book

1. J. McMaster, *Annu. Rep. Prog. Chem., Sect. A*, 101, 607-630 (2005); 102, 564-583 (2006); 103, 492-517 (2007) (Reviews).

CHMI-620 Aqueous and Non-aqueous Solvents (Cr.2)

Aqueous solvents: Introduction, properties, reactions, applications. **Non-aqueous solvents:** Properties of ionizing solvents, classification, types of reactions, chemistry in non-aqueous solvents such as NH₃, HF, CH₃COOH, H₂SO₄, SO₂, BrF₃, N₂O₄ etc. **Fused salts systems:** Reactions in molten salt systems (high temperature and low temperature molten salts. **Inorganic rings and cages:** Clathrates, inorganic rings, chains, cages of B, Si, N, P, S.

Recommended Books

1. A.K. Holliday and A.G. Massey, *Inorganic Chemistry in non-aqueous solvents*, Pergamon Press Ltd. (1965).
2. H.H. Sisler, *Chemistry in Non-aqueous solvents*, Chapman & Hall Ltd. (1965).
3. J.E. Huheey, *Inorganic Chemistry, Principles of Structures and Reactivity*, 4th ed., Addison Wesley, Reading (1993).

CHMI-621 Physical Methods in Inorganic Chemistry (Cr. 3)

Thermogravimetric Analysis (TGA), Thermogravimetry (TG), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC), Electroanalytical techniques, Atomic Spectroscopy.

Recommended Books

1. R.S. Drago, *Physical Methods in Inorganic Chemistry*, 1st ed., Van Nostrand Reinhold (1965).
2. F .A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 6th ed., John Wiley (1999).
3. E.A.V. Ebsworth and D.W.H. Rankin, *Structural Methods in Inorganic Chemistry*, Blackwell Scientific Publications, Oxford (1987).
4. R.D. Braun, *Introduction to Instrumental Analysis*, McGraw-Hill Ryerson, Limited (1987).

Note:- In accordance with the policy of the department one of the following two courses (CHMI-612 and CHMI-699) will be offered in the third semester:

CHMI-622 Inorganic Chemistry Laboratory-III (Cr. 3)

The course teacher(s) shall offer practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

Note:- In accordance with the policy of the department one of the following two courses (CHMI-613 and CHMI-699) will be offered in the fourth semester:

CHMI-623 Advanced Inorganic Chemistry Laboratory (Cr. 3)

The course teacher(s) shall offer advanced level practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

CHMI-699 Thesis/Research Project in Inorganic Chemistry (Cr. 3)

The student shall undertake and complete short research project under the supervision of a teacher. The evaluation shall be based on its oral presentation or oral examination (viva) and written report.

III. Organic Chemistry (3rd and 4th Semester)

CHMO-611 Chemistry of Heterocycles (Cr. 2)

Heterocycles: Introduction, significance and their uses. **Nomenclature:** Naming of heterocycles according to IUPAC, Hantzsch-Widmann- Pettersen system and SMILES. **Geometry and stereochemistry:** Saturated, unsaturated and aromatic heterocycles. aromaticity, tautomerism in small to large ring heterocycles. **Synthesis and reactions:** three-seven member heterocycles and fused ring heterocyclic systems.

Recommended Books

1. R.K. Bansel, *Heterocyclic Chemistry*, 4th ed., New Age International Pvt. Ltd., India (2005).
2. T. Eicher and S. Hauptmann, *The Chemistry of Heterocycles*, George Thieme Verlag, New York (1995).
3. J.A. Joule, K. Mills, G.F. Smith, *Heterocyclic Chemistry*, Stanley Thomes Publications. Ltd.; (1998).

Supplementary Books

1. R.H. Acheson, *An Introduction to Chemistry of Heterocycles*, John Wiley, New York (1987).
2. G.M. Loudon, *Organic Chemistry*, 4th ed., Oxford University Press, New York (2002).
3. M.A. Fox and J.K. Whitesell, *Organic Chemistry*, 3rd ed., Jones and Bartlett, Boston (2003).
4. M. Samisburg, *Heterocyclic Chemistry*, Royal Society Of Chemistry (2001)

CHMO-612 Reaction Mechanism –I (Cr. 3)

Introduction to reaction mechanism: Basic concepts, energy profile diagrams, intermediate vs transition state and significance of reaction mechanism. **Methods of determination of reaction mechanism:** Identification of products, testing possible intermediates, trapping of intermediates, crossover experiments, isotopic labeling,

stereochemical studies, catalysis and kinetic studies. **Mechanisms of different types of reactions:** Substitution, addition and elimination reactions.

Recommended Books

1. P. Sykes, *A Guidebook to Mechanism in Organic Chemistry*, 6th ed., Longman Scientific & Technical, London (1986).
2. M.B. Smith and J. March, *March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure*, John Wiley & Sons, New York (2007).
3. B.K. Carpenter, *Determination of Organic Reaction Mechanisms*, John Wiley & Sons, New York (1984).

Supplementary Books

1. T.H. Lowry and K.W. Richardson, *Mechanism and Theory in Organic Chemistry*, Harper & Row Publishers, New York (1987).
2. Jacobs, *Understanding Organic Reaction Mechanisms*, The University Press, Cambridge (1997).
3. M.G. Moloney, *Reaction Mechanisms at a Glance: a Stepwise Approach to Problem-Solving in Organic Chemistry*, Blackwell Science, Oxford (2000).
4. R. Bruckner, *Advanced Organic Chemistry: Reaction Mechanisms*, Harcourt Science, San Diego (2002).

CHMO-613 Spectroscopic Methods in Organic Chemistry-I (Cr. 2)

Introduction: Fundamentals of spectroscopy. **UV-Visible spectroscopy:** Introduction, theory, instrumentation and sample handling. **Infra Red spectroscopy:** Introduction, theory, instrumentation and sample handling. **Mass spectrometry:** Introduction, theory, instrumentation and sample handling. **Applications:** Structure elucidation of simple organic molecules by UV, IR and MS.

Recommended Books

1. R.M. Silverstein, F.X. Webster and D.J. Kiemle, *Spectrometric Identification of Organic Compounds*, John Wiley & Sons Inc., USA (2005).
2. D.L. Pavia, G.M. Lampman, and G.S. Kriz, *Introduction to Spectroscopy: a Guide for Students of Organic Chemistry*, Thomson Learning, Australia (2001).

Supplementary Books

1. D.W. Brown, A.J. Floyed and M. Sainsbury, *Organic Spectroscopy*, I. Wiley and Sons, Chichester (1998).

2. D.H. Williams and I. Fleming, *Spectroscopic Methods in Organic Chemistry*, 4th ed., McGraw-Hill Book Co., London (1987).
3. M. Hesse, H. Nleir and U. Zech, *Spectroscopic Methods in Organic Chemistry*, Georg Thieme, Stuttgart, New York (1997).
4. Y.C. Ning, *Spectral Identification of Organic Compounds with Spectroscopic Techniques*, Wiley-VCH, Weinheim (2005).
5. M. Younas, *Organic Spectroscopy*, Ilmi Kitab Khana, Lahore (2004).

CHMO-614 Chemistry of Natural Products (Cr. 3)

Introduction: Primary and secondary metabolites, isolation and structure elucidation by physical and chemical methods, pharmacological importance of secondary metabolites,
Partial and total synthesis: Terpenoids, steroids, alkaloids, fatty acids and flavonoids.
Microbial and Marine Natural Products: Biosynthesis, structure elucidation, pharmacological importance

Recommended Books

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, Oxford University (2001).
2. J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, *Natural Products*, Longman Group Ltd., U.K. (1994).
3. K. Nakanishi, T. Goto, S. Ioto, S. Natori, S. Nozone, et al., *Natural Products Chemistry*, Vol. 1, Academic Press Inc, New York (1974).
4. E. Fattorusso, W.H. Gerwick, O. Taglialatela-Scafati, *Handbook of Marine Natural Products*, Springer Dordrecht, Heidelberg, New York, London (2012).
5. S.K. Kim (Ed.), *Springer handbook of marine biotechnology*, Springer (2015).

Supplementary Books

1. I.L. Finar, *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*, Vol. 2, Pearson Education, Delhi (1975).
2. R.O.C. Norman and J.M. Coxon, *Principles of Organic Synthesis*, 3rd ed., Chapman Hall, London (1993).

CHMO-615 Name Reactions (Cr. 2)

Recent developments, mechanistic, stereochemical aspects and synthetic applications of various Name reactions: Aldol Condensation, Micheal Addition, Knoevenagel Condensation, Claisen Condensation, Dickmann Condensation, Mannich

Reaction, Wittig Reaction, Peterson Reaction, Heck Reaction, Friedel-Craft Alkylation, Acylation and Related Reactions, Favorski Rearrangement, Hunsdiecker Reaction And Fischer Indole Synthesis.

Recommended Book

1. B.P. Mundy, M.G. Ellerd, F.G. Favalozo and F.G Favalozo, jr., *Name Reactions and Reagents in Organic Synthesis*, John Wiley, New York (2005).

Supplementary Books

1. M.B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanism and Structure*, 5th ed., John Wiley, New York (2001).
2. R.O.C. Norman, *Principles of Organic Synthesis*, 3rd ed., Chapman-Hall, London (1993).

CHMO-616 Introduction to Polymer Chemistry (Cr. 3)

Introduction: Definition, nomenclature. **Classification of polymers:** Thermoplastics, thermosets, elastomers, rubbers etc. **Types of polymerization reactions:** Step growth, chain growth, free radical, ionic polymerizations, co-polymerization. **Characterization of polymers:** Spectroscopic methods such as infra red, nuclear magnetic resonance; Thermal methods such as differential scanning calorimetry, thermal gravimetric analysis, thermo mechanical and some physico-chemical methods.

Recommended Books

1. F.W. Billmeyer, *Textbook of Polymer Science*, Interscience (1994).
2. G. Odian, *Principles of Polymerization*, 3rd ed., John Wiley & Sons (2004).

Supplementary Books

1. H.R. Ailcock and F.W. Lampe, *Contemporary Polymer Chemistry*, 4th ed., Prentice Hall (2003).
2. M.S. Bhatnagar, *A Textbook of Polymers*, Vol. I, II, III, S. Chand & Co. Ltd. (2004).
3. J.R. Fried, *Polymer Science & Technology*, Prentice Hall, Inc. (1995).

CHMO-617 Reaction Mechanism-II (Cr. 3)

Rearrangements: Reactions involving 1,2 and non-1,2 rearrangements and their mechanism. **Oxidations:** Reactions involving removal of hydrogen, cleavage of C-C bond, replacement of hydrogen by oxygen, addition of oxygen and oxidative coupling along with their mechanisms. **Reductions:** Reactions involving replacement of oxygen

by hydrogen, removal of oxygen, reductive cleavage and reductive coupling, selectivity in reductions. **Organometallic compounds:** Chemical properties and synthetic applications of organometallic compounds of Li, Mg & Zn.

Recommended Books

1. J. March. *Advanced Organic Chemistry: Reaction, Mechanism and Structure*, 5th ed., John Wiley, New York (2007).
2. W. Caruthers, *Some modern Methods of Organic Synthesis*, 3rd ed., Cambridge University Press, Cambridge (1986).
3. F.L. Ansari, R. Quershi and M.L. Quershi, *Electrocyclic Reactions*, John Wiley & Sons (1999).

Supplementary Books

1. R.O.C. Norman, *Principles of Organic Synthesis*, 3rd ed., Chapman and Hall, London (1993).
2. R.T. Morrison and R.N. Boyd, *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey (1992).
3. P. Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th ed., Longman Scientific and Technical, London (1986).

CHMO-618 Stereochemistry (Cr. 3)

Introduction: History and significance. **Static stereochemistry:** Structure and symmetry, conformations and configurations, methods for determination of relative and absolute configuration, stereochemical nomenclature. **Types of chirality:** Central, axial and planar chiral compounds, atropisomerism, molecular overcrowding and cyclostereoisomerism. **Dynamic stereochemistry:** Stereochemical reactions, stereoselectivity and stereospecificity, prostereoisomerism and prochirality. **Analytical methods:** Determination of enantiomer and diastereomer composition using chiroptical, chromatographic and NMR spectroscopic methods. **Resolution:** Diastereoisomer formation, chiral derivatization agents (CDAs), chiral resolving agents (CRAs), chromatographic, kinetic, mechanical and enzymatic resolutions, preferential crystallization.

Recommended Books

1. E.L. Eliel, S.H. Wilen, M.P. Doyle, and P. Michael, *Basic Organic Stereochemistry*, Wiley Interscience, New York (2003).
2. P.S. Kalsi, *Stereochemistry and Mechanism through Solved Problems*, New Age International Publishers, New Delhi, India (2001).

3. K. Mislow, *Introduction to Stereochemistry*, W.A. Benjamin, New York (1966).

Supplementary Books

1. J. Eames (Queen Mary and Westfield College, University of London) and J.M. Peach, *Stereochemistry at a Glance*, Blackwell Publishing (2003).
2. D.G. Morris, *Stereochemistry*, Royal Society of Chemistry, U.K (2001).
3. M. North, *Principles and Applications of Stereochemistry*, Stanley Thornes: Cheltenham, UK (1998).

CHMO-619 Retrosynthesis (Cr. 2)

Introduction to retrosynthesis: Concepts of synthons and retrosynthetic approach. **Synthesis and uses:** alkyl halides, alkenes, alkynes, alcohols, ethers, aromatic compounds, carbonyl and nitrogen compounds. **Bond formations:** C-C, C-N, and C-O bond formation. **Difunctionalised compounds:** 1,2; 1,3; 1,4; 1,5; and 1,6. **Cyclizations:** Simple intramolecular reactions such as aldol, Claisen condensation and Robinson annulation reaction leading to cyclic structures. **Application:** Application of the concepts to various target molecules.

Recommended Books

1. S. Warren, *Organic Synthesis: The Disconnection Approach*, John Wiley and Sons, Chichester (1992).
2. R.O.C. Norman and J.M. Coxon, *Principles of Organic Synthesis*, Blackie Academic and Professional, London (1993).
3. J. Clayden, N. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, Oxford University (2001).

Supplementary Books

1. C. Willis and M. Willis, *Organic Synthesis*, Oxford Science Press (1995).
2. G.D. Meakins, *Functional Groups: Characteristics and Interconversions*, Oxford Science Press (1996).

CHMO-620 Quantum Organic Chemistry (Cr. 2)

Basic concepts: Wave-particle duality, properties of wave function and wave equation. **Hückel molecular orbital method (HMO):** Hückel systems, HMO relationship and energy level patterns of linear and cyclic conjugated polyenes. **Applications of HMO results:** Correlation of HMO results with molecular properties, prediction and interpretation of IR, UV spectra, chemical reactivity and reaction mechanism by using

HMO software. **Pericyclic reactions:** Introduction and significance, classification and their mechanistic analysis based on Woodward-Hoffmann rules and frontier orbitals method.

Recommended Books

1. F.L. Ansari, R. Quershi and M.L. Quershi, *Electrocyclic Reactions*, John Wiley & Sons (1999).
2. C.M. Quinn, *Computational Quantum Chemistry*, Academic Press (2002).
3. K. George, *Introductory Organic Quantum Chemistry*, Academic Press, New York (1962).
4. R.A Jackson, *Mechanism in organic reactions*, Royal Society of Chemistry (2004).

Supplementary Books

1. D. Young, *Computational Chemistry: A practical Guide for Applying Techniques to Real World Problems*, Wiley Interscience (2001).
2. F. Jonsen, *Introduction to Computational Chemistry*, John Wiley (1999).
3. E. Lewars, *Computational Chemistry*, Kluwer Academic Press (2003).
4. C.J. Cremer, *Essentials of computational Chemistry*, JW. (2004).

CHMO-621 Spectroscopic Methods in Organic Chemistry-II (Cr. 3)

Nuclear magnetic resonance: Introduction, theory, instrumentation and sample handling. **Chemical shifts:** Chemical shifts in ^1H - and ^{13}C -NMR, factors affecting chemical shifts, chemical shift equivalence and magnetic equivalence. **Spin couplings:** Spin couplings and factors affecting spin couplings, first order spin systems. **Double resonance experiments:** Selective spin decoupling, nuclear overhauser effect. NOE difference spectra, ^1H BB decoupled and DEPT spectra. **Applications:** Shift reagents, dynamic NMR, stereochemical assignments in different types of compounds, NMR in biochemistry and medicine, structure elucidation of organic compounds by joint applications of UV, IR, NMR and MS.

Recommended Books

1. M. Hesse, H. Meier and B. Zeeh, *Spectroscopic Methods in Organic Chemistry*, Georg Thieme Verlag, Stuttgart, Germany (1997).
2. D.L. Pavia, G.M. Lampman and G.S. Kirz, *Introduction to Spectroscopy*, Brooks/Cole Thomson Learning, USA (2001).

3. R.M. Silverstein, F.X. Webster and D.J. Kiemle, *Spectrometric Identification of Organic Compounds*, John Wiley & sons Inc., USA (2005).

Supplementary Books

1. L.M. Harwood and T.D.W. Claridge, *Introduction to Organic Spectroscopy*, Oxford University Press Inc., New York (1997).
2. R.S. Macomber, *NMR Spectroscopy: Basic Principles and Applications*, Harcourt Brace Jovanovich Publishers, San Diego (1988).
3. H. Friebolin, *Basic one-and two-dimensional NMR spectroscopy*, 4th ed., Wiley-VCH, New York (2005).
4. J.K.M. Sanders and B.K. Hunter, *Modern NMR Spectroscopy: a Guide for Chemists*, The University Press, Oxford (1993).
5. E. Breitmaier, *Structure Elucidation by NMR in Organic Chemistry: a Practical Guide*, John Wiley, West Sussex (2002).
6. M. Younas, *Organic Spectroscopy*, Ilmi Kitab Khana, Lahore (2004).
7. Y.C. Ning, *Spectral Identification of Organic Compounds with Spectroscopic Techniques*, Wiley-VCH, Weinheim (2005).
8. C.J. Creswell, O.A. Runquist and M.M. Campbell, *Spectral Analysis of Organic Compounds*, 2nd Edition, Longman, London (1972).

CHMO-622 Extraction and Separation Methods in Organic Chemistry (Cr. 2)

Extraction and Separation Techniques: Solvent Steam Distillation Extraction (SDE), Microwave-assisted extraction (MAE), Ultrasound-assisted extraction (UAE), Supercritical fluid extraction (SFE), Solid Phase Extraction (SPE), Enzyme-assisted extraction (EAE), **Chromatographic Techniques:** Gas chromatography mass spectroscopy (GC-MS). **Liquid Chromatography:** High performance liquid chromatography (HPLC), Ultra performance liquid chromatography (UPLC), Liquid chromatography-mass spectrometry (LC-MS)

Recommended Books

1. S.H. Rizwi, *Separation, Extraction and Concentration Processes in the Food, Beverage, and Nutraceuical Industries*, 1st edition, Woodhead Pulishing (2010).
2. V.S. Kislik, *Solvent Extraction Classical and Novel Approaches*, 1st edition, Elsevier (2011).

3. E. Lundanes, L. Reubaet and T. Greibrokk, *Chromatography Basic principles, sample preparation and related methods*, Wiley.VCH (2013).
4. O. D. Sparkman, Z. Penton, F. G. Kitson, *Gas Chromatography and Mass Spectrometry*, Elsevier Science Publishing Co. Inc. (2011).
5. L.R. Snyder, J.J. Kirkland, J.W. Dolan, *Introduction to Modern Liquid Chromatography*, 3rd ed., John Wiley & Sons Ltd (2009).
6. V.R. Meyer, *Practical High Performance Liquid Chromatography*, 5th ed., John Wiley & Sons Ltd (2010).

Note:- In accordance with the policy of the department one of the following two courses (CHMO-613 and CHMO-699) will be offered in the third semester:

CHMO-623 Organic Chemistry Laboratory-III (Cr. 3)

The course teacher(s) shall offer practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

Note:- In accordance with the policy of the department one of the following two courses (CHMO-614 and CHMO-699) will be offered in the fourth semester:

CHMO-624 Advanced Organic Chemistry Laboratory (Cr. 3)

The course teacher(s) shall offer advanced level practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

CHMO-699 Thesis/Research Project in Organic Chemistry (Cr. 3)

The student shall undertake and complete short research project under the supervision of a teacher. The evaluation shall be based on its oral presentation or oral examination (viva) and written report.

IV. Physical Chemistry (3rd and 4th Semester)

CHMP-611 Polymer Chemistry (Cr. 2)

Definition and classification of polymers: Linear polymer, block copolymers and graft copolymers. **Polymerization and co-polymerization:** Polycondensation polymerization, free radical polymerization, anionic and cationic polymerization. **Polymer molecular characterization;** number-average and weight-average molar mass. **Characterization techniques:** Gel permeation chromatography, dilute solution viscometry, vapour pressure osmometry, membrane osmometry, ultra-centrifugation, static and dynamic

laser light-scattering techniques and polymer rheology. **Structure-property relationship:** Elastomers; plastics; blends and alloys.

Recommended Books

1. F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed., John Wiley and Sons, Singapore (1994).
2. J.E. Fried, *Polymer Science and Technology*, Prentice-Hall, New Jersey (1995).

3. Supplementary Books

1. P. Munk, *Introduction to Macromolecular Science*, Singapore, John Wiley and Sons, New York (1989).
2. B. Chu, *Laser Light-Scattering, Basic Principle and Practice*, 2nd ed., Academic Press, Inc., New York (1991).

CHMP-612 Molecular Spectroscopy (Cr. 3)

Introduction: Principles and classification of spectroscopy; interaction of light and matter; de-excitation modes; various spectra and their characterization. **Rotational spectroscopy:** classification of molecules; diatomic rigid and non-rigid molecules; polyatomic linear molecules; symmetric tops; applications. **Vibrational spectroscopy:** Classification of vibrational modes; diatomic molecules; diatomic vibrating-rotator; breakdown of the Born-Oppenheimer approximation; polyatomic linear vibrators and vibrating symmetric tops. **Electronic spectroscopy of diatomic molecules:** Vibrational coarse structure; the Frank-Condon principle and dissociation. **Nuclear magnetic resonance spectroscopy:** Principles; applications.

Recommended Books

1. C.N. Banwell, *Fundamentals of Molecular Spectroscopy*, 3rd ed., McGraw-Hill, UK (1983).
2. G.M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw-Hill (International Student Edition) (1990).
3. G. Aruldhas, *Molecular Structure and Spectroscopy*, Prentice-Hall (India) (2004).
4. H. Friebolin, *Basic One- and Two- Dimensional NMR Spectroscopy*, VCH, Weinheim (1993).

CHMP-613 Chemical Kinetics (Cr. 3)

Transition state theory: Temperature effects; heat capacity of activation; composite rate constants; pressure effects and volume of activation; interpretation of activation parameters. **Reaction mechanisms:** Mechanistic interpretation of rate laws, equivalent kinetic expressions, kinetically indistinguishable schemes, pH- rate profiles. **Composite reactions:** Reversible 1st and higher order reactions, parallel and concurrent reactions, consecutive first order reactions; steady state approximation; rate controlling step; catalyzed and enzyme catalyzed reactions. **Chain reactions:** Decomposition of acetaldehyde; autoxidation of an organo-chromium complex. **Fast reactions:** Flow methods for rapid reactions, shock wave methods, chemical relaxation methods, quenching by fluorescence method, flash and laser photolysis.

Recommended Books

1. J.H. Espenson, *Chemical Kinetics and Reaction Mechanisms*, 2nd ed., McGraw Hill, Singapore (1995).
2. A.A.M. Frost and R.G. Pearson, *Kinetics and Mechanism*, 3rd ed., Butterworths, London (1969).

Supplementary Books

1. I.N. Levine, *Physical Chemistry*, McGraw Hill, New York (2002).
2. K.J. Laidler, *Chemical Kinetics*, 3rd ed., Pearson Education Ins., Singapore (1987).
3. S.R. Logan, *Fundamentals of Chemical Kinetics*, Longman Group Limited (1996).

CHMP-614 Solid State Chemistry (Cr. 2)

Unit cells and crystal systems: Lattices and their description: Bravais lattice; Miller indices; unit cell contents. Point groups and their relevant classification based on symmetry. **Space groups and crystal structures:** Close-packed structures (cubic, hexagonal, tetragonal and other packing arrangements). Important structure types (Rutile, Rock Salt, Zinc Blend, Wurtzite. etc). **Perfect and imperfect crystals:** Types of defects with description. Diffusion of ions in solids; dislocation; mechanical properties and reactivity of solids. **Theories of electrical conductance:** Different types of solids, metals and non-metals.

Recommended Books

1. A.R. West, *Solid State Chemistry*, 2nd ed. John Wiley, Singapore (2002).
2. W.J. Moore, *Seven Solid States*, W.A. Benjamin Inc., New York (1967).

3. R.H. Bube, *Electrons in Solids*, 3rd ed., Academic Press, San Diego (1992).

Supplementary Books

1. W.D. Callister, *Material Science and Engineering*, 6th ed. John Wiley, New York (2003).
2. *Electronic Materials Handbook*, Vol. I, Packaging, ASM International Materials Park, Ohio (1989).
3. R.E. Hummel, *Electronic Properties of Materials*, 3rd ed. Springer-Verlag, New York (2000).

CHMP-615 Electrochemistry (Cr. 2)

Basic concepts of electrochemistry: Types of Electrodes and electrochemical cells. **Theories of electrolytes:** Interfacial phenomenon; electrical double layer: Gouy, Stern, Helmholtz models. **Electrode kinetics:** Difference between controlled potential and controlled current techniques; essentials of heterogeneous kinetics, Butler-Volmer's equation, concept and use of exchange current, Tafel's equation and Tafel's plots. **Batteries and fuel cells:** Principle, working and types.

Recommended Books

1. P.H. Rieger, *Electrochemistry*, 2nd ed., Chapman and Hall, New York (1993).
2. A.J. Bard and L.R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, 2nd ed., Wiley (2001).

Supplementary Books

1. J. O'M Bockris, A.K.N. Reddy and M.F. Gomboa, *Modern Electrochemistry: Fundamentals of Electrodes*, 2nd ed., Springer (2000).
2. V.S. Bagotskii, *Fundamentals of Electrochemistry*, 2nd ed., Wiley, New York (2005).

CHMP-616 Surface Chemistry (Cr. 2)

Adsorption: Surface and interface; interfacial tension; adsorption forces, thermodynamics of adsorption; porosity; particle size distribution. Physisorption and chemisorption; adsorption isotherms and their types (Freundlich, Langmuir, BET etc.). Force field in fine pores; microporosity. **Catalysis:** homogeneous and heterogeneous catalysis and gas-solid interface; enzyme catalysis; gas reactions at solid surfaces; diffusion limitations and compensation effect.

Recommended Book

1. G.C. Bond, *Heterogeneous Catalysis: Principles and Applications*, 2nd ed., Clarendon Press, Oxford (1987).

Supplementary Book

1. S.J. Gregg and K.S.W. Sing, *Adsorption, Surface Area and Porosity*, 2nd ed., Academic Press, London (1982).

CHMP-617 Chemical Thermodynamics (Cr. 3)

Basic concepts: Relations used in thermodynamics, free energy, enthalpy, entropy, laws of thermodynamics. **Systems of variable compositions:** Mixtures of gases; the fugacity function; partial molal quantities; ideal solutions. **Laws of dilute solutions:** Henry's law; Nernst's distribution law; Raoult's law; activity and activity coefficients; equilibrium constants; free energy changes in solutions. **Colligative properties:** Vapour-pressure lowering, freezing point depression, elevation of boiling point and osmotic pressure. **Phase rule:** Phase equilibrium, one component system, multicomponent systems.

Recommended Books

1. I.M. Klotz, *Chemical Thermodynamics*, 3rd ed., W.A. Benjamin Inc., California; (1972).
2. I.N. Levine, *Physical Chemistry*, McGraw Hill, New York (2002).

Supplementary Books

1. K.S. Pitzer, *Thermodynamics*, 3rd ed. McGraw-Hill, New York (1995).
2. J.B. Ott and J.B. Goates, *Chemical Thermodynamics*, Elsevier, New York (2000) ISBN: 0125309902.
3. D.A. McQuarrie and J D Simon, *Molecular Thermodynamics*, Viva Books, Pvt. Ltd., New Delhi (2004).

CHMP-618 Solution Chemistry (Cr. 2)

Solutions: Their role in chemistry; classification; concept of solute and solvent; mixtures and their importance. **Interactions in solutions:** Solvent-solvent interactions; solute-solvent interactions. **Electrolyte solutions:** Ion-ion interactions; ion-pairing; structure of solvates. **Measurement:** Microscopic and macroscopic properties: transport properties.

Recommended Books

1. J. Burgess, *Metal Ions in Solutions*, 2nd ed., Ellis Harwood Ltd. UK (1978).

2. C. Reichardt, *Solvents and Solvent Effects in Organic Chemistry*, 2nd ed., VCH, Weinheim, Germany (1988).
3. I.N. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill (2002).

CHMP-619 Colloids and Surfactants (Cr. 2)

Capillarity: Surface tension, Young and Laplace and Kelvin equations, orientation at interfaces, thermodynamics of binary systems, the Gibbs adsorption equation. **Surfactants:** Nature and classification, micellization, solubilization, critical micelle concentration, micellar catalysis. **Emulsion:** Emulsion stability, aging and inversion of emulsions, hydrophile-lipophile balance, microemulsions, wetting and contact angle. **Colloidal solutions:** Rheology of dispersions, static and dynamic light-scattering, lyophobic and association colloids, forces in colloidal systems.

Recommended Books

1. A.W. Adamson, *Physical Chemistry of Surfaces*, 5th ed. Wiley-Interscience Publication, John Wiley & Sons, Inc., New York (1990).
2. P.C. Hiemenz and Rajagopalan, *Principles of Colloid & Surface Chemistry*, 3rd ed. Marcel Dekker Inc., New York (1997).
3. M.J. Rosen, *Surfactants and Interfacial Phenomena*, Wiley-Interscience Publication, John Wiley & Sons, New York (1978).

Supplementary Book

1. D.F. Evans and H Wennerström, *The Colloidal Domain Where Physics, Chemistry, Biology and Technology Meet*, VCH Publishers, Inc., New York (1994).

CHMP-620 Quantum Chemistry (Cr. 3)

Basic postulates and theorems of quantum mechanics. Operators: Hermetian angular momentum; eigen function, eigen values and eigen value equation. **Quantum mechanical treatment (solution of Schrödinger equation) of some representative systems:** Particle in three-dimensional box; harmonic oscillator; rigid rotor; hydrogen like atoms. **Treatment of many electron atoms:** Paulis' principle; Hund's rule; spin-orbit interaction. Variation method. Perturbation theory. Molecular symmetry. **Chemical bonding:** Valence bond (VB) and molecular orbital (MO) theories, HMO calculation and band gap theory.

Recommended Books

1. D.O. Hayward, *Quantum Mechanics for Chemists*, Royal Society of Chemistry, UK (2002).

2. J.P. Lowe, *Quantum Chemistry*, 2nd ed., Academic Press, New York (1993).
3. D.A. McQuarrie, *Quantum Chemistry*, Oxford University Press, Oxford, UK (1983).

Supplementary Books

1. F.L. Pilar, *Elementary Quantum Mechanics*, 2nd ed., McGraw Hill, New York (2001).
2. I.N. Levine, *Quantum Chemistry*, 4th ed. Prentice Hall, New Delhi (1991).

CHMP-621 Statistical Mechanics (Cr. 2)

Historic background and basics: Probability; description of various systems; ensembles; concepts of states and accessible states; distribution of energy; Maxwell-Boltzmann's statistic (MBS) of the systems of independent particles. **Partition functions:** Derivations and determinations for simple molecules. **Statistical thermodynamics:** Correlation of partition functions and thermodynamic functions. **Applications:** To chemical equilibrium and chemical kinetics; Fermi-Dirac's (FD) and Bose-Einstein's (BE) statistics.

Recommended Books

1. R. Reif, *Statistical Physics*, McGraw-Hill Book Co., New York (1967).
2. D.A. McQuarrie and J.D. Simen, *Physical Chemistry (A molecular approach)*, Viva Books Pvt. Ltd., New Delhi (2004).
3. Fritz & Fritz, *Statistical Thermodynamics*, Wiley, New York (1959).
4. J.M. Seddon and J.D. Gale, *Thermodynamics and Statistical Mechanics*, RSC Publishers (2001).
5. K. Nash, *Elements of Classical and Statistical Thermodynamics*, Addison-Wesley Publishing Company, London (1970).
6. Sears and W. Francis, *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, Addison and Wile, London (1975).

Note:- In accordance with the policy of the department one of the following two courses (CHMP-612 and CHMP-699) will be offered in the third semester:

CHMP-622 Physical Chemistry Laboratory-III (Cr. 3)

The course teacher(s) shall offer practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

Note:- In the fourth semester the student shall have to take one of the following two courses (CHMP-613 and CHMP-699) as offered by the department.

CHMP-623 Advanced Physical Chemistry Laboratory (Cr. 3)

The course teacher(s) shall offer advanced level practicals involving different experimental facilities available in the section/department. The details of the laboratory work and the equipment involved shall be decided by the teacher concerned on the basis of the courses taught.

CHMP-699 Thesis/Research Project in Physical Chemistry (Cr. 3)

The student shall undertake and complete short research project under the supervision of a teacher. The evaluation shall be based on its oral presentation or oral examination (viva) and written report.
