

**KAVAYITRI BAHINABAI CHAUDHARI
NORTH MAHARASHTRA UNIVERSITY, JALGAON**

**SCHOOL OF CHEMICAL SCIENCES
DEPARTMENT OF ORGANIC CHEMISTRY
(Academic Flexibility since 2009)**



**MASTER OF SCIENCE IN CHEMISTRY
(With specialization in Organic Chemistry)**

**PART- I
(Semester I and II)**

**Choice Based Credit System, 60:40 Pattern
(Outcome Based Curriculum)**

w. e. f. June 2019

**Summary of Distribution of Credits under CBCS Scheme
for
M.Sc. Organic Chemistry
at
School of Chemical Sciences
[at University Campus under Academic Flexibility w.e.f. 2019-20]**

Sr. No	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Core	12	12	12	12
02	Skill based	08	08	06	06
03	School Elective	-	-	04	-
04	Project	-	-	-	06
05	Audit	02	02	02	02
06	Total Credits	22	22	24	26

Subject Type	Core	Skill based	School Elective	Project	Audit	Total
Credits	48	28	04	06	08	94

Total Credits = 94

Department of Organic Chemistry, School of Chemical Sciences
Kavayitri Bahinabai Chaudhari North Maharashtra University
Jalgaon

M. Sc. Organic Chemistry
Choice Based Credit System (Outcome Based Curriculum) with effect from
2019 -2020

Course credit scheme

Semester	(A) Core Courses			(B) Skill Based / Elective Course			(C) Audit Course (No weightage in CGPA)			Total Credits (A+B+C)
	No. of Courses	Credits (T)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (Practical)	Total Credits	
I	3	12	12	4	2 + 6	8	1	2	2	22
II	3	12	12	4	2 + 6	8	1	2	2	22
III	3	12	12	2	4 + 6	10	1	2	2	24
IV	3	12	12	2	0 + 12	12	1	2	2	26
Total Credits	48			38			8			94

(T, Theory; P, Practical)

Structure of Curriculum

		First Year				Second Year				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
(A)	Prerequisite and Core Courses									
	Theory	12	3	12	3	12	3	12	3	48
(B)	Skill Based / Subject Elective Courses									
1	Theory (Skill Based)	2	1	2	1	-	-	-	-	04
2	Practical (Skill Based)	6	3	6	3	6	1	12	2	30
3	Subject Elective Course	-	-	-	-	4	1	-	-	04
(C)	Audit Course (No weightage in CGPA calculations)									
1	Practicing Cleanliness	2	1							2
2	Personality and Cultural Development Related Course			2	1					2
3	Technology Related + Value Added Course					2	1			2
4	Professional and Social + Value Added Course							2	1	2
	Total Credit Value	22	8	22	8	24	6	26	6	94

List of Audit Courses (Select any ONE course of Choice from Semester II; Semester III and Semester IV)

Semester I (Compulsory)		Semester II (Choose One)		Semester III (Choose One)		Semester IV (Choose One)	
		Personality and Cultural Development		Technology + Value Added Course		Professional and Social + Value Added Course	
Course Code	Course Title	Course Code	Course Title	Course Code	Course Title	Course Code	Course Title
AC-101	Practicing Cleanliness	AC-201A	Soft Skills	AC-301A	Computer Skills	AC-401A	Human Rights
		AC-201B	Practicing Sport Activities	AC-301B	Cyber Security	AC-401B	Current Affairs
		AC-201C	Practicing Yoga	AC-301C	Introduction to Research	AC-401C	Technical Report Writing
		AC-201D	Introduction to Indian Music	AC-301D	Seminar on Review of Research Paper	AC-401D	Intellectual Property Rights (IPR)

Department of Organic Chemistry, School of Chemical Sciences
Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon
Syllabus under CBCS for M.Sc. Chemistry (with specialization in Organic Chemistry)
Syllabus Structure (w.e.f. 2019-20)
Semester-I

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
CH-101	Core	Inorganic Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-102	Core	Organic Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-103	Core	Physical Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-104	Skill Base	Laboratory Safety Practices	02	--	02	20	--	30	--	50	--	02
CH-105	Skill Base	Inorganic Chemistry Practical-I	--	04	04	--	20	--	30	--	50	02
CH-106	Skill Base	Organic Chemistry Practical-I	--	04	04	--	20	--	30	--	50	02
CH-107	Skill Base	Physical Chemistry Practical-I	--	04	04	--	20	--	30	--	50	02
AC-101	Audit Course	Practicing Cleanliness	--	02	02	--	100	--	--	--	100	02

Semester-II

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th (L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
CH-201	Core	Inorganic Chemistry-II	04	--	04	40	--	60	--	100	--	04
CH-202	Core	Organic Chemistry-II	04	--	04	40	--	60	--	100	--	04
CH-203	Core	Physical Chemistry-II	04	--	04	40	--	60	--	100	--	04
OC-204	Skill Base	Basic Concepts in Instrumentation and Analysis	02	--	02	20	--	30	--	50	--	02
CH-205	Skill Base	Inorganic Chemistry Practical-II	--	04	04	--	20	--	30	--	50	02
CH-206	Skill Base	Organic Chemistry Practical-II	--	04	04	--	20	--	30	--	50	02
CH-207	Skill Base	Physical Chemistry Practical-II	--	04	04	--	20	--	30	--	50	02
AC-201 (A)/(B)/(C)/(D)	Audit Course	Choose one out of four (AC-201 A/B/C/D) (Personality and Cultural Development Related)	--	02	02	100	--	--	--	100	--	02

List of elective courses to be offered in Semester-II:

AC-201 (A): Soft Skills AC-201 (B): Practicing Sports Activities AC-201 (C): Practicing Yoga
AC-201 (D): Introduction to Indian Music

Semester-III

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th (L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
OC-301	Core	Organic Reaction Mechanism	04	--	04	40	--	60	--	100	--	04
OC-302	Core	Spectroscopic Methods in Structure Determination	04	--	04	40	--	60	--	100	--	04
OC -303	Core	Organic Stereochemistry	04	--	04	40	--	60	--	100	--	04
OC-304	Elective	Choose one out of four (OC-304 A/B/C/D) (A) Heterocyclic Chemistry (B) Modern Separation Science (C) Advanced Agrochemicals, Biopesticides and Fertilizers (D) Physical and Mechanical Properties of Polymers	04	--	04	40	--	60	--	100	--	04
OC -305	Skill base	Organic Chemistry Practical Course-III	--	12	12	--	40	--	60	--	100	06
AC-301 (A)/(B)/(C)/(D)	Audit Course	Choose one out of four (AC-301 A/B/C/D) (Technology + Value Added Course)	02	--	02	100	--	--	--	100	--	02

List of Audit courses to be offered in Semester-III:

AC-301 (A): Computer Skills AC-301 (B): Cyber Security AC-301 (C): Introduction to Research

AC-301 (D): Seminar on Review of Research Paper

Semester-IV

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th (L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
OC-401	Core	Chemistry of Natural Products	04	--	04	40	--	60	--	100	--	04
OC-402	Core	Synthetic Methods in Organic Chemistry	04	--	04	40	--	60	--	100	--	04
OC-403	Core	Drug Chemistry	04	--	04	40	--	60	--	100	--	04
OC-404	Skill base	Organic Chemistry Practical Course-IV	--	12	12	--	40	--	60	--	100	06
OC-405*	Skill base	A Short Research Project	--	06	06	--	40	--	60	--	100	06
AC-401 (A)/ (B)/(C)/(D)	Audit Course	Choose one out of four (AC-401/402/403/404) (Professional & Social + Value Added Course)	02	--	02	100	--	--	--	100	--	02

* To be started from Semester-III & evaluated at the end of Semester-IV

List of Audit courses to be offered in Semester-IV:

AC-401 (A): Human Rights AC-401 (B): Current Affairs

AC-401 (C): Technical Report Writing AC-401 (D): Intellectual Property Rights

* To avoid ambiguity with audit course (AC), the course codes of pesticides and agrochemicals have been changed as AC to PA.

Semester-wise Course Structure of M.Sc. Organic Chemistry
Program at a Glance

Name of the program (Degree)	: M. Sc. (Organic Chemistry)
Faculty	: Science and Technology
Duration of the Program	: Two years (four semesters)
Medium of Instruction and Examination	: English
Exam Pattern	: 60 : 40 (60 marks University exam and 40 marks continuous internal departmental exam/assessment)
Passing standards	: 40% in each exam separately (separate head of passing)
Evaluation mode	: CGPA
Total Credits of the program	: 94 (52 core credits including 6 credits of project/dissertation, 34 skill enhancement credits, 04 subject elective credits and 08 audit credits)

Program Objectives for M.Sc. Program:

1. To impart the profound theoretical and practical knowledge of the specific science discipline along with the fundamental core concepts.
2. To train the students to employ modern techniques, tools, methodologies, equipment, hardware/software etc. to perform objective oriented scientific and planned experiments.
3. To groom the students for all-round development and mould them in a trained workforce to provide teaching-learning, research, business, professional supports in the various science disciplines.
4. To make the student to develop the ability to think analytically, independently and draw logical conclusions to solve real-life problems.
5. To utilize the skills and knowledge gained through the subject to deal with real life situations and problems related to society, environment, research and development etc.

Program Outcomes (PO) for M.Sc. Program:

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	PO	Cognitive level
PO1	Understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.	2
PO2	Administer the skills in handling scientific instruments, planning and performing in laboratory experiments	3
PO3	Analyse the given scientific experimental data critically and systematically and the ability to draw the objective conclusions.	4
PO4	Develop various skills such as communication, managerial, leadership, entrepreneurship, teamwork, social, research etc., which will help in expressing ideas and views clearly and effectively	3
PO5	Model and formulate the real problems and find solution based-on knowledge acquired	6
PO6	To evaluate how developments in any science subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments.	5

Program Specific Objectives for M.Sc. Organic Chemistry Program:

- To learn basic concepts, experiments of Physical and Inorganic Chemistry.
- Determine molecular structure by using UV, IR, NMR and Mass.
- Draw mechanism for organic reactions.
- Learn the basic skills of research.
- To learn chemistry of natural products and drugs.
- Study of stereochemical aspects of organic reactions.
- Design the organic synthesis using retrosynthesis and synthetic catalysts/reactions.
- To get laboratory skills of organic synthesis.

Program Specific Outcomes (PSOs) for M.Sc. Organic Chemistry Program:

After successful completion of two-year master's degree program in Organic Chemistry, should be able to;

PSO No.	PSO	Cognitive level
PSO1	Demonstrate an understanding of the basic concepts, fundamental principles, and the scientific theories related to Physical, Inorganic, Organic Chemistry and their relevancies in the day-to-day life, industry, and health.	2
PSO2	Gain proficiency and skills in laboratory techniques of Chemistry with handling scientific instruments, planning and performing in laboratory experiments.	3
PSO3	Acquire significant knowledge on various aspects related to Chemistry including synthesis, reaction mechanism, qualitative and quantitative analysis, characterization, stereochemistry, natural products, heterocycles, drugs.	4
PSO4	Analyze the given scientific experimental data (reactants, intermediates, products, reagents, catalyst, solvent, temperature, yield, purity, spectral data etc.) critically and systematically and the ability to draw the objective conclusions.	4
PSO5	Decide, evaluate, estimate, and justify real problems of the Chemistry in the society.	5
PSO6	Designing synthesis and applications of organic compounds.	6

Semester-I

CH-101: Inorganic Chemistry-I (Core course; Theory; 60 h, 100 Marks and 4 Credits)

Course Objectives:

- The course offers the basic concepts of inorganic chemistry lying on synthesis, structure, bonding and properties of some selected main group elements.
- The course helps to build up a conceptual framework for understanding the principles and theories for chemical bonding and properties of inorganic compounds.
- The course furnishes detail knowledge about synthesis, types of bonding, properties etc.

Course Contents (Topics and subtopics)

Unit I	Molecular Symmetry and Applications	12 h
	Symmetry elements and operations, Classification of symmetry elements, Orbital symmetry, point groups, Examples of C_n , C_{nv} , C_{nh} , D_n , D_{nh} , D_{nd} , T_d , T_h , O , O_h ,. Identification of optical Isomerism and Dipole moment.	
Unit II	Organometallic compounds of transition metals	12 h
	Molecular Orbital Theory and its application. BeH_2 , BF_3 , CH_4 , NH_3 , H_2O . Organometallic compounds, Molecule orbital theory and 18 electron rule, Counting electrons in complexes. Alkyl and aryl complexes, Alkene complexes. Metal π complexes- Metal carbonyl and metal nitrosyls.	
Unit III	Chemistry of non transition elements	12 h
	Hydrides-classification, electron deficient, precise and rich hydrides. Study of PH_3 , SbH_3 , AsH_3 , selenides, Tellurides. Synthesis, properties and structures of alkali and alkaline earth metal compounds, Synthesis and reactivity of inorganic polymer of Si and P. Metal Clusters: Boranes: Classification, synthesis, structure and topology (B_2H_6 to $B_{10}H_{14}$) Carboranes: Classification, Synthesis and structure.	
Unit IV	Ionic solids	12 h
	The Ionic solids. Classification of ionic structures, radius ratio rules, calculation of some limiting radius ratio values, close packing, Structures of ionic solids. A cautionary word on radius ratios. Lattice energy. The Born - Haber cycle,	

Applications of lattice energy. Resonance: resonance energy. Concept of formal charge, criteria for resonating structures. Hydrogen bonding concept and structure of water, alcohols, phenols, types, properties.

Unit V Bioinorganic chemistry

12 h

Introduction to bio-inorganic chemistry, Metalloproteins and metalloenzymes, amino acids in metal binding sites. Selective transport and storage of iron (siderophores, iron transport proteins in higher organisms, release of iron transferrin, ferritin, the cellular Fe store), electron transfer (General considerations, Electron transfer cytochrome, FeS clusters, copper transfer centers), ionophores.

Recommended Books:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry Principles of Structures and Reactivity, 4th edition, New York, NY: Harper Collins College Publishers, 1993.
2. J. D. Lee, Concise Inorganic Chemistry, 5th edn., Blackwell Science, London, 2006.
3. A. G. Sharpe, Inorganic chemistry, 3rd edition, ISBN 9788131706992, Pearson Education, 1981.
4. F.A. Cotton, Chemical Applications of Group Theory, ISBN: 978-0-471-51094-9, 1990.
5. D.F. Shriver, P.W. Atkins and C.H. Langford, Inorganic Chemistry, CH Langford, 1990.
6. B.R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Shoban Lal Nagin Chand and Co., 2005.
7. H. B. Gray, Electrons and Chemical Bonding. W. A. Benjamin, Inc., New York, 1965.
8. H. J. Emeleus and A.G. Sharpe, Modern Aspects of Inorganic Chemistry, Universal Book Stall, New Delhi.
9. K. Lal, S.K. Agarwal, Advanced Inorganic Chemistry, Pragati Prakashan, Meerut, 2017
10. G. S. Manku, Theoretical Principles of Inorganic Chemistry, Tata McGraw-Hill Ed
11. B. Douglas, D.H. Mc. Daniel, J.J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd edition.
12. R. Sarkar, General and Inorganic Chemistry, Part one, New Central Book Agency, Kolkata.
13. P. K. Bhattacharya, Group Theory and its Chemical applications, Himalaya Publishing House.
14. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, Sixth Edition, John Wiley & Sons, Inc.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH101.1	Demonstrate knowledge of advanced content in the areas of inorganic chemistry such as in Molecular symmetry, organometallic compounds, bioinorganic compounds, Chemistry of non transition element and ionic solids	3
CH101.2	Understand fundamental reaction types and mechanisms in organometallics	2
CH101.3	Identify point groups and illustrate MOT diagram of inorganic compounds	4
CH101.4	Determine and explain the structure of ionic solids	5
CH101.5	Analyze the chemical and physical properties of metal ions responsible for their biochemical action as well as the techniques frequently used in bio inorganic chemistry such as oxygen transport, e-transfer, catalysis, transport, storage etc.	4

CH-102: Organic Chemistry-I
(Core course; Theory; 60 h, 100 Marks and 4 Credits)

Course Objectives:

- To learn IUPAC nomenclature and aromaticity of organic compounds.
- To identify electrophiles, nucleophiles, and intermediates in organic reactions.
- To understand the types, mechanism, and course of organic reactions.

Course Contents (Topics and subtopics)

Unit I	A] IUPAC Nomenclature of Organic Compounds including Regio- and Stereoisomer's B] Aromaticity - Huckel's rule and Concept of Aromaticity, Non aromaticity and Antiaromaticity, Annulenes and Heteroannulenes, Fullerenes (C ₆₀).	12 h
Unit II	Nucleophilic substitutions at saturated carbon The Reaction Mechanism: Reactivity at a Saturated Carbon Atom, Available Pathways, The S _N 1 Mechanism, S _N 2 Mechanism. Stereochemistry of Nucleophilic Substitution: The S _N 2 reaction, S _N 1 reaction. The Variables in Nucleophilic Substitution: The Leaving Group, The Nucleophile, The Site of Substitution, Solvent Effects, Solvolysis, S _N 1 versus S _N 2. Neighboring Group Participation.	12 h
Unit III	Electrophilic aromatic substitution Mechanism and Orientation in Electrophilic Aromatic Substitution: An Addition-Elimination Mechanism, Ortho, Meta and Para Orientation, Relative Rates of Substitution, The Rate Orientation Relation, Orientation in Multiply Substituted Aromatics, A Pi-complex intermediate. Electrophilic Aromatic Substitution Reactions– Heteroatom's as the Electrophiles: Nitration, Halogenation, Sulfonation, Diazonium Coupling, Ipso Substitution. Carbon as the Electrophiles: Friedel-Craft Alkylation, Friedel-Craft Acylation. Nucleophilic Aromatic Substitutions: The Addition-Elimination Mechanism, The Elimination-Addition Mechanism Benzyne, The Aryl Cation Mechanism - Diazonium Salts.	12 h
Unit IV	Elimination reactions-alkenes and alkynes The Reaction Mechanism: The E1, E2 & E1cB Mechanism, Mechanistic Variables,	12 h

E1 Versus E2. Elimination Versus Substitution: Basicity Versus Nucleophilicity, Substrate Structure, Solvent, Temperature. The Direction of Elimination: Formation of the More-Substituted Alkene, Formation of the Less-Substituted Alkene. Stereochemistry: Anti Elimination, Stereo electronic Factors, Syn Elimination. Formation of Alkenes: Dehydrohalogenation, Dehalogenation, Dehydration, Hofmann Elimination, Pyrolytic Elimination, Catalytic Dehydrogenation. Formation of Alkynes.

Unit V Electrophilic additions to unsaturated carbon

12 h

The Mechanism of Electrophilic Addition: The Ad_E2 Mechanism, Structural Effects and Reactivity. Direction and Stereochemistry of Addition: Markovnikov Orientation, Stereochemistry of Addition. Additions to Alkenes and Alkynes: Halogenations, Hydrohalogenation, Hydration, Hydroboration, Epoxidation-Hydroxylation, Carbene Addition, Hydrogenation, Ozonolysis.

Additions to conjugated compounds:

Conjugated Dienes: The Mechanism of Electrophilic Conjugate Addition, Kinetic and Equilibrium Control. Double Bonds Conjugated with Carbonyl Groups: Mechanism of Nucleophilic Conjugate Addition, Conjugate Additions in Synthesis.

Recommended Books:

1. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, IInd Edition, Oxford University Press.
2. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson.
3. J. March, Advance Organic Chemistry: Reactions, Mechanisms and Structure, 4th Edition, Wiley.
4. S. H. Pine Organic Chemistry, 5th Edition, McGraw-Hill.
5. P. S. Kalsi, Stereochemistry: Conformation and Mechanism, 8th Edition, New Age International.
6. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, Revised 2nd Edition, New Age International.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH102.1	Understand the fundamental concepts of organic reaction mechanism.	2
CH102.2	Analyze different types of organic reactions.	4
CH102.3	Predict organic reactions and their mechanism.	5

CH-103: Physical Chemistry-I
(Core course; Practical; 60 h, 100 Marks and 4 Credits)

Course Objectives:

- To impart intensive and extensive knowledge of the subject enriching graduate to understand the role of thermodynamic chemistry in the field of science.
- To develop skill and capabilities of student insolving problem of daily routine life using thermodynamic and statistical thermodynamics.
- To understand principles of quantum mechanics and their applications to various chemistry phenomenon's.

Course Contents (Topics and subtopics)

Unit I	Thermodynamics	12 h
	Laws of thermodynamics, Maxwell relations, thermodynamic equation of state, partial molar quantity and its significance, partial molar volumes, chemical potential, Gibbs-Duhem equation, thermodynamics of mixing- Gibb's free energy of mixing, entropy of mixing, enthalpy of mixing, volume of mixing.	
Unit II	Phase equilibria	12 h
	Phase, components, degree of freedom, the Gibb's phase rule, derivation of phase rule, phase equilibria of one component system (water and carbon dioxide system), phase equilibrium of two component system (two component system solid-liquid equilibria and simple eutectic systems), phase equilibrium of three component system, Clapeyron equation, Clausius-Clapeyron equation, integrated form of Clausius-Clapeyron equation.	
Unit III	Electrochemistry	12 h
	Anomalies of strong electrolytes, Debye-Hückel theory of strong electrolytes, relaxation effect (asymmetry effect), electrophoretic effect, activity coefficients of electrolytes, mean ionic activity coefficient, ionic strength of a solution, Debye-Hückel limiting law equation (derivation not expected) and experimental verification of it.	
Unit IV	Nuclear Chemistry	12 h

Radioactive elements, types of radioactive decay, decay kinetics-the decay constant, the half life period and mean life, units of radioactivity, nuclear reactions, Bethe's notation, types of nuclear reactions, special nuclear reactions, cross-section, Q-value of nuclear reactions, nuclear fission, nuclear fusion, nuclear detectors (Proportional counter and Geiger-Muller counter).

Unit V Chemical Kinetics

12 h

Reaction rates, rate laws and rate constants, effect of temperature on reaction rates, complex reactions, types of complex reactions and their kinetics (opposing reactions, parallel reactions, consecutive reactions), chain reactions and its characteristics, kinetics of chain reactions, Michaelis-Menten mechanism and equation.

Recommended Books:

1. P. W. Atkins, Physical Chemistry, ELBS, 1998
2. G. M. Barrow, Physical Chemistry, International student edition, 2003.
3. G. W. Castellan, Physical Chemistry, AddisonWesley.
4. W. J. Moore, Physical Chemistry, Orient Longman, 1998.
5. S. Glasstone, D. Van Nostrand, Thermodynamics for Chemist, 1965.
6. S. Glasstone, V. Nostrand An Introduction to Electrochemistry, East-West 1965.
7. J. O'M Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. I and II, 2nd Edition, Plenum, 1977.
8. R. A. Robinson and R. H. Stokes, Electrolytic Solutions, Butterworths, London, 1959.
9. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age Publication Ltd., 1995.
10. G. Friedlander, J. W. Kennedy, E. S. Macias, J. M. Miller, Nuclear and Radiochemistry, John-Wiley, 1981.
11. B. G. Harwey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, 1963.
12. Source book of Atomic Energy, S. Glasstone, van Nostrand, 1967.
13. K. J. Laidler, Chemical Kinetics, McGraw Hill, 1985.
14. J. W. Moore, R. G. Pearson, Kinetics and Mechanism, John Wiley & Sons, 1981

15. G. L. Agrawal, Basic Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH103.1	Acquire knowledge on the fundamental and advance concepts of thermodynamics	3
CH103.2	Familiarize with phase rule	2
CH103.3	Apply the knowledge to explore applications of electrochemistry	3
CH103.4	Gain thorough knowledge about fundamental aspects on Nuclear chemistry	3
CH103.5	Understand fundamental as well as kinetics of Complex reactions	2

CH-104 Laboratory Safety and Practices

(Core course; Practical; 30 h, 50 Marks and 2 Credits)

Course Objectives:

- This course offers to create awareness about laboratory safety.
- This course offers to increase alertness about any hazardous handling at workplace.
- This course offers to increase awareness about personal protective equipment.

Course Contents (Topics and subtopics)

Unit I	A. History and importance of safety and health in Laboratory - Moral, legal and financial reasons B. Different types of Hazards at workplace handling chemicals C. Physical, chemical, biological, allergens, hazards pertaining electrical system - Effect of hazards on health - Where to find Hazard information-Reading Labels D. Safety Measures: Safe clothing, hair, dangling jewellery responsible attitude, good House Keeping, use of proper PPE, No food in the laboratories.	06 h
Unit II	Personal Protective and other safety equipment and their uses and demonstration, Different types of safety goggles, apron, masks, different filters for masks, face shield, full body suit, safety shoes, helmet, breathing apparatus suit, safety belt and ear muffs along with inspection methods. Emergency exit, its location and approach path, periodic inspection fire extinguishers, first aid kit, its contents and need for monitoring. Eye wash fountains and safety showers, fire drill, and chemical accident drills, accident free days and incentives to follow safety rules, accident recording and investigation for future controls.	06 h
Unit III	Types of fire extinguishers and their method of use Material Safety Data Sheets, Globally Harmonised System (GHS) Signs(http://www.calstatela.edu/univ/ehs/msds.php) Importance and use of current 16 points format, Labels, Pictograms and some of their discrepancies,	06 h

Globally Harmonized System for Safety Data Sheets (SDS), label changes (2014).

Unit IV Inventory Management, Storage and Disposal, Waste classification, **06 h**
Hazardous waste, Non-Hazardous waste, mixed waste, Waste disposal, Actions required for – Chemical spills, Mercury spills, Injuries, Fires, Building evacuations, Emergency evacuation procedure.

Unit V Good Laboratory Practices (GLP), Introduction and principles of GLP, **06 h**
Performance of laboratory studies and calibration using Standard Operating Procedures (SOPs), Instrument validation, Reagent certification, Laboratory notebook maintenance to contemporary standards, maintenance of laboratory records based on instrument and reagent certification. Introduction to ISO and NABL accreditation.

Recommended Books:

1. L. Moran, T.Masciangioli, Chemical Laboratory Safety and Security : A Guide to Prudent Chemical Management, The National Academies Press, Washington, DC, 2010.
2. D. C. Finster, Safety in Academic Chemical Laboratory, Vol. II, ACS Publication, 7th Edition, 2003.
3. OECD Series on Principles of Good Laboratory Practices and Compliance Monitoring, 1997.
4. Handbook of Good Laboratory Practices, TDR, WHO, UNICEF, UNDP, 2009.
5. L. Huber, A Primer for Good Laboratory Practices and Good Manufacturing Practices, Agilent Technologies, 2002.
6. T. Kletz, What Went Wrong, Gulf Professional Publisher, 1998.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH104.1	To adapt the rules and regulations of safety practices in the laboratory.	6
CH104.2	To develop the experimental skill while performing in the laboratory.	3
CH104.3	To practice for the laboratory working.	3

CH-105: Laboratory Course in Inorganic Chemistry-I

(50 Marks and 2 Credits)

Course Objectives:

- The course offers to develop the experimental skills in inorganic chemistry.
- The course also offers to use different analysis techniques required in analysing inorganic compounds.
- The course helps in developing skills of the graduate in the preparation and purity estimation of inorganic compounds.

Course Contents (Topics and subtopics)

Perform **any eight experiments** out of the followings:

1. Pyrolusite ore - Estimation of silica gravimetrically and Manganese volumetrically.
2. Analysis of Alloy: Solder alloy – Estimation of Tin gravimetrically and Lead volumetrically.
3. Drug Analysis: Determination of iron from given drug sample.
4. Preparation and purity determination of Bis (ethylene diamine) copper (II) sulphate.
5. Preparation and purity determination of Chloro penta-ammino cobalt (III) chloride.
6. To determine the amount of copper present in given solution by iodometric method potentiometrically.
7. Preparation and purity determination of Tris (acetylacetonato) Iron (I II).
8. Preparation and purity determination of Tris (ethylene diamine) nickel (II) thioisulphate.
9. Preparation and purity determination of potassium trioxalato Aluminate (III).
10. Preparation and purity determination of hexamine nickel (II) chloride.

Recommended Books:

1. A.I. Vogel, Text book of Quantitative Analysis, 4th edition, 1992.

2. A.B. P. Lever, Inorganic electronic spectroscopy. Amsterdam, The Netherlands: Elsevier, 1984.
3. Inorganic Synthesis (Vol. Series).

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH105.1	Analyze the alloy concentration and estimate volumetrically the concentration of Mn, Sn and Pb using titration method	4
CH105.2	Carry out the preparation and purity determination of the metal complexes Potassium trioxalatoaluminate (III), Bis (ethylene diamine) copper (II) sulphate., Hexamminenickel(III) chloride.	3
CH105.3	Carry out Ca-Drug Analysis and the volumetric estimation of Ca.	3

CH-106: Laboratory Course in Organic Chemistry-I

(50 Marks and 2 Credits)

Course Objectives:

- To learn different techniques for purification of organic compounds.
- To synthesis derivatives of organic compounds.
- To get knowledge of utilizing computer software's for drawing structures of organic compounds.

Course Contents (Topics and subtopics)

1. Techniques: (At least one practical of each technique)

Crystallization, Sublimation, Distillation, Steam Distillation, Column Chromatography, Thin Layer Chromatography, Solvent Extraction.

2. Preparation of Derivatives: (Each Derivative of at least one Compounds)

Oxime, 2, 4-DNP, Acetyl, Benzoyl, Semicarbazone, Anilide, Amide, Aryloxyacetic acid, Ester.

3. Use of Computer - Chem Draw-Sketch, ISI – Draw: (Max. 09 Hours for each batch)

Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituent's.

Get the correct IUPAC name.

Recommended Books:

1. A.J. Hannaford, A.R. Tatchell, B.S. Furniss, P.W.G. Smith, Vogel's Textbook of Practical Organic Chemistry, 5th Edition
2. R. K. Bansal, Laboratory Manual of Organic Chemistry, New Age International Publisher
3. L. D. Field, S. Sternhell, J. R. Kalman, Organic Structures from Spectra, 4th Edition, John Wiley & Sons, Ltd.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH106.1	Purify the organic compounds using different purification techniques or methods.	4
CH106.2	Prepare the derivatives of organic compounds.	4
CH106.3	Draw the structures and reactions using chem draw computer software.	3

CH-107: Laboratory Course in Physical Chemistry-I (50 Marks and 2 Credits)

Course Objectives:

- This course offers to develop the experimental skills in physical chemistry.
- This course also offers to analyse data based on instrumental methods for analysis.
- This course helps in determining the physical constants by different methods.

Course Contents (Topics and subtopics)

Perform **any eight experiments** in Semester I of the followings:

1. To determine the pK_a value of a given weak monobasic acid potentiometrically.
2. To determine the redox potential of Fe²⁺/Fe³⁺ system potentiometrically.
3. To determine the hydrolysis constant of sodium acetate conductometrically.
4. To determine the concentration of hydrochloric acid and acetic acid in a given mixture by titrating it with a standard solution of sodium hydroxide conductometrically.
5. To determine the pH values of various mixtures of sodium acetate and acetic acid in aqueous solutions and find out the dissociation constant of the acid.
6. To determine the pK_a value of the acetic acid pH-metrically.
7. To test the validity of Beer's-Lambert's law and hence determine the concentration of given unknown solution spectrophotometrically.
8. To investigate the kinetics of a reaction between potassium persulphate and potassium iodide.
9. To determine the concentration of a given solution of an optically active substance by polarimetric measurements.
10. To determine the specific and molar refraction of a given liquid by refractometer.

Recommended Books:

1. J. A. Kitcher, Findlay's Practical Physical Chemistry, 1963.
2. A. I. Vogel, Text Book of Quantitative Inorganic Analysis.

3. R. C. Das and B. Behera, Experimental Physical Chemistry, 1984.
4. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing.
5. F. Daniels and J. Williams. Experimental Physical Chemistry, McGraw-Hill Publishing Co., Ltd
6. D. Shoemaker, Advanced Physical Chemistry Experiments.
7. H. H.; Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Jr. Instrumental Methods of Analysis.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH-107.1	Provide guidance and practice about each experiment by studying lab handouts and links therein.	3
CH-107.2	Practice learned for safety requirements and lab skills to perform physico-chemical experiments.	3
CH-107.3	Provide guidance and practice about to keep records of instruments, parameters, and experimental observations reporting of experimental result.	3
CH-107.4	An appraise for modern problems and scientific controversies in physical chemistry.	5
CH-107.5	Develop more interest to learn and handle new instruments.	6

M.Sc. Part I Semester I Organic Chemistry: Audit Courses

AC-101: Practicing Cleanliness (Compulsory; Campus-level Audit Course; Practical; 2 Credits)		
Course Objectives (COs): To make students aware of Clean India Mission and inculcate cleanliness practices among them.		
	- Awareness program on - Swachh Bharat Abhiyan (Clean India Mission) - Clean Campus Mission - Role of youth in Clean India Mission - Cleaning activities inside and surroundings of Department buildings. - Tree plantation and further care of planted trees - Waste (Liquid/Solid/e-waste) Management, Japanese 5-S practices - Planning and execution of collection of Garbage from different sections of University campus - Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance. - Cleanest School/Department and Cleanest Hostel contests - Painting and Essay writing competitions	

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC101.1	Identify need at of cleanliness at home/office and other public places.	2
AC101.2	Plan and observe cleanliness programs at home and other places.	4
AC101.3	Practice Japanese 5-S practices in regular life.	3

Semester-II
CH- 201: Inorganic Chemistry-II
(60 h, 100 Marks and 4 Credits)

Course Objectives:

- This course offers to impart the basic knowledge about spectroscopy of inorganic compounds.
- This course also offers to study the reaction mechanism in transition metal complexes.
- This course helps to understand catalysis and structure reactivity of molecules.

Course Contents (Topics and subtopics)

Unit I	Spectroscopic term symbols	12 h
	Microstates- significance and their determinations, Groundstate terms, energy ordering of terms, derivation of the total term symbols for a d^1 to d^5 configuration, correlation diagram for d^2 and d^8 configuration in tetrahedral and octahedral complexes, Orgel diagram for d^1 to d^{10} configuration in tetrahedral and octahedral complexes, selection rule, noncrossing rule.	
Unit II	Charge transfer transition	12 h
	Types of charge transfer transition, interpretation of electronic spectra of octahedral complexes, intensity of spectral bands, d-d bands, charge transfer bands, Konig's methods for calculations of Dq , B and β parameters, numerical	
	Magnetic properties of complexes, paramagnetism, quenching of orbital angular momentum by ligand fields, Magnetic properties of A, E and T ground terms in complexes, Spin free - spin paired equilibria.	
Unit III	Reaction mechanism in transition metal complexes	12 h
	Ligand substitution reaction, classification of mechanism, substitution of square planer complexes, nucleophilicity of entering group, shape of activated complexes, K_1 pathway, substitution in octahedral complexes, rate law and their interpretation, activation of octahedral complexes, base hydrolysis, stereochemistry, isomerisation reactions.	
Unit IV	Catalysis	12 h

Catalysis, description of catalyst, properties of catalyst, types of catalyst, catalytic steps in organotransition metal catalyst, hydrogenation of alkenes, hydroformylation, Monsanto acetic acid synthesis, Wacker oxidation of alkenes, alkene polymerization, heterogeneous catalysis, nature of heterogeneous catalyst. examples of heterogeneous catalysts (hydrogenation, oxidation).

Unit V The Structure and Reactivity of molecules 12 h

VSEPR Theory, structures of molecules containing lone pair of electrons, Sulphur tetrafluoride, Bromine trifluoride, dichloroiodate(I)anion, pentafluorotellurate (IV)anion, tetrachloroiodate (III)anion, nitrogen dioxide, nitrite ion and nityrl ion, phosphorus trihalides, carbonyl fluoride, summary of VSEPR Rules,

Recommended Books:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry Principles of Structures and Reactivity, 4th edition, New York, NY: Harper Collins College Publishers, 1993.
2. J.D. Lee, Concise Inorganic Chemistry, 5thedn., Blackwell Science, London, 2006.
3. A. G. Sharpe, Inorganic chemistry, 3rd edition, ISBN 9788131706992, Pearson Education,1981.
4. F.A. Cotton, Chemical Applications of Group Theory, ISBN: 978-0-471-51094-9, 1990.
5. D.F. Shrivvers, P.W. Atkins and C.H. Langfor, Inorganic Chemistry, CH Langford, 1990.
6. B.R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Shoban Lal Nagin Chand and Co.,2005.
7. H. B. Gray, Electrons and Chemical Bonding. W. A. Benjamin, Inc., New York, 1965.
8. H. J. Emeleus and A.G. Sharpe, Modern Aspects of Inorganic Chemistry, Universal Book Stall, New Delhi.
9. K. Ial, S.K. Agarwal, Advanced Inorganic Chemistry, Pragati Prakashan, Meerut, 2017.
10. G.S. Manku, Theoretical Principles of Inorganic Chemistry, Tata

McGraw-Hill Ed.

11. B. Douglas, D.H. Mc. Daniel, J.J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd edition.
12. R. Sarkar, General and Inorganic Chemistry, Part one, New Central Book Agency, Kolkata.
13. P.K. Bhattacharya, Group Theory and its Chemical applications, Himalaya Publishing House.
14. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, JOHN WILEY & SONS, INC.
15. K. Arora, Concept and Applications of Group Theory, Anmol Publication Pvt. Ltd., New Delhi.
16. W. L. Jolly, Modern Inorganic Chemistry, 2nd edition, Tata McGraw Hill Co.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH201.1	Illustrate microstates, spectroscopic terms and Orgel and Tanabe-Sugano diagram of inorganic molecules for octahedral and tetrahedral complexes.	4
CH201.2	Classifies ligand substitution reactions and explains its kinetics and various mechanisms.	2
CH201.3	Understand theory and mechanism of catalytic action of catalysts.	2
CH201.4	Understand VSEPR theory and explain the structures based on it.	2

CH-202: Organic Chemistry-II

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- To learn various name reactions, rearrangements, and reagents useful in organic chemistry.
- To study the basic concepts of stereochemistry.
- To determine structures of organic compounds by UV, IR, and NMR spectroscopy.

Course Contents (Topics and subtopics)

Unit I	Selective name reactions Strok Enamine Reaction, Michael addition, Mannich reaction, Sharpless asymmetric epoxidation, Ene reaction, Barton reaction, Hofmann Löffler-Freytag reaction, Shapiro reaction, Chichibabin reaction, Wittig reaction, Aldol, Perkin, Stobbe, Benzoin, Claisen, Dieckmann, Pechmann Condensation.	12 h
Unit II	Rearrangements Wagner-Meerwein, Pinacol, Wolff, Arndt-Eistert Synthesis, Hofmann, Curtius, Schmidt, Lossen, Beckmann, Baeyer-Villiger, Favorskii, Benzilic acid, Stevens, Wittig, Meisenheimer, Claisen, Cope.	12 h
Unit III	Reagents in organic synthesis Gilman's reagent, diisopropylamide (LDA), dicyclohexylcarbodiimide (DCC), 1, 3-dithiane (reactivity umpolung), Trimethylsilyl iodide, tri-n-butyltin hydride, Woodward and Prevost hydroxylation, osmium tetroxide (OsO ₄), DDQ, selenium dioxide, Chromic acid, phase transfer catalysts, B ₂ H ₆ , Peterson's synthesis, Wilkinson's catalyst, Baker's yeast.	12 h
Unit IV	Stereochemistry Stereoisomers, Chirality, Enantiomers, Diastereoisomers, R-S nomenclature, E-Z isomerism, Meso Compounds, Threo and Erythroisomers. Interconversion of Fischer into Sawhorse and Newman Projections. Conformations and Stereoisomerism of acyclic compounds (ethane, propane, butane) and cyclic compounds (cyclohexane, substituted cyclohexanes).	12 h
Unit V	A] U.V. spectroscopy Woodward-Fisher rules for conjugated dienes and carbonyl compounds, applications of UV. B] IR Spectroscopy Characteristics vibrational frequencies of alkanes, alkenes, aromatic compounds, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, amides, anhydrides, lactones and lactams. Effect of hydrogen bonding and solvent effect on vibrational frequencies, applications of IR. C] ¹H NMR Spectroscopy Chemical shift, factors influencing chemical shift, shielding-deshielding, spin-spin coupling (n+1) rule, Pascals triangle, factors affecting on coupling constant.	12 h

Joint Problems based on UV, IR & ^1H NMR.

Recommended Books:

1. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, IInd Edition, Oxford University Press.
2. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson.
3. J. March, Advance Organic Chemistry: Reactions, Mechanisms and Structure, 4th Edition, Wiley.
4. S. H. Pine Organic Chemistry, 5th Edition, McGraw-Hill.
5. P. S. Kalsi, Stereochemistry: Conformation and Mechanism, 8th Edition, New Age International.
6. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, Revised 2nd Edition, New Age International.
7. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry Part-B: Reactions and Synthesis, 5th Edition, Springer.
8. E. L. Eliel, Stereochemistry of Carbon Compounds, McGraw-Hill.
9. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th Edition, New Age International.
10. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH202.1	Identity selected named reactions and reagents.	2
CH202.2	Discuss useful rearrangements.	2
CH202.3	Acquire basic knowledge of stereochemistry in organic synthesis.	4
CH202.4	To predict the structure of organic compounds.	5

CH-203: Physical Chemistry-II (60 h, 100 Marks and 4 Credits)

Course Objectives:

- This course offers to gain the basic knowledge about quantum chemistry and macromolecule.
- This course helps to understand the principles and laws in photochemistry.
- This course offers to know about the theory behind microwave and infrared spectroscopy.

Course Contents (Topics and subtopics)

Unit I	Quantum Mechanics Introduction to quantum mechanics, wave function and its physical meaning, conditions for acceptable wave function, operators, algebra of operators (addition subtraction and multiplication), commutative property, linear operator, commutator operator, the operator ∇ and ∇^2 , eigen values and eigen functions, basic postulates of quantum mechanics.	12 h
Unit II	Macromolecules Macromolecules, degree of polymerization, high polymers and oligomers, molecular weight of macromolecules (number average molecular weight and weight average molecular weight), determination of molecular weight of macromolecules (by viscometry and osmometry method), chain polymerization and its kinetics, kinetic chain length and its significance, step growth polymerization and its kinetics.	12 h
Unit III	Microwave Spectroscopy Introduction, the rotation of molecules, classification of molecules on the basis of the relative values of their three principal moments of inertia (linear, symmetric top, spherical top and asymmetric top molecules), rotational spectra of diatomic molecules, polyatomic molecules, Stark effect in microwave spectra, microwave oven, techniques and instrumentation.	12 h
Unit IV	Infra-red Spectroscopy Introduction, principle of infra-red spectroscopy, theory-molecular vibrations, vibrational frequency, force constant, calculations of number of fundamental modes of vibrations for linear and non-linear molecules, fundamental modes of vibrations of water molecule and carbon dioxide molecule and their infra-red activity, techniques and instrumentation.	12 h
Unit V	Photochemistry Introduction, photochemical reactions, quantum yield, Jablonski diagram, photosensitization reactions, fluorescence (resonance fluorescence, sensitized fluorescence and quenching of fluorescence), phosphorescence,	12 h

Stern-Volmer equation.

Recommended Books:

1. R. K. Prasad, Quantum Chemistry, Wiley Eastern Ltd, 1992.
2. Introductory to Quantum Chemistry, A. K. Chandra, Tata McGraw Hill, 1979.
3. I. N. Levine, Allyn and Bacon Quantum Chemistry.
4. M. Hanna, Quantum Mechanics in Chemistry, John Wiley and Sons 1970.
5. P. W. Atkins, Physical Chemistry, ELBS, 1998
6. G. M. Barrow, Physical Chemistry, International student edition, 2003.
7. F.W. Billmeyer Jr., Polymer Chemistry, John-Wiley and sons 1971.
8. D. D. Deshpande, Polymer Chemistry of Macromolecules, Vishal Publications, 1984.
9. C. N. Banwell, E. M. Mac Cash, Fundamentals of Molecular Spectroscopy, fourth Edition, McGraw Hill.
10. G. M. Barrow. Molecular Spectroscopy,
11. Rohatgi-Mukherjee, Fundamentals of Photochemistry, Wiley-Eastern Ltd., New Delhi, 1978.
12. R. P. Wayne, Principles and Application of Photochemistry, Oxford University Press, 1988.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH203.1	Understand the fundamental and advance concepts of quantum chemistry.	2
CH203.2	Know more about Macromolecules.	2
CH203.3	Describe theoretical aspect of spectroscopy, which is helpful in development of theoretical research in physical chemistry.	2

PC-204: Basic Concepts of Polymer Chemistry/PA-204: Basic Concepts of Pesticides and Agrochemical Chemistry/ IC-204: Basic Concepts of Industrial Chemical Processes/ PH-204: Chemical Mathematics/ AN-204: Basic Concepts of Instrumentation and Analysis

(Choose Any One out of five: PC/PA/IC/PH/AN-204)

PC-204 Basic Concepts of Polymer Chemistry

(30 h, 50 Marks and 2 Credits)

Course Objectives:

- The graduate will be able to know basics concepts of polymer chemistry.
- The graduate will also be able to study various mechanisms of polymerization and learn different techniques of polymerization.
- The graduate will also be able to understand biodegradation of polymers and its importance.

Course Contents (Topics and subtopics)

Unit I	Basic concepts and classification of polymers	06 h
	Basic concepts - polymer, monomer and polymerization, functionality and reactivity, Classification of polymers based on - source, chemical nature, thermal response, ultimate form and branched/network structures, homopolymer and copolymer (types)	
Unit II	Mechanisms of polymerisations	06 h
	Mechanisms of chain and step growth polymerizations, ring opening polymerisation, Miscellaneous polymerisations - electrochemical polymerisation, metathesis polymerisation, group transfer polymerisation	
Unit III	Techniques of polymerisations	06 h
	Bulk polymerisation, solution polymerisation, suspension polymerisation, emulsion polymerisation, melt polycondensation, solution polycondensation, and interfacial polycondensation, solid and gas phase polymerisation	
Unit IV	Molecular weights and nomenclature of polymers	06 h

Degree of polymerisation, various average molecular weights (M_n , M_w , M_v and M_z) and molecular weight distribution (MWD), nomenclature of polymers based on - source, structure, IUPAC

Unit V Polymer degradation

06 h

Polymer degradation and stability, thermal degradation, chain scission, non-chain scission, oxidative and UV stability, chemical and hydrolytic stability, radiation effect, mechano degradation, biodegradation – biodegradable polymers (PLA) and starch additives.

Recommended Books:

1. V. R. Gowarikar, N. V. Viswanathan and Jayadev Sreedhar, Polymer Science, New Age International (P) Limited, New Delhi, 1988.
2. M. P. Stevens, Polymer Chemistry an Introduction, 2nd Edition, Oxford University Press, New York, 1999.
3. J. R. Fried, Polymer Science and Technology, Eastern Economic Edition, Printice Hall of India, New Delhi, 2000.
4. C. E. Carraher Jr Introduction to Polymer Chemistry, Special Indian Edition, Taylor and Francis, New Delhi, First reprint, 2010.
5. P. Ghosh, Polymer Science and Technology, Plastics, Rubbers, Blends and Composites, , 3rd Edition, Tata McGraw Hill Education Private Ltd., New Delhi, 2011.
6. ,F. W. Billmayer, Text Book of Polymer Science John Wiley and Sons, New Delhi, 1984.
7. G. Odian, Principles of Polymerisation, 3rd Edition, Odian, John Wiley & Sons (Asia) Pvt. Ltd., Singapore, 2002.
8. P. Bahadur and N. V. Sastry, Principles of Polymer Science, 2nd Edition, Narosa Publishing House, New Delhi, 2012.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
PC204.1	To recall the basic concepts and classification of polymers.	2
PC204.2	To explain the basic techniques of polymerisation.	4

PA-204: Basic Concepts of Pesticides and Agrochemical Chemistry

(30 h, 50 Marks and 2 Credits)

Course Objectives:

- This course gives basic knowledge and importance of agrochemicals.
- This course helps to distinguish types of pesticides based on their properties and their effects.
- This course offers to study the ways of pest control.

Course Contents (Topics and subtopics)

Unit I	Pests Definition, introduction, Classification of pests, Concept of insect pest-definition, life cycle, Non-Insect pests Introduction, weeds, bacteria, molluscs, birds, mites, nematodes, vermins, arthropods, plant pathogens, bacteria, viruses, fungi,	06 h
Unit II	Pest Control Classification: Natural and applied control [Physical, mechanical, cultural, biological, genetic, regulatory, chemical controls] Integrated pest management. Chemo-sterilants, attractants, repellents, Pheromones, IGRs, Biotechnology in pest management, Life cycle, nature of damage and management strategy for mosquito (<i>Aedes Aegypti</i>), housefly (<i>Musca domestica</i>), red cotton bug (<i>Dysdercus koenigii</i>), ballworm (<i>Heliothis Armigera</i>).	06 h
Unit III	Agrochemicals Definition, importance and general classification, Pesticides-History of pesticides, invention of pesticides chemistry, development of pesticides. Classification of pesticides based on mode of action, according to target species and chemical nature, Formulations-Conventional and Advanced formulations- Types, uses & current trends.	06 h
Unit IV	Biopesticides Botanicals and Bioorganisms: Azadirachtin and its role in pest management, Use of predators (lady bird beetle, crysopa) and parasites (<i>Trichogramma</i>) in pest management, pathogens in disease and insectpest management (<i>Bacillus thuringiensis</i> , NPV).	06 h
Unit V	Effects of Pesticides Pesticide residues, toxicity, warning symbols, safety with pesticides, First aid and antidotes.	06 h

Recommended Books:

1. S. K.Handa, Principles of pesticide chemistry. Agrobios (India); 2012.
2. A.Knowles, New developments in crop protection product formulation. T and F Informa UK Ltd. 2005.
3. D.S..Hill, Agricultural insect pests of the tropics and their control. CUP Archive; 1983.

4. S. B. Chattopadhyay Principles and procedures of plant protection. Oxford & IBH Publishing Company, Pvt. Limited; 1991.
5. A. S. Atwal Agricultural Pests of India and South-East Asia. Agricultural pests of India and South-East Asia. 1976. Pradhan S. Insect pests of crops. University of California; 1969.
6. S. Subramanian, S. Subramanian, A. Mohamed, J. Kumar, All about weed control. Kalyani Publishers; 2001.
7. Ó. López, J. Fernandez-Bolanos, editors. Green trends in insect control. Royal Society of Chemistry; 2011.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
PA204.1	To classify the basic terms in agrochemicals.	4
PA204.2	To apply the basic knowledge of pesticides and agrochemicals in the agriculture and industry.	3

IC-204 Basic Concepts of Industrial Chemical Processes

(30 h, 50 Marks and 2 Credits)

Course Objectives:

- This course offers to study basics concepts of industrial chemistry and studying various parameters required for chemical industries.
- This course offers to learn different unit processes and unit operations.
- Student will learn about development of variety of chemical reactions.

Course Contents (Topics and subtopics)

Unit I	a) Chemical Industry Introduction, Chemical production, Raw materials and their sources b)Parameters of Chemical Industry Plant location, Safety, Construction of plant, Management for productivity and creativity, Training for plant procedure and labour, Chemical processtechnology, Classification of chemical reactions, Batch and continuous operations, Industrial chemical reactions, Conversion, Selectivity and Yield.	06 h
Unit II	Unit Operations Introduction, Unit operations- Conveying, Crystallization, Distillation, Drying, Evaporation, Filtration, Leaching, Liquid-liquid extraction, Membrane separation, Particle size reduction and enlargements, Solid -solid separation.	12 h
Unit III	Unit processes Introduction, Industrial unit processes- Definition and examples of Alkylation, Amination by aminolysis, Calcination, Carbonylation, Double decomposition, Esterification, Halogenation, Hydro formulation, Hydrolysis, Nitration, Oxidation, Polymerisation, Sulphonation.	12 h

Recommended Books:

1. P. G. More, Comprehensive Industrial Chemistry, Pragati Edition, Meerut, 2010.
2. P. H. Groggins, Unit Processes in Organic Synthesis- Tata McGraw-Hill, 5th Edition, New Delhi, 2010.
3. M. Gopal Rao, Dryden's Outline of Chemical Technology, Marshall Sittig, East-West Press, 3rd Edition, 2014

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
IC204.1	Distinguish between unit processes and unit operations of chemical industries.	5
IC204.2	Apply the knowledge on newer techniques in industrially important products with the help of various unit processes.	3

PH-204: Chemical Mathematics

(30 h, 50 Marks and 2 Credits)

Course Objectives:

- This is a basic mathematics course, which is essential for chemical sciences.
- This knowledge is also required for solving various mathematical equations that need to be solved in several physical chemistry courses.
- Student will be able to solve numerical problems in physical chemistry.

Course Contents (Topics and subtopics)

Unit I	Curve sketching, linear graphs and slopes, general equation of a straight line, slope-intercept form, slope-point form, two-point form, intercept form, parallel and perpendicular lines, curve sketching, graphs of linear equations.	06 h
Unit II	Differentiation, derivative of a function, differentiation formulas, the chain rule, partial differentiation, numerical.	06 h
Unit III	Integration, integration formulas-indefinite and finite integrals, numerical.	06 h
Unit IV	Permutations and combinations: fundamental theorem, permutations, combinations, probability, numerical.	06 h
Unit V	Vectors, matrices, determinants, sterling approximation, numerical	06 h

Recommended Books:

1. P. W. Atkins, Physical Chemistry, ELBS, 1998
2. G. M. Barrow, Physical Chemistry, International student edition, 2003.
3. Principles of Physical Chemistry, Vishal Publishing Co., Jalandhar, 2008

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
PH204.1	Understand the fundamental and advance concepts of basic mathematics course, which is essential for chemical sciences.	2
PH204.2	Solving various mathematical equations that will be useful in Chemistry.	3

AN-204: Basic Concepts of Instrumentation and Analysis

(30 h, 50 Marks and 2 Credits)

Course Objectives:

- This course covers both fundamental and practical aspects of chemical analysis.
- The student will learn about instrumentation, working and applications in chemistry.
- This course also covers solving numerical problems.

Course Contents (Topics and subtopics)

Unit I	Theory of volumetric and gravimetric analysis:	12 h
	Introduction, Titrimetric analysis, classifications of reactions in titrimetric analysis, standard solutions, preparation of standard solutions, primary and secondary standards, Indicators, theory of indicators, Acid–base titrations in non-aqueous media. Gravimetric Analysis.	
Unit II	Errors, statistics and sampling:	12 h
	Accuracy and precision, Error, types of error, systematic and random errors, minimisation of errors, mean and standard deviations, reliability of results, confidence interval, comparison of results, student T test, F test, Comparison of two samples (Paired T test), correlation and regression, correlation coefficient and liner regression, Sampling , the basis of sampling, sampling procedure, sampling statistics.	
Unit III	Ultra purity and ultra trace analysis:	12 h
	Ultra purity and ultra trace analysis, laboratory dosing, purification of reagents, Preconcentration Techniques, , contamination control during analytical operation.	
Unit IV	Basic analytical process:	12 h
	Separation methods, Precipitation, solvent extraction and chromatographic methods. Activation analysis, basic principles, fast neutron activation analysis, radiochemical methods in activation analysis.	
Unit V	Complexometric equilibria:	12 h
	Introduction, Titration curves, Types of EDTA titrations, Types of Complexometric Titrations (a) Direct Titration (b) Back Titration (c)	

Replacement titration (d) Indirect Titration (e) Applications of Complexometric Titrations.

Recommended Books:

1. H. H.; Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Jr. Instrumental Methods of Analysis.
2. G. R. Chattwal and S. Anand, Instrumental Methods and Chemical Analysis.
3. D. A. Skoog and D. M. West, Fundamentals of Analytical Chemistry”, 4th Ed., CBS College, Publishing, New York.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AN204.1	Analyse the fundamental methods of chemical analysis.	4
AN204.2	Apply the basic analytical processes in chemical analysis.	4

CH-205: Laboratory Course in Inorganic Chemistry-II

(50 Marks and 2 Credits)

Course Objectives:

- The course is designed to develop experimental skills and conceptual understanding related to analysis of alloy, ore and inorganic complexes.
- This course offers to develop experimental skills in quantitative analysis.
- The student will earn knowledge about applications of coordination complexes in various fields of chemistry.

Course Contents (Topics and subtopics)

Perform **any eight experiments** out of the followings:

- 1) Chalcopyrite ore – Estimation of silica by gravimetrically and copper by volumetrically.
- 2) Analysis of Alloy: Brass alloy – Estimation of copper and zinc by volumetrically.
- 3) Preparation and purity determination of Potassium trioxalatochromate (III).
- 4) Preparation and purity determination of Nitro penta-ammine cobalt (III) chloride.
- 5) Drug Analysis: Determination of calcium from given drug sample.
- 6) Determination of heat of dissociation and lattice energy of given salt.
- 7) Preparation and purity determination of Tris (thiourea) cuprous sulphate.
- 8) Determination of barium in the given sample solution by homogeneous precipitation by gravimetrically.
- 9) Preparation and purity determination of Tris (acetyl acetonato) manganese (III).
- 10) Chromite ore – Estimation of Iron by gravimetrically and Chromium by volumetrically

Recommended Books:

1. A.I. Vogel, Text book of Quantitative Analysis, 4th edition, 1992.
2. A.B. P. Lever, Inorganic electronic spectroscopy. Amsterdam, The Netherlands: Elsevier, 1984.

3. Inorganic Synthesis (Vol. Series).

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH205.1	Analyze the alloy concentration and estimate volumetrically the concentration of Zn and Cu using titration method.	4
CH205.2	Determine the lattice energy of various chemical ionic compounds.	3
CH205.3	Carry out Fe-Drug Analysis and the volumetric estimation of Fe.	4
CH205.4	Perform experiment for the preparation and purity determination of coordination compounds.	4

CH-206: Laboratory Course in Organic Chemistry-II

(50 Marks and 2 Credits)

Course Objectives:

- To develop the experimental skills in organic synthesis.
- To prepare organic compounds in single stage.
- To interpret UV, IR and NMR spectra.

Course Contents (Topics and subtopics)

1. Preparations: Single Stage (Any 06 preparations)

- 1) Cyclohexanone to Adipic acid
- 2) Benzophenone to Benzhydral
- 3) Anthracene to Anthraquinone
- 4) Chlorobenzene to 2,4-Dinitrochlorobenzene
- 5) 2,4-Dinitrochlorobenzene to 2,4-Dinitrophenol
- 6) Acetoacetic ester to 1-Phenyl-3-methyl-5 pyrazolone
- 7) Benzaldehyde to Cinnamic acid
- 8) 4-Chlorobenzaldehyde to 4-Chlorobenzoic acid + 4-Chlorobenzyl alcohol
- 9) Benzene to β -Benzoyl propionic acid
- 10) Benzaldehyde to Dibenzylidene acetone
- 11) p-Aminobenzoic acid to p-Chlorobenzoic acid
- 12) N,N-Dimethylaniline to 4-Formyl-N, N-dimethyl aniline
- 13) Benzophenone to Benzpinacol
- 14) p-Nitrotoluene to p-Nitrobenzoic acid
- 15) Anisole to 2,4-Dinitroanisole
- 16) Phthalic anhydride to phthalimide
- 17) Phthalimide to Anthranilic acid
- 18) Acetanilide to p-Bromoacetanide
- 19) p-Bromoacetanide to p-Bromoaniline
- 20) m-Dinitrobenzene to m-Nitroaniline

2. Interpretation of UV, FT-IR and ¹H-NMR spectrum of above synthesized compounds.

(Any 06 Compounds)

Recommended Books:

1. A.J. Hannaford, A.R. Tatchell, B.S. Furniss, P.W.G. Smith, Vogel's Textbook of Practical Organic Chemistry, 5th Edition.
2. R. K. Bansal, Laboratory Manual of Organic Chemistry, New Age International Publisher.
3. L. D. Field, S. Sternhell, J. R. Kalman, Organic Structures from Spectra, 4th Edition, John Wiley & Sons, Ltd.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH206.1	Prepare and purify the organic compounds.	4
CH206.2	Determine the structure of organic compound from spectral graphs.	3

CH-207: Laboratory Course in Physical Chemistry-II (50 Marks and 2 Credits)

Course Objectives:

- The course is designed to develop the experimental skills in physical chemistry.
- To furnish the knowledge about the potentiometry, pHmetry, etc.
- To get acquainted with knowledge about verification of theoretical aspects such as reaction kinetics by experimental techniques.

Course Contents (Topics and subtopics)

Perform **any eight experiments** out of the followings:

- 1) To determine the amount of iodide and bromide present in their mixture by potentiometric titration.
- 2) To determine the solubility product of the given sparingly soluble salts by potentiometric method.
- 3) To determine the equivalent conductance of a weak electrolyte at infinite dilution using the Kohlrausch law of independent migration of ions.
- 4) To determine the hydrolysis constant of the aniline hydrochloride pH-metrically.
- 5) To determine the dissociation constants of the given dibasic acid pH-metrically.
- 6) To determine the isosbestic point of given indicator (methyl red) spectrophotometrically.
- 7) To determine the order of reaction between potassium persulphate and potassium iodide by fractional change method.
- 8) To construct the phase diagram of toluene, alcohol and water system.
- 9) To determine the molecular weight of a given polymer by viscometry method.
- 10) To determine the transition temperature of sodium sulphate decahydrate by thermometric method.

Recommended Books:

1. J. A. Kitcher, Findlay's Practical Physical Chemistry, 1963.
2. A. I. Vogel, Text Book of Quantitative Inorganic Analysis.
3. R. C. Das and B. Behera, Experimental Physical Chemistry, 1984.
4. J. B. Yadav, Advanced Practical Physical Chemistry, Goel

Publishing.

5. F. Daniels and J. Williams. Experimental Physical Chemistry, McGraw-Hill Publishing Co., Ltd
6. D. Shoemaker, Advanced Physical Chemistry Experiments,
7. H. H.; Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Jr. Instrumental Methods of Analysis.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
CH 207.1	Provide guidance and practice for each experiment.	3
CH 207.2	Acquire safety requirements and lab skills	4
CH 207.3	Practice on each instrument.	3

M.Sc. Part I Semester II: Audit Courses

	AC-201(A): Soft Skills (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives (CObs): To inculcate different soft skills among students.	
Unit 1	Introduction to soft skills Formal definition, Elements of soft skills, Soft vs. Hard skills, Emotional quotient, Goal setting, life skills, Need for soft skills, Communication skills, Etiquettes & Mannerism.	2 hrs.
Unit 2	Self-Assessment Goal setting, SWOT analysis, attitude, moral values, self-confidence, etiquettes, non-verbal skills, achievements, positive attitude, positive thinking and self-esteem. Activity: The teacher should prepare a questionnaire which evaluate students in all the above areas and make them aware about these aspects.	4 hrs.
Unit 3	Communication Skills Types of communication: Verbal, Non-verbal, body language, gestures, postures, gait, dressing sense, facial expressions, peculiarity of speaker (habits). Rhetoric speech: Prepared speech (topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver, Extempore speech (students deliver speeches spontaneously for 5 minutes each on a given topic), Storytelling (Each student narrates a fictional or real-life story for 5 minutes each), Oral review (Each student orally presents a review on a story or a book read by them) Drafting skills: Letter, Report & Resume writing, business letters, reading & listening skills Activity: The teacher should teach the students how to write the letter, report and build resume. The teacher should give proper format and layouts. Each student will write one formal letter, one report and a resume.	8 hrs.
Unit 4	Formal Group Discussion, Personal Interview & Presentation skills Topic comprehension, Content organization, Group speaking etiquettes, driving the discussion & skills. Preparation for personal interview: dress code, greeting the panel, crisp self-introduction, neatness, etiquettes, language tone, handling embarrassing & tricky questions, graceful closing. Activity: Each batch is divided into two groups of 12 to 14 students each. Two rounds of a GD for each group should be conducted and teacher should give them feedback. Mock interview are to be conducted.	4 hrs.
Unit 5	Aptitude and analytical skills Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	8 hrs.
Unit 6	Life skills Time management, critical thinking, sound and practical decision making by dealing with conflicts, stress management, leadership qualities Activity: The teacher can conduct a case study activity to train students for decision making skills. The teacher should conduct a session on stress management and guide students on how to manage stress. The teacher may conduct a stress relieving activity in the class. He/she may counsel students individually to know their problems and guide them on dealing with them effectively.	4 hrs.
Suggested readings: - Basics of Communication In English: Francis Sounderaj, MacMillan India Ltd. - English for Business Communication: Simon Sweeney, Cambridge University Press - An Introduction to Professional English and Soft Skills: Das, Cambridge University Press		

4. Quantitative Aptitude: R.S. Agrawal
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Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201A.1	Identify their lacunas about some soft skills and try to overcome the same.	2
AC201A.2	Practice learned soft skills in real life and do their jobs more effectively.	3

AC-201(B): Practicing Sports Activities (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)				
Course Objectives (CObs): To motivate students towards sports and provide them required training.				
SR NO.	NAME OF THE SPORT/GAME (Select ONE of the Following)	SYLLABUS OF THE COURSE	TIMING (02 Hours in a Week)	SEMESTER
1	Volleyball	- General Fitness - Basic Fitness - Specific Fitness - History of the Game - Basic Skill of the Game - Major Skill of the Game - Technique & Tactics of the Game - Game Practice	Morning : 07 to 09 AM OR Evening : 05 to 07 PM	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			
6	Handball			
7	Kabaddi			
8	Kho-Kho			
9	Table-Tennis			
10	Swimming			

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201B.1	Identify one or more sports of their choice and develop more interest to participate at University/National level sport events.	2
AC201B.2	Practice the learned sports activities regularly in real life.	3

AC-201(C): Practicing Yoga (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives: To motivate students towards yoga and provide them required training.
	- Yog: Meaning, Definition & Introduction, Objectives - Primary Introduction of Ashtanga Yoga - Preparation of Yogabhyas - Omkar Sadhana, Prayer, Guru Vandana - SukshmaVyayamas - Suryanamaskar (12 Postures) - Asanas : - Sitting (Baithaksthiti) - Vajrasana, Padmasan, Vakrasan, Ardha-Pashchimotanasanan - Supine (Shayansthiti) - UttanPadaasan(Ekpad/Dwipad), Pavanmuktasana, ViparitakaraniAasan, Khandarasan, Shavasana - Prone (Viparitshayansthiti) - Vakrahasta, Bhujangasana, SaralhastaBhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana - Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, ArdhChakrasana - Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types - Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201C.1	Identify and practice some Yoga asanas regularly in their life to remain healthy.	2
AC201C.2	Provide guidance and practice about Yoga to their friends, parents and relatives.	3

AC-201(D): Introduction to Indian Music (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives: To motivate students towards Indian music and provide them minimum required training.
	- Definition and brief about generation of Swar, Saptak, Thaata, Raaga, Aavartan, Meend, Khatka, Murkee, Taal, Aalaap etc. - Taal and its uses - Treetaal, Daadraa, Zaptaal, Kervaa. - Information of Badaakhyaal, Chhotaakhyaal (one), Sargam, Lakshangeet (information) - Detailed information of Tambora - Detailed information of Harmonium and Tablaa. - Five filmy songs based on Indian Classical Music (Theory and Presentation) - Sound Management - Basic information of Sound Recording (including Practicals) - Composition of Music as per the Story - Preparing news write-ups of the Seminars, Library Musical Programmes held at the nearest Akashwani, by personal visits.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201D.1	Identify different types of Indian music.	3
AC201D.2	Develop more interest to learn and practice Indian music.	4

**KAVAYITRI BAHINABAI CHAUDHARI
NORTH MAHARASHTRA UNIVERSITY, JALGAON**

**SCHOOL OF CHEMICAL SCIENCES
DEPARTMENT OF ORGANIC CHEMISTRY
(Academic Flexibility since 2009)**



**MASTER OF SCIENCE IN CHEMISTRY
(With specialization in Organic Chemistry)**

**PART- II
(Semester III and IV)**

**Choice Based Credit System, 60:40 Pattern
(Outcome Based Curriculum)**

w. e. f. June 2020

Important Notes:

1. Each theory course prescribed for M. Sc. should be covered in 4 lectures, each of 60 minutes duration per week per course including lectures, tutorials, seminars, classroom discussions etc. (Total 60 hrs / theory course)
2. Each practical course will require 12 hours of laboratory work per week per semester. The research project will be extended over two semesters (06 hrs/week) and will be examined at the end of the year. (Total 180 hrs / practical course)
3. There should not be more than 10 students in a batch for M. Sc. Practical course.
4. For theory course the question paper (Internal/External) should include numerical, short answer, long answer, MCQ questions to test understanding of the subject.
5. Of the 60 lectures in each course about 10 lectures will include tutorials, student seminars, classroom discussions and tests.
6. The marks for each paper are distributed as external examination 60 marks and internal examination 40 marks. For internal assessment of each theory and practical course, 2 written tests will be taken.
7. The 80 % attendance of students is compulsory.
8. Students should visit at least five chemical industries in two years of M. Sc. and submit the observations/report to the Department.
9. Department of Organic Chemistry has implemented **CGPA system from July 2009 and CBCS from July 2015.**

OC-301: Organic Reaction Mechanism

(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. Understand the Linear free energy relationship, Hammett and Taft equation, substituent and reaction constants.
2. Study of reactive intermediates - formation, stability and related name reactions.
3. Study of free radicals: generation of radicals, Nucleophilic electrophilic radicals, inter and intra molecular C-C bond formation, reactions of free radicals.
4. Study of basics of photochemical reactions and learn various photochemical reactions.
5. Understanding of mechanism of biological chemistry.
6. To learn all the major types of organic reaction mechanisms.

Course Contents (Topics and subtopics)

1 **Linear free energy relationship:** (12 L)

Hammett plot, Hammett equation, substituent and reaction constants, physical significance of substituent and reaction constants, substituent constant involving through conjugation. Use of Hammett plot and equation. Deviations from straight line plot. Concave upward deviation. Concave downward deviation. Steric effects, Taft equation, Steric parameters, solvent effects, change of reaction constant.

2 **Organic Reactive Intermediates:** (12 L)

Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzyne and nitrenes. Important reactions involving reactive intermediates.

3 **Free Radical Reactions:** (12 L)

Formation, stability and detection of long and short-lived radicals. Homolysis and free radical displacement, Fragmentation, substitution, addition, oxidation,

reduction, and rearrangements, Radical cyclisation in synthesis.

4 Photochemistry: (12 L)

General principles, orbital symmetry considerations, photochemistry of carbonyl groups, alkenes and dienes, aromatic compounds.

5 Mechanism in Biological Chemistry: (12 L)

Nature's NaBH_4 in a nucleotide: NADH or NADPH, reductive amination in nature, Nature's enols-lysine enamines and coenzyme A, Nature's acyl anion equivalent in thiamine pyrophosphate, rearrangements in the biosynthesis of valine and isoleucine, carbon dioxide is carried by biotin, the shikimic acid pathway, hemoglobin carries oxygen as an iron (II) complex.

References:

1. A guide book to mechanism in Organic Chemistry 6th edition, By Peter Sykes: Orient Longman
2. Mechanism and structure in Organic Chemistry, Edwin S. Gould, Holt, Rinehart and Winston.
3. Organic Chemistry 5th edition, By S. H. Pine. McGraw-Hill International editions.
4. Advanced Organic Chemistry 3rd edition, by R. O. C. Norman and J. M. Coxon 3rd edition ELBS.
5. Advanced Organic Chemistry Part A and B 2nd edition, by F. A. Carey and R. J. Sundberg. Plenum Press. New York and London.
6. Organic Chemistry-Clayden, Greeves, Warren and Wothers, OXFORD.
7. Advance Organic Chemistry: Reactions, Mechanisms and Structure by Jerry March.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC301.1	Acquire the skills to identify the pathway of organic reaction.	4
OC301.2	Formulate his/her own reasoned opinions in the mechanistic side of organic reactions.	4
OC301.3	Predict the major and minor products of a variety of organic reactions with appropriate stereochemistry.	5

OC-302: Spectroscopic Methods in Structure Determination

(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. Study ^1H NMR Spectroscopy: Chemical Shift, deshielding, correlation for protons bonded to carbon and other nuclei.
2. Study of ^{13}C NMR spectroscopy: FT- NMR, type of ^{13}C NMR spectra, proton decoupled, off resonance, DEPT, DANTE, Chemical shift, nuclear and hetero nuclear coupling constant
3. To learn 2D NMR techniques: COSY, homo and hetero nuclear 2D resorts spectroscopy, NOESY and the applications.
4. Study of mass spectrometry: Instrumentation, various methods of ionization, FAB, ESI, TPSI, MALDI, TOF, Mass spectral fragmentation of Organic compounds

Course Contents (Topics and subtopics)

- 1 **Proton Magnetic Resonance:** (10 L)
Recapitulation, advanced ideas of chemical shift, chemical exchange, effect of deuteration, stereochemistry, hindered rotation, identification of complex spin system. AB, ABC, ABX and AMX systems. Factors affecting vicinal and germinal coupling, long range coupling. Simplification of complex spectra, nuclear double resonance, nuclear overhauser effect, shift reagents.
- 2 **Carbon Magnetic Resonance:** (12 L)
Elementary means, instrumentation, chemical shift, chemical shift features of aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon. DEPT, DANTE.
- 3 **Two-Dimensional NMR Correlation Spectroscopy:** (10 L)
Two dimensional NMR spectroscopy, 2D-HETCOR, ^1H - ^1H COSY, types of COSY experiments, 2D TOCSY, NOESY, ROESY, J resolved 2D NMR spectroscopy, HSQC, HMQC and HMBC.

4 NMR Spectroscopy of Some Other Nuclei - ^{15}N , ^{19}F , ^{31}P and D and ^{11}B . (06 L)

5 Mass Spectrometry: (14 L)

Theory, Instrumentation, EI, Chemical Ionization, Field Desorption, FAB, ESI, MALDI, TPSI, TOF, MALDI-TOF, Mass Spectral fragmentation of Organic compounds containing common functional groups, McLafferty rearrangement, Molecular Ion peak, metastable peak, isotope peaks, Examples of Mass spectral fragmentation of Organic compounds with respect of their structure determination.

6 Problems: (08 L)

Based on joint application of U.V., I.R., NMR, CMR and Mass spectroscopy (including reaction sequence and spectral analysis).

References:

1. Spectroscopic methods in Organic Chemistry, D. H. William and Ian Flemming-4th edition.
2. Spectrometric identification of organic compounds, T. C. Morrill, R. S. Silverstein, G. C. Bessler 4th edition.
3. Mass Spectroscopy, K.G. Das.
4. Absorption Spectroscopy of Organic Molecules, V. M. Parikh
5. Organic Spectroscopy- S. K. Dewan, CBS Publishers.
6. Nuclear Magnetic Resonance-Basic Principles-Atta-Ur-Rehman, Springer-Verlag (1986).
7. One- and two-dimensional NMR spectroscopy, Atta-Ur-Rehman, Elsevier (1989).

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC302.1	Understand the basics concepts of Spectroscopy.	2
OC302.2	Interpret the spectral graphs.	3
OC302.3	Deduce molecular structure by using UV, IR, NMR and Mass.	4

OC-303: Organic Stereochemistry

(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. To learn and apply various concepts such as stereochemistry and fundamental principles of stereoselectivity in organic chemistry.
2. To familiarize with different types of pericyclic reactions.
3. Study of stereochemical aspects of fused and bridged rings.
4. To learn ORD, CD and cotton effect.

Course Contents (Topics and subtopics)

- 1 Principles of Stereochemistry: (10 L)**
Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.
- 2 Asymmetric Synthesis: (10 L)**
Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution - optical and kinetic.
Racemic modification and resolution of racemic mixture.
- 3 Pericyclic Reactions: (16 L)**
Electrocyclic, Cycloaddition and Sigmatropic reactions and other related concerted reactions.
- 4 Fused Rings and Bridged Rings: (10 L)**
Decaline, Perhydrophenanthrene, Perhydroanthracene, Bridged Compounds and Other related compounds
- 5 Stereoisomerism of Allenes, Spiranes, Biphenyls compounds and related compounds (04 L)**

6 ORD & CD:**(10 L)**

Linearly and circularly polarized light, Circular birefringence and circular dichroism, ORD and CD curves, Cotton effect and its applications, The Octant rule and the axial α -haloketone rule with applications.

References:

1. Stereochemistry of carbon compounds. E L. Eliel.
2. Conservation of Orbital symmetry. R. B. Woodward and Hofmann.
3. Stereochemistry. Nasipuri.
4. Orbital Symmetry: Problem Solving Approach. R. E. Lehr and Merchand.
5. Frontal orbitals and Organic Chemical Reactions. I N Fleming.
6. Organic Chemistry- by Finar
7. Organic Chemistry-Clayden, Greeves, Warren and Wothers-OXFORD
8. Stereoselective synthesis—Mihaly Nograd VCH, Weinheim, 1995.
9. Principles and applications of Asymmetric Synthesis—Gou-Qiang Lin, Yue-Ming Li and S. C. Chan---Wiley-Interscience, John Wiley and Sons, Inc. Publication 2001.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC303.1	Apply the basics concepts of Stereochemistry.	3
OC303.2	Differentiate stereoisomers.	4
OC303.3	Evaluate stereochemical aspects of organic reactions.	5

M.Sc. Part II Semester III (Organic Chemistry): Elective Course

OC-304: Heterocyclic Chemistry

(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. Study of heterocyclic chemistry: Five and six members heterocyclic with one or two hetero atoms.
2. Study of condensed five- and six-member heterocyclic compounds.
3. To learn the synthesis, reactivity, aromatic character and important reactions of heterocyclic compounds.

Course Contents (Topics and subtopics)

Introduction, Synthetic Approaches & Reactions of following Heterocyclic Compounds:

- 1 **Three Membered and Four Membered Rings containing One Hetero Atom:** (08 L)
Aziridine, Oxirane, Thiirane and Azetidine, Oxetane, Thietane
- 2 **Five Membered Heterocyclic Compounds with One Hetero Atom:** (10 L)
Pyrrole, Furan, Thiophene
- 3 **Five Membered Heterocyclic Compounds with Two Hetero Atoms:** (08 L)
Imidazole, Oxazole, Thiazole
- 4 **Condensed Five-Membered Heterocycles:** (10 L)
Indole, Benzofuran, Benzothiophene
- 5 **Six Membered Heterocyclic Compounds with One Hetero Atom:** (16 L)
Pyridine, Quinoline, Isoquinoline
- 6 **Six Membered Heterocyclic Compounds with Two Hetero Atoms:** (08 L)
Pyridazine, Pyrimidine, Pyrazine

References:

1. Heterocyclic Chemistry – J. Joule and G. Smith
2. Modern Heterocyclic chemistry – L. A. Paquette (Benjamin).
3. Heterocyclic chemistry – 5th edition Raj K. Bansal, New Age International (P) Ltd. (2014).

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC304.1	Acquire knowledge on various methods of synthesis of heterocyclic compounds.	4
OC304.2	Acquire skill to predict reactivity of heterocyclic compounds.	4
OC304.3	To predict the product and suggest the mechanism.	5

OC-305: Organic Chemistry Practical Course-III

(180 Hrs, 100 Marks and 6 Credits)

Course Objectives: To make the students conversant with the

1. To learn techniques for separation of ternary mixture.
2. Study of isolation of natural products.
3. Interpretation of UV, IR, NMR and Mass Spectra.

Ternary Mixture Separation (Minimum Twelve)

Separation of mixtures containing three components. The mixtures should also involve separation of nitro phenols, amino acids, low boiling substances, water soluble substances. Amines, Phenols and acids used should also contain other elements and functional groups. The mixture separation should be carried out on micro-scale using ether. The purity of the separated compounds should be checked by TLC.

Isolation and separation of Natural products: (Minimum Four)

It should involve solvent extraction, chromatographic & distillation techniques.

- 1) Isolation of Hesperdin from orange peel
- 2) Isolation of Eugenol from cloves
- 3) Isolation of Caffeine from tea
- 4) Isolation of Nicotine from tobacco
- 5) Isolation of Piperine from black pepper
- 6) Isolation of Lactose and casein from milk
- 7) Isolation of Cellobiose-octa-acetate from cotton
- 8) Isolation of Stigmasterol from soya bean oil
- 9) Isolation of β -carotene from carrot

Interpretation of UV, IR, NMR and Mass Spectra: (Minimum 20 Organic Compounds)

References:

1. Vogel's, Practical Organic Chemistry.
2. Practical Organic Chemistry, R. K. Bansal.
3. Organic Structures from Spectra, 4th Edition, L. D. Field, S. Sternhell, J. R. Kalman, John Wiley & Sons, Ltd.
4. Practical Organic Chemistry by Mann & Saunders.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC305.1	Separate the ternary mixture with proper technique and identify the type of given compound.	3
OC305.2	Collect the data and solve the structure by given spectral data.	3
OC305.2	Isolate and separate the natural products.	4

M.Sc. Part II Semester III (Organic Chemistry): Audit Courses

AC-301(A): Computer Skills (Technology + Value added Audit course; Practical; 2 Credits) (Optional: Campus + Program level)		
Course Objectives (CObs): To inculcate different daily useful computer skills among students.		
Unit 1	Elements of Information Technology 1.1 Information Types: Text, Audio, Video, and Image, storage formats 1.2 Components: Operating System, Hardware and Software, firmware 1.3 Devices: Computer, Mobile Phones, Tablet, Touch Screen, Scanner, Printer, Projector, smart boards 1.4 Processor & Memory: Processor functions, speed, Memory types: RAM /ROM /HDD /DVD-ROM/Flash drives, memory measurement metrics	2 L
Unit 2	Office Automation-Text Processing 2.1 Views: Normal View, Web Layout View, Print Layout View, Outline View, ReadingLayout View 2.2 Working with Files: Create New Documents, Open Existing Documents, SaveDocuments to different formats, Rename Documents, Close Documents 2.3 Working with Text: Type and Insert Text, Highlight Text, Formatting Text, Delete Text, Spelling and Grammar, paragraphs, indentation, margins 2.4 Lists: Bulleted and Numbered Lists, 2.5 Tables: Insert Tables, Draw Tables, Nested Tables, Insert Rows and Columns, Moveand Resize Tables, Moving the order of the column and/or rows inside a table, TableProperties 2.6 Page Margins, Gutter Margins, Indentations, Columns, Graphics, Print Documents, 2.7 Paragraph Formatting, Paragraph Attributes, Non-printing characters 2.8 Types of document files: RTF, PDF, DOCX etc.	5 L
Unit 3	Office Automation-Worksheet Data Processing 3.1 Spreadsheet Basics: Adding and Renaming Worksheets, Modifying Worksheets, 3.2 Moving Through Cells, Adding Rows, Columns, and Cells, Resizing Rows and Columns, Selecting Cells, Moving and Copying Cells 3.3 Formulas and Functions: Formulas, Linking Worksheets, Basic Functions, AutoSum, Sorting and Filtering: Basic Sorts, Complex Sorts, Auto-fill, Deleting Rows, Columns, and Cells 3.4 Charting: Chart Types, drawing charts, Ranges, formatting charts	5 L
Unit 4	Office Automation- Presentation Techniques and slide shows 4.1 Create a new presentation, AutoContent Wizard, Design Template, Blank Presentation, Open an Existing Presentation, PowerPoint screen, Screen Layout 4.2 Working with slides: Insert a new slide, Notes, Slide layout, Apply a design template, Reorder Slides, Hide Slides, Hide Slide text, Add content, resize a placeholder or textbox, Move a placeholder or text box, Delete a placeholder or text box, Placeholder or Text box properties, Bulleted and numbered lists, Adding notes	6 L

	4.3 Work with text: Add text and edit options, Format text, Copy text formatting, Replace fonts, Line spacing, Change case, Spelling check, Spelling options 4.4 Working with tables: Adding a table, Entering text, Deleting a table, Changing row width, Adding a row/column, Deleting a row/column, Combining cells, Splitting a cell, Adding color to cells, To align text vertically in cells, To change table borders, Graphics, Add clip art, Add an image from a file, Save & Print, slide shows, slide animation/transitions.	
Unit 5	Internet & Applications: 5.1 Computer Network Types: LAN, PAN, MAN, CAN, WAN, Defining and describing the Internet, Brief history, Browsing the Web, Hypertext and hyperlinks, browsers, Uniform resource locator 5.2 Internet Resources: Email, Parts of email, 5.3 Protecting the computer: Password protection, Viruses, Virus protection software, Updating the software, Scanning files, Net banking precautions. 5.4 Social Networking: Features, Social impact, emerging trends, issues, Social Networking sites: Facebook, Twitter, LinkedIn, Orkut, online booking services 5.5 Online Resources: Wikipedia, Blog, Job portals, C.V. writing 5.6 e-learning: e-Books, e-Magazines, e-News papers, OCW (open course wares): Sakshat (NPTEL) portal, MIT courseware	4 L
Unit 6	Cloud Computing Basics 6.1 Introduction to cloud computing 6.2 Cloud computing models: SAS, AAS, PAS 6.3 Examples of SAS, AAS, PAS (DropBox, Google Drive, Google Docs, Office 365 Prezi, etc.)	3 L
Suggested readings: 1. TCI, "Introduction to Computers and Application Software", Publisher: Jones & Bartlett Learning, 2010, ISBN: 1449609821, 9781449609825 2. Laura Story, Dawna Walls, "Microsoft Office 2010 Fundamentals", Publisher: Cengage Learning, 2010, ISBN: 0538472464, 9780538472463 3. June Jamrich Parsons, Dan Oja, "Computer Concepts Illustrated series", Edition 5, Publisher Course Technology, 2005, ISBN 0619273550, 9780619273552 4. Cloud computing online resources		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301A.1	Identify their lacunas about some computer skills and try to overcome the same.	2
AC301A.2	Practice the learned computer skills in real life and do their jobs more effectively.	3

AC-301(B): Cyber Security (Technology + Value added Audit course; Practical; 2 Credits) (Optional: Campus + Program level)		
Course Objectives (CObs): To make students aware of different daily useful cyber security skills/rules.		
Unit 1	Networking Concepts Overview Basics of Communication Systems, Transmission Media, ISO/OSI and TCP/IP models, Network types: Local Area Networks, Wide Area Networks, Internetworking, Packet Formats, Wireless Networks: Wireless concepts, Advantages of Wireless, Wireless network architecture, Reasons to use wireless, Internet	3 L
Unit 2	Security Concepts Information Security Overview, Information Security Services, Types of Attacks, Goals for Security, E-commerce Security, Computer Forensics, Steganography. Importance of Physical Security, Biometric security & its types, Risk associated with improper physical access, Physical Security equipments. Passwords: Define passwords, Types of passwords, Passwords Storage – Windows & Linux.	7 L
Unit 3	Security Threats and vulnerabilities Overview of Security threats, Hacking Techniques, Password Cracking, Types of password attacks, Insecure Network connections, Wi-Fi attacks & countermeasures, Information Warfare and Surveillance. Cyber crime: e-mail related cyber crimes, Social network related cyber crimes, Desktop related cyber crimes, Social Engineering related cyber crimes, Network related cyber crimes, Cyber terrorism, Banking crimes	7 L
Unit 4	Cryptography Understanding cryptography, Goals of cryptography, Types of cryptography, Applications of Cryptography, Use of Hash function in cryptography, Digital signature in cryptography, Public Key infrastructure	5 L
Unit 5	System & Network Security System Security: Desktop Security, email security: PGP and SMIME, Web Security: web authentication, Security certificates, SSL and SET, Network Security: Overview of IDS, Intrusion Detection Systems and Intrusion Prevention Systems, Overview of Firewalls, Types of Firewalls, VPN Security, Security in Multimedia Networks, Fax Security.	3 L
Unit 6	OS Security OS Security Vulnerabilities updates and patches, OS integrity checks, Anti-virus software, Design of secure OS and OS hardening, configuring the OS for security, Trusted OS.	2 L
Unit 7	Security Laws and Standards Security laws genesis, International Scenario, Security Audit, IT Act 2000 and its amendments.	3 L
Suggested readings: Skills Factory, Certificate in Cyber Security, Text Book Special edition, Specially published for KBC NMU, Jalgaon		

2. BPB Publication, “Fundamentals of Cyber Security”, Mayank Bhushan, Rajkumar Singh Rathore , Aatif Jamshed
3. CreateSpace Independent Publishing Platform, “Cyber Security Basics”, Don Franke, ISBN-13: 978-1522952190 ISBN-10: 1522952195
4. Online references

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301B.1	Practice learned cyber security skills/rules in real life.	3
AC301B.2	Provide guidance about cyber security skills/rules to their friends, parents and relatives.	2

AC-301(C): Introduction to Research

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (COs):

- To create interest of research amongst the students.
- To learn the basic knowledge and steps involved in the research.

Course layout

<https://nptel.ac.in/courses/121/106/121106007/>

https://onlinecourses.nptel.ac.in/noc20_ge22/preview

Week 1 : A group discussion on what is research; Overview of research;

Week 2 : Literature survey , Experimental skills;

Week 3 : Data analysis, Modelling skills;

Week 4 : Technical writing; Technical Presentations; Creativity in Research

Week 5 : Creativity in Research; Group discussion on Ethics in Research

Week 6 : Design of Experiments

Week 7 : Intellectual Property

Week 8 : Department specific research discussions

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301C.1	Understand literature survey, data analysis, report writing.	2
AC301C.2	To choose research problem.	3
AC301C.3	Develop interest of research.	3

AC-301(D): Seminar on Review of Research Paper (Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)	
Course Objectives (COs): To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant research paper.	
Seminar Activity: - Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journals from ACS, RSC, Elsevier, Springer etc. to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities. - Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation.	

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301D.1	Deliver the interactive presentation of scientific data before audience and participate in open discussion with confidence.	2
AC301D.2	Prepare seminar on research paper using ICT tools.	3
AC301D.3	Retrieve, analyze, comprehend the scientific information on a given research paper.	4

OC-401: Chemistry of Natural Products

(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. Study of Natural products like Hardwickiic acid, Camptothecin and Podophyllotoxin.
2. Synthesis of some natural products.
3. Learn biogenesis terpenoids, alkaloids and shikimate pathway.

Course Contents (Topics and subtopics)

- | | | |
|----------|---|---------------|
| 1 | Structure, Stereochemistry and Biogenesis of
Hardwickiic acid, Camptothecin and Podophyllotoxin | (12 L) |
| 2 | Synthesis of Some Natural Products
i) Reserpine (Woodward synthesis)
ii) Taxol
iii) Estrone
iv) Strychnine (Overman's synthesis)
v) Fredericamycin A
vi) Prostaglandin (E. J. Corey synthesis) | (14 L) |
| 3 | Secondary Metabolism:
Introduction, Primary and Secondary Metabolism, Enzymes and Coenzymes.
Metabolites Derived from Mevalonates
Metabolites Derived from Shikimic acid
Secondary Metabolism of Amino acids | (26 L) |
| 4 | Chemistry of Carbohydrates, Proteins and Peptides, Fatty acids, Nucleic acids | (08 L) |

References:

1. Secondary Metabolism, J. Mann, 2nd Edition (Oxford University Press).
2. Chemical aspects of Biosynthesis – J. Mann (1994).
3. Organic Chemistry, Vol. II I. L. Finar.

4. Principles of organic synthesis by R. O. C. Norman and J. M. Coxon; Chapman and Hall.
5. Steroids. L. Fieser and Fieser.
6. Structure Determination, P. Yates.
7. Biosynthesis of Natural Products. P. Manitto.
8. Classics in Organic Synthesis – K. C. Nicolaou & E. J. Sorensen.
9. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren and Peter Wothers, Oxford University Press.
10. J. Am Chem. Soc. 88, 3888 (1966).
11. Chemistry of Natural Products- Kalsi
12. M. C. Wani and M. E. Wall J. Org. Chem. 34, 1364 (1969).
13. (i) Tetrahedron Letters, 3751 (1964)., (ii) Tetrahedron Letters, 2861 and 2865 (1968).
14. i) J.C.S. Perkin Transactions II, 288-292, (1973). ii) J. Am. Chem. Soc. Vol.77.432-437, (1955).
15. Organic Chemistry by Morrison and Boyd.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC401.1	Analyze biogenesis route of natural products.	4
OC401.2	Learn synthesis of some important natural products.	2
OC401.3	To predict the possible pathway of natural product.	5

OC-402: Synthetic Methods in Organic Chemistry

(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. To learn and apply various concepts retrosynthesis.
2. Study of different types of coupling reactions.
3. Study of protecting groups, umpolung and enamines.
4. Study of transition metal complexes in organic synthesis.

Course Contents (Topics and subtopics)

- | | | |
|---|--|--------|
| 1 | Use of Boron, Silicon, Thallium and Tin in organic synthesis | (07 L) |
| 2 | Transition metal complexes in organic synthesis:
Cu, Ni, Co, Hg, Pd, Pt, Fe, Rh, Ru; Wilkinson Catalyst, Ziegler Natta catalyst | (10 L) |
| 3 | Enamines & Umpolung in Organic Synthesis | (04 L) |
| 4 | Nitrogen, Phosphorous and Sulphur Ylides in Organic synthesis | (03 L) |
| 5 | Protecting groups in Organic Synthesis:
Protection & deprotection of Hydroxyl, Carbonyl, amino and carboxylic acid functional groups & its applications | (04 L) |
| 6 | Designing in Organic Synthesis:
Retrosynthesis, disconnection, synthons, linear and convergent synthesis | (16 L) |
| 7 | Coupling Reactions and Process:
Stills Coupling, Sonogashira reaction, Buchwald reaction, Pudovik-Kahn Reaction, Suzuki Coupling, Mitsunobu reaction, Baylis-Hillman reaction, Mukaiyama's esterification, Metathesis reaction | (08 L) |
| 8 | Green Chemistry: Basic Principles, Methods & Reactions | (08 L) |

Supramolecular Chemistry

Nano Chemistry

References:

1. Transition metal intermediates in Organic Synthesis, C. W. Birds.
2. Organometallic in Organic Synthesis, Swan and Black.
3. Designing Organic Synthesis, Stuart Warren.
4. Some Modern methods of organic Synthesis, W. Carruthers.
5. Principles of Organometallic Chemistry, Coats, Green and Wada.
6. Organic Chemistry, By Robert Morrison and Robert N. Boyd. 5th Edition.
7. Organic Chemistry, by I. L. Finar, Vol. 8, 5th Edition.
8. Transition Metal Clusters, B. F. G. Johansson - Wiley 1980.
9. Comprehensive Organometallic Chemistry - G. Wilkinson, F.G.A. Stone and E. Abel – Pergamon - 1980.
10. Organometallic Chemistry, G. O. Spessard; G. L. Miessler - Prentice Hall, 1997.
11. Palladium in Organic Synthesis, A. F. Heck.
12. Ring Closing Metathesis, Grubbs, R. H.; Miller, S. J.; Fu, G. C. Acc. Chem. Res. 1995, 28, 446.
13. Organic Synthesis: Concepts, methods, starting materials, J.-H. Fuhrhop and G. Penzlin, VCH-Verlag, Weinheim, 1994.
14. Protective groups in organic synthesis, T. W. Greene and P. G. M. Wuts, 2nd Ed. John Wiley and Sons, 1991.
15. Green Chemistry - Paul T. Anastas; John C. Warner - Oxford University.
16. Supramolecular Chemistry: Concepts and Perspectives, Jean-Marie Lehn, Wiley.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC402.1	Choose the specific protecting groups in multistep organic synthesis.	3
OC402.2	Planning of green synthetic approaches to prevent hazards.	4
OC402.3	Distinguish various synthetic methods for organic synthesis.	5
OC402.4	Design the synthetic pathway from target molecule by applying the retrosynthesis, disconnection approach.	6

OC-403: Drug Chemistry
(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. To learn structure features of various drug molecules.
2. To familiarize with symptoms, treatment of different diseases.
3. Study of synthesis of various drugs molecules.

Course Contents (Topics and subtopics)

- | | | |
|----------|--|---------------|
| 1 | Classification of Drugs | (04 L) |
| 2 | Antibiotics:
Introduction, Classification, Structure & Uses of Streptomycin, Penicillin, Tetracycline, Other common antibiotics | (06 L) |
| 3 | Antidiabetics:
Introduction, Classification, Management of Diabetes Mellitus, Insulin & Synthesis of Glibenclamide, Metformin | (06 L) |
| 4 | Anticancer / Antineoplastic agents:
Introduction, Classification, Causes, Treatment of Cancer, Synthesis of Mechlorethamine, Melphalan, Uracil Mustards, Cis-platin. | (08 L) |
| 5 | Anti-HIV Drugs:
Introduction, Classification, Causes, Prevention, Treatment, Synthesis of AZT | (06 L) |
| 6 | Cardiovascular Drugs:
Introduction, Classification, Cardiovascular diseases, Synthesis of Amyl Nitrite, Sorbitrate, Atenolol. Antihypertension Drugs | (06 L) |
| 7 | Antimalarial Drugs:
Introduction, Types, Life-cycle, Treatment, Synthesis, Dengue | (04 L) |

- 8 Antihistamines: (04 L)**
Introduction, Synthesis of Methapyrilene, Chlorpheniramine
- 9 Antivirals Drugs: (04 L)**
Introduction, Chikungunya, Swine flu, Synthesis of Amantadine
- 10 Local Anti-infective Drugs: (04 L)**
Introduction, Classification, Synthesis of Sulphonamides, Dapsone, Aminosalicyclic acid
- 11 Psychoactive Drugs: (04 L)** Introduction, Classification, Synthesis of Diazepam, Oxazepam, Alprazolam
- 12 Antibacterial Drugs, Antitubercular Drugs (04 L)**

References:

1. Medicinal Chemistry. G. R. Chatwal.
2. Medicinal Chemistry—By A. Kar, Wiley, 2000.
3. Strategies for Organic Drug synthesis and design—By D. Lednicer John Wiley 1998.
4. Synthetic drugs—G. R. Chatwal—Himalaya, New Delhi 1995.
5. Total synthesis of Natural product: The chiral approach Vol. III, S. Hanessian Pergamon Press 1983.
6. Principles of Medicinal Chemistry (4th Edition) W. D. Foye, T. L. Lemke, D. A. Williams.
7. Organic Chemistry of Drug action and Design. R. B. Siwerman, (Academic press, 1993).
8. Medicinal Chemistry - Alka L. Gupta.
9. Medicinal Chemistry - V. K. Ahluwalia & Madhu Chopra.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC403.1	Understand symptoms, treatment of various diseases.	2
OC403.2	Knowledge of drugs available for life saving.	2
OC403.3	Classify and compare the available drugs.	4

OC-404: Organic Chemistry Practical Course-IV

(180 Hrs, 100 Marks and 6 Credits)

Course Objectives: To make the students conversant with the

1. To learn techniques for preparation of compounds.
2. To learn two stage, three stage, multicomponent synthesis.
3. To learn total synthesis technique.

Two Stage Preparations (Minimum Eight)

At least eight two stage preparations should be carried out. The exercise should illustrate the use of organic reagents and may involve the name reactions.

Three Stage Preparations (Minimum Four)

Minimum four experiments should be carried out to demonstrate multistep synthesis technique.

Total Synthesis (Minimum Two)

Total synthesis of minimum two compounds should be carried out to learn the technique.

Multicomponent Reactions (Minimum Eight)

Reactions involving 3, 4, 5 compounds should be carried out on the basis Green Chemistry Principles. The synthesis should be carried out on micro scale. The progress of reaction should be monitored by TLC.

References:

1. Vogel's, Practical Organic Chemistry.
2. Practical Organic Chemistry, R. K. Bansal.
3. Systematic lab experiment in Organic Chemistry by Arun Sethi.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC404.1	Apply the organic synthesis techniques.	3
OC404.2	Plan and execute the total synthesis of important organic compounds.	6

OC-405: A Short Research Project

(180 Hrs, 100 Marks and 6 Credits)

Course Objectives: To make the students conversant with the

1. To learn literature survey.
2. To learn purification techniques.
3. To learn organic synthesis techniques.

Students should carry out a small research project. This should make them familiar with literature survey, research methodologies, identification of products by analytical and spectral methods and familiarity with chromatographic techniques. Students should be present their research work in Avishkar / Conferences.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
OC405.1	Acquire skills of literature survey, research methodology and technical report writing.	4
OC405.2	Design the synthesis and applications organic compounds.	6

M.Sc. Part II Semester IV (Organic Chemistry): Audit Courses

	AC-401(A): Human Rights (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives (CObs): To make students aware about human rights and human values.	
Unit 1	Introduction to Human Rights 1.1 Concept of Human Rights 1.2 Nature and Scope of Human Rights 1.3 Fundamental Rights and Fundamental Duties 1.4 Interrelation of Rights and Duties	6 L
Unit 2	Human Rights in India 2.1 Meaning and Significance of : 1) Right to Equality 2) Right to Freedom, 3) Right against Exploitation, 4) Right to Freedom of Religion, 5) Cultural and Educational Rights, and 6) Right to Constitutional Remedies. 2.2 Constitutional Provisions for Human Rights 2.3 Declaration of Human Rights 2.4: National Human Rights Commission	8 L
Unit 3	Human Values 3.1: Meaning and Definitions of Values 3.2: Importance of values in the life of Individual 3.3: Types of Values 3.4: Programmes for conservation of Values	8 L
Unit 4	Status of Social and Economically Disadvantaged people and their rights 4.1: Rights of women and children in the context of Social status 4.2: The Minorities and Human Rights 4.3: Status of SC/ST and other Indigenous People in the Indian Scenario 4.4: Human rights of economically disadvantaged Society	8 L
Suggested readings: 1. Human rights education – YCMOU, Nasik 2. Value education – SCERT, Pune 3. Human rights reference handbook – Lucille whare		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401A.1	Practice the learned issues under human rights and human values in real life.	3
AC401A.2	Provide social justices to people around them and provide guidance about human rights to their friends, parents and relatives.	5

	AC-401(B): Current Affairs (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)		
	Course Objectives (COs): • To make students updated about current affairs of India and world.		
	Title	Content	
Unit 1	Politics & Economy	• National & International Political Activity, Organization. • Economy & Business, Corporate world	08 L
Unit 2	Awards and recognitions	• National & International Awards and recognitions • Books and authors	07 L
Unit 3	Science & Technology	• Software, Automobile, Space Research • New inventions and discoveries	07 L
Unit 4	Environment & Sports	• Summit & conference, Ecology & Climate, Organization. • National & International Games, Olympics, commonwealth etc.	08 L
Suggested readings (Use recent years' data and current literature): 1. India 2019, by Publications Division Government of India 2. Manorama Year Book by Philip Mathew, 3. India 2019, Rajiv Maharshi 4. Quick General Knowledge 2018 with Current Affairs Update, Disha Experts 5. General Knowledge 2018: Latest Who's Who & Current Affairs by RPH Editorial Board.			

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401B.1	Identify important issues currently/ recently happening in India or world.	5
AC401B.2	Summarize current affairs regularly.	6

	AC-401(C): Technical Report Writing (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Program-level)	
	Course Objectives (COs): - To provide basic knowledge of report writing and their implications. - To identify, who you're producing the report for, why you're producing the report and what information you're covering	
Unit 1	Introduction Importance of report writing in academics and research. Various kinds of academic and research activities. Necessity of report writing for achievement of academic and research goals. Various kinds of reports / presentations. Characteristics of academic and research reports / presentations.	6 L
Unit 2	Research paper writing Types of research papers, Structure of research papers, Research paper formats, Abstract writing, Methodology, Results and discussions, Different formats for referencing, Ways of communicating a research paper.	6 L
Unit 3	Thesis writing Structure of a thesis, Scope of the work, Literature review, Experimental / computational details, Preliminary studies, Results and Discussions, Figures and Tables preparation, Conclusions and future works, Bibliography, Appendices	6 L
Unit 4	Tools and Techniques Various word processors, e.g, MS Word, Libre-office, Latex etc. Making effective presentations using Power Point and Beamer, Uses of plagiarism detection tools.	6 L
Unit 5	Miscellaneous Reports Writing research proposals, Writings project proposals, Lecture notes, Progress reports, Utilization reports, Scientific reports etc.	6 L
Suggested readings: - Academic Research & Report Writing By Dr. Samir Roy ,National Institute of Technical Teachers Training and Research, Kolkata https://onlinecourses.swayam2.ac.in/ntr21_ed23/preview https://www.youtube.com/watch?v=Xp2PVO3do34 https://www.theiet.org/media/5182/technical-report-writing.pdf http://www2.hawaii.edu/~sugihara/courses/HCU2016s_TC/notes/TechWriting1.html - A Step-by-Step Guide to Writing Academic Papers, by Anne Whitaker September 2009 - On Writing a Thesis by C P Ravikumar, IETE Journal of Education, 2000		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401C.1	Write reports on various activities including academic and research effectively and efficiently.	3
AC401C.2	Apply the principles and techniques of report writing for effective dissemination of the academic and research findings.	3

	AC-401(D): Intellectual Property Rights (IPR) (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Program-level)	
	Course Objectives (CObs): - To provide basic knowledge on intellectual property rights and their implications. - To understand patent rights and ownership of patents.	
Unit 1	Intellectual Property Rights: What is IPR?, Types of IPR- Patent, Copyright, Designs, Trade mark, Trade secret, Domain names, Geographical indications, Difference between IP and IPR, Relevance of IPR in today's world	4 h.
Unit 2	Patents:- History of Indian Patent System, Indian patent Law 1970 at a glance, Criteria for patenting an invention, Routes to file patents in India, Procedure to file patent in India,	4 L
Unit 3	Structure of IPR Offices in India, Fees of patenting in India, Restoration of Patents,	3 L
Unit 4	Patent rights and ownership of patents: Ownership of patent, Rights of patent holder and co-owners, Duties of patent holder and co-owners, Transfer of patent Rights, Limitations of patent Rights, Compulsory Licence	4 L
Unit 5	Infringement of patent Infringement of patent Rights and Offences, Actions against Infringement and Remedies and Relief	4 L
Unit 6	Discussion on Case studies - Trade secret, Geographical indication	4 L
Unit 7	Discussion on case studies – Trade mark, Compulsory Licence	4 L
Unit 8	Discussion on - Career in Intellectual Property Rights	3 L
Suggested readings: - Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct. - Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub. - National Portal of India. http://www.archive.india.gov.in - Office of the Controller General of Patents, Design & Trademarks; Government of India. http://www.ipindia.nic.in/ - World Intellectual Property Organization. http://www.wipo.int - World Trade Organization. http://www.wto.org https://www.youtube.com/watch?v=2YEr9hpuAfA&t=12s - Patent Act 1970 - https://www.youtube.com/watch?v=9r3OneOW6YE - Career in IP https://www.youtube.com/watch?v=iwI8lyo90mM https://www.youtube.com/watch?v=vdJm7pY2JoU - Infringement of patent https://www.youtube.com/watch?v=6y5j7HoixhU https://www.youtube.com/watch?v=7ihGrOxxe88 - Geographical indication https://www.youtube.com/watch?v=7k5rCsnlMSI - Copyright act https://www.youtube.com/watch?v=owhEPIEb5JA		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401D.1	Understand basics of intellectual property rights.	2
AC401D.2	Explain patent rights and ownership of patents.	3
