

**KAVAYITRI BAHINABAI CHAUDHARI NORTH
MAHARASHTRA UNIVERSITY, JALGAON, MS, INDIA
(Academic Flexibility Since-2009)**



SYLLABUS

for

**Master of Science (M. Sc.) in Chemistry
(with specialization in Industrial Chemistry)**

**Department of Industrial Chemistry,
School of Chemical Sciences,
Kavayitri Bahinabai Chaudhari North Maharashtra
University Jalgaon, MS, India Pin 425 001**

**Semester I to IV
(Choice Based Credit System, 60:40 Pattern)**

w. e. f. June 2019

**Summary of Distribution of Credits under CBCS Scheme
for
M.Sc. in Chemistry
(with specialization in Industrial Chemistry)
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	06	06	06
03	School Elective	-	02	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	26	06	06	08	94

Total Credits = 94

Department of Industrial Chemistry, School of Chemical Sciences
Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon
M. Sc. in Chemistry (with specialization in Industrial 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+P)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (Practical)	Total Credits	
I	03	12+00	12	04	02+06	08	1	2	2	22
II	03	12+00	12	04	02+06	08	1	2	2	22
III	3	12+00	12	02	04 + 06	10	1	2	2	24
IV	3	12+00	12	2	00 + 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	03	12	03	12	03	12	03	48
(B)	Skill Based / Subject Elective Courses									
1	Theory	02	01	02	01	04	01	--	--	08
2	Practical	06	03	06	03	06	01	12	02	30
(C)	Audit Course (No weightage in CGPA calculations)									
1	Practicing Cleanliness	02	01							02
2	Personality and Cultural Development Related Course			02	01					02
3	Technology Related + Value Added Course					02	01			02
4	Professional and Social + Value Added Course							02	01	02
	Total Credit Value	22	08	22	08	24	06	26	06	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	Sport Activities	AC-301B	Cyber Security	AC-401B	Current Affairs
		AC-201C	Yoga	AC-301C	Introduction to Research	AC-401C	Technical Report Writing
		AC-201D	Music	AC-301D	Seminar on Review of Research Paper	AC-401D	Intellectual Property Rights (IPR)

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

M. Sc. I in Chemistry (with specialization in Industrial Chemistry)

Common Course Structure for the First Year (60+40 Pattern)
(w. e. f. June 2019)

Semester-I
Common Course Structure for the First Year (60+40 Pattern)

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 Based	Laboratory Safety and Practices	02	--	02	20	--	30	--	50	--	02
CH-105	Skill Based	Laboratory Course in Inorganic Chemistry-I	--	04	04	--	20	--	30	--	50	02
CH-106	Skill Based	Laboratory Course in Organic Chemistry-I	--	04	04	--	20	--	30	--	50	02
CH-107	Skill Based	Laboratory Course in Physical Chemistry-I	--	04	04	--	20	--	30	--	50	02
AC-101	Audit Course	Practicing Cleanliness		02	02		100	--	--	--	100	02
Total Credit for Semester I: 22 (T = Theory: 14; P = Practical: 06; Audit Course:02)												

Semester-II
Common Course Structure for the First Year (60+40 Pattern)

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
PC-204	Elective (Choose Any One out of five: PC/PA/IC/PH/ AN-204)	Basic Concepts of Polymer Chemistry	02	--	02	20	--	30	--	50	--	02
PA-204		Basic Concepts of Pesticides and Agrochemical Chemistry	02	--	02	20	--	30	--	50	--	02
IC-204		Basic Concepts of Industrial Chemical Process	02	--	02	20	--	30	--	50	--	02
PH-204		Chemical Mathematics	02	--	02	20	--	30	--	50	--	02
AN-204		Basic Concepts of Instrumentation and Analysis	02	--	02	20	--	30	--	50	--	02
CH-205	Skill Based	Laboratory Course in Inorganic Chemistry-I	--	04	04	--	20	--	30	--	50	02
CH-206	Skill Based	Laboratory Course in Organic Chemistry-I	--	04	04	--	20	--	30	--	50	02
CH-207	Skill Based	Laboratory Course in Physical Chemistry-I	--	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
Total Credit for Semester I: 22 (T = Theory: 14; P = Practical: 06; Audit Course:02)												

List of elective courses to 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
Fully Specialized Course Structure for the Second Year (60+40 Pattern)

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	
IC-301	Core	Unit Operations in Chemical Industries	04	--	04	40	--	60	--	100	--	04
IC-302	Core	Synthetic Methods in Organic Synthesis	04	--	04	40	--	60	--	100	--	04
IC-303	Core	Industrial Polymers and Paint Technology	04	--	04	40	--	60	--	100	--	04
IC-304	Elective (any one)	Physical and Mechanical Properties of Polymers	04	--	04	40	--	60	--	100	--	04
PA-304		Advanced Agrochemicals, Biopesticides and Fertilizer										
IC-304		Pharmaceutical Chemistry										
OC-304		Heterocyclic Chemistry										
PH-304		Physical Chemistry of Polymers										
AN-304		Modern Separation Science										
IC-305	Skill base	Laboratory Course in Industrial Chemistry – I	--	12	12	--	40	--	60	--	100	06
AC-301 (A)/(B)/ (C)/(D)	Audit Course	Choose one out of five(AC-301(A)/(B)/(C)/(D)) (Technology + value added course)	02	--	02	100	--	--	--	100	--	02
Total Credit for Semester I: 24 (T = Theory: 16; P = Practical: 06; Audit Course:02)												

List of elective courses to 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

Important Note:

The projects will be initiated in the beginning of Semester III and the examination will be conducted at the end of Semester IV.

Semester-IV

Fully Specialized Course Structure for the Second Year (60+40 Pattern)

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	
IC-401	Core	Applied Industrial Chemistry-I	04	--	04	40	--	60	--	100	--	04
IC-402	Core	Agrochemical Industries	04	--	04	40	--	60	--	100	--	04
IC-403	Core	Applied Industrial Chemistry-II	04	--	04	40	--	60	--	100	--	04
IC-404	Skill base	Laboratory Course in Industrial Chemistry - II	--	12	12	--	40	--	60	--	100	06
IC-405	Skill base	Short Research Project *	--	12	12	--	40	--	60	--	100	06
AC-401 (A)/(B)/(C)/(D)	Audit Course	Choose one out of four (AC-401 (A)/(B)/(C)/(D)) (Professional and Social + value added course)	02	--	02	100	--	--	--	100	--	02
Total Credit for Semester I: 26 (T = Theory: 12; P = Practical: 12; Audit Course:02)												

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

AC-401 (A): Human Rights,

AC-401 (C): Technical Report Writing,

AC-401(B): Current Affairs,

AC-401(D): Intellectual Property Rights

Important Notes:

- 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 h / theory course)
- Each practical course will require 12 h of laboratory work per week per semester. The research project will be extended over two semesters (06 h/week) and will be examined at the end of the year. (Total 180 h / practical course)
- There should not be more than 10 students in a batch for M. Sc. Practical course.
- For theory course the question paper (Internal/External) may include numerical, short answer, long answer, MCQ questions to test understanding of the subject.
- Of the 60 lectures in each course about 10 lectures will include tutorials, student seminars, classroom discussions and tests.
- 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.
- The 80 % attendance of students is compulsory.
- It is expected that students should visit chemical industries in two years of M. Sc. and submit the observations/report to the Department.
- Students are expected to undergo one-month practical training (at their own cost) in relevant industries. The said training is proposed after II / III semester.
- Organizing educational tour aiming at giving practical exposure to students is expected (at their own cost). At the end of tour, students should submit the observations/report to the respective department.

**School of Chemical Sciences,
Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, MS, India**

M. Sc. Chemistry (with specialization in Industrial Chemistry)

Program at a Glance

Name of the program (Degree)	: M. Sc. in Chemistry (with specialization in Industrial 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 examination and 40 marks continuous internal departmental examination/assessment)
Passing standards	: 40% in each examination separately (separate head of passing)
Evaluation mode	: CGPA
Total Credits of the program	: 94 (48 core credits including 6 credits of project/dissertation, 26 skill enhancement credits, 06 subject elective credits and 08 audit credits)

School of Chemical Sciences,
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M. Sc. Chemistry (with specialization in Industrial Chemistry)

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, independent 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
PO 1	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
PO 2	Administer the skills in handling scientific instruments, planning and performing in laboratory experiments	3
PO 3	Analyze the given scientific experimental data critically and systematically and the ability to draw the objective conclusions.	4
PO 4	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
PO 5	Model and formulate the real problems and find solution based-on knowledge acquired	6
PO 6	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

School of Chemical Sciences,
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M. Sc. Chemistry (with specialization in Industrial Chemistry)

Program specific objectives of M. Sc. in Chemistry (with specialization in Industrial Chemistry)

- To provide the graduate with overall knowledge and skills on industrial or applied chemistry.
- To achieve peer- recognition as a modern chemist with understanding of various unit operations and unit processes of different industrial products.
- To make the graduates competent to take up the challenging positions in academic and research as well as in chemical industries and R and D laboratories.
- To make the graduate able to come forward as an entrepreneur.

Program Specific Outcomes (PSOs) of M. Sc. in Chemistry (with specialization in Industrial Chemistry)

After completing this program, the graduate should be able to

PSO No.	PSO	Cognitive level
PSO1	Determine fundamentals of industrial or applied chemistry.	3
PSO2	Recognize the graduate with thorough understanding on various unit operations and processes of different chemical industries.	1
PSO3	Focus on responsibilities in institutes in synthesis, characterization, and applications of industrial products pertaining to various fields and as an entrepreneur.	4

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 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_h ,. Identification of optical Isomerism and Dipole moment. Molecular Orbital Theory and its application. BeH_2 , BF_3 , CH_4 , NH_3 , H_2O .	12 h
Unit II	Organometallic compounds of transition metals 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.	12 h
Unit III	Chemistry of non transition elements 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.	12 h
Unit IV	Ionic solids 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.	12 h
Unit V	Bioinorganic chemistry 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.	12 h

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. 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 (COs):

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:

- The course offers the basic concepts of Organic Chemistry.
- The course helps to understand the principles involved in organic Chemistry.
- The course also helps to understand the organic reactions with mechanism and their applications in laboratory as well as in industry.

Course Contents (Topics and subtopics)

Unit I	<p>A] IUPAC Nomenclature of Organic Compounds including Regio- and Stereoisomer's</p> <p>B] Aromaticity - Huckel's rule and Concept of Aromaticity, Non aromaticity and Antiaromaticity, Annulenes and Heteroannulenes, Fullerenes (C60).</p>	12 h
Unit II	<p>Nucleophilic substitutions at saturated carbon</p> <p>The Reaction Mechanism: Reactivity at a Saturated Carbon Atom, Available Pathways, The S_N1 Mechanism, S_N2 Mechanism. Stereochemistry of Nucleophilic Substitution: The S_N2 reaction, S_N1 reaction. The Variables in Nucleophilic Substitution: The Leaving Group, The Nucleophile, The Site of Substitution, Solvent Effects, Solvolysis, S_N1 versus S_N2. Neighboring Group Participation.</p>	12 h
Unit III	<p>Electrophilic aromatic substitution</p> <p>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.</p> <p>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.</p> <p>Nucleophilic Aromatic Substitutions: The Addition-Elimination Mechanism, The Elimination-Addition Mechanism Benzyne, The Aryl Cation Mechanism - Diazonium Salts.</p>	12 h
Unit IV	<p>Elimination reactions-alkenes and alkynes</p> <p>The Reaction Mechanism: The $E1$, $E2$ & $E1cB$ Mechanism, Mechanistic Variables, $E1$ 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.</p>	12 h
Unit V	<p>Electrophilic additions to unsaturated carbon</p> <p>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.</p> <p>Additions to conjugated compounds:</p> <p>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.</p> <p>Recommended Books:</p>	12 h

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	To memorize the fundamental and concepts of organic reaction mechanism	1
CH102.2	Explain Importance of types of organic reactions.	4
CH102.3	Study of Aromaticity	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 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.	12 h
Unit II	Phase equilibria 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	12 h

Unit III	<p>equation.</p> <p>Electrochemistry</p> <p>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.</p>	12 h
Unit IV	<p>Nuclear Chemistry</p> <p>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).</p>	12 h
Unit V	<p>Chemical Kinetics</p> <p>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.</p> <p>Recommended Books:</p> <ol style="list-style-type: none"> 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 Lid., New Delhi. 	12 h

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	4
CH103.3	Apply the knowledge to explore applications of electrochemistry	3
CH103.4	Get thorough knowledge about fundamental aspects on Nuclear chemistry	5
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	<p>A. History and importance of safety and health in Laboratory - Moral, legal and financial reasons</p> <p>B. Different types of Hazards at workplace handling chemicals</p> <p>C. Physical, chemical, biological, allergens, hazards pertaining electrical system</p> <p>- Effect of hazards on health</p> <p>- Where to find Hazard information-Reading Labels</p> <p>D. Safety Measures: Safe clothing, hair, dangling jewellery responsible attitude, good House Keeping, use of proper PPE, No food in the laboratories.</p>	06 h
Unit II	<p>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.</p>	06 h
Unit III	<p>Types of fire extinguishers and their method of use</p> <p>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, Globally Harmonized System for Safety Data Sheets (SDS), label changes (2014).</p>	06 h
Unit IV	<p>Inventory Management, Storage and Disposal, Waste classification, Hazardous waste, Non-Hazardous waste, mixed waste, Waste disposal, Actions required for – Chemical spills, Mercury spills, Injuries, Fires, Building evacuations, Emergency evacuation procedure.</p>	06 h
Unit V	<p>Good Laboratory Practices (GLP), Introduction and principles of GLP, Performance of laboratory studies and calibration using Standard Operating Procedures (SOPs), Instrument validation, Reagent certification, Laboratory notebook maintenance to contemporary standards, maintenance of</p>	06 h

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.	6
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 (III).
 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	Analyse 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.	4
CH105.3	Carry out Ca-Drug Analysis and the volumetric estimation of Ca.	4

CH-106: Laboratory Course in Organic Chemistry-I
(50 Marks and 2 Credits)

Course Objectives:

- This course offers the skills involved in utilization of different techniques required for purification of organic compounds.
- This course also offers skill development in the preparation of derivatives of selected organic compounds.
- This course also offers knowledge of utilizing computer software for drawing 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.	3
CH106.2	Prepare the derivatives of organic compounds.	6
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	4
CH-107.4	An appraise for modern problems and scientific controversies in physical chemistry	5
CH-107.5	Develop more interest to learn and practice new instruments	4

M.Sc. Part I Semester I:

Audit Courses:-

AC-101: Practicing Cleanliness

(Compulsory; Campus-level Audit Course; Practical; 2 Credits)

AC-101: Practicing Cleanliness (Compulsory; Campus-level Audit Course; Practical; 2 Credits)		
Course Objectives (COs): <ul style="list-style-type: none">To make students aware of Clean India Mission and inculcate cleanliness practices among them.		
	<ul style="list-style-type: none">Awareness program on<ul style="list-style-type: none">Swachh Bharat Abhiyan (Clean India Mission)Clean Campus MissionRole of youth in Clean India MissionCleaning activities inside and surroundings of Department buildings.Tree plantation and further care of planted treesWaste (Liquid/Solid/e-waste) Management, Japanese 5-S practicesPlanning and execution of collection of Garbage from different sections of University campusRole 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 contestsPainting 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 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.	12 h
Unit II	Charge transfer transition 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.	12 h
Unit III	Reaction mechanism in transition metal complexes 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.	12 h
Unit IV	Catalysis 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).	12 h
Unit V	The Structure and Reactivity of molecules VSEPR Theory, structures of molecules containing lone pair of electrons,Sulphurtetrafluoride, Bromine trifluoride, dichloroiodate(I)anion, pentafluorotellurate (IV)anion, tetrachloroiodate (III)anion, nitrogen dioxide, nitrite ion and nitryl ion, phosphorus trihalides, carbonyl fluoride, summary of VSEPR Rules,	12 h

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.
- J.D. Lee, Concise Inorganic Chemistry, 5thedn., Blackwell Science, London, 2006.
 - A. G. Sharpe, Inorganic chemistry, 3rd edition, ISBN 9788131706992, Pearson Education, 1981.
 - F.A. Cotton, Chemical Applications of Group Theory, ISBN: 978-0-471-51094-9, 1990.
 - D.F. Shriver, P.W. Atkins and C.H. Langford, Inorganic Chemistry, CH Langford, 1990.
 - B.R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Shoban Lal Nagin Chand and Co., 2005.
 - H. B. Gray, Electrons and Chemical Bonding. W. A. Benjamin, Inc., New York, 1965.
 - H. J. Emeleus and A.G. Sharpe, Modern Aspects of Inorganic Chemistry, Universal Book Stall, New Delhi.
 - K. Lal, S.K. Agarwal, Advanced Inorganic Chemistry, Pragati Prakashan, Meerut, 2017.
 - G.S. Manku, Theoretical Principles of Inorganic Chemistry, Tata McGraw-Hill Ed.
 - B. Douglas, D.H. Mc. Daniel, J.J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd edition.
 - R. Sarkar, General and Inorganic Chemistry, Part one, New Central Book Agency, Kolkata.
 - P.K. Bhattacharya, Group Theory and its Chemical applications, Himalaya Publishing House.
 - F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, JOHN WILEY & SONS, INC.
 - K. Arora, Concept and Applications of Group Theory, Anmol Publication Pvt. Ltd., New Delhi.
 - 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
C201.1	illustrate microstates, spectroscopic terms and Orgel and Tanabe-Sugano diagram of inorganic molecules for octahedral and tetrahedral complexes	3
C201.2	classifies ligand substitution reactions and explains its kinetics and various mechanisms.	2
C201.3	understand theory and mechanism of catalytic action of catalysts	5
C201.4	understand VSEPR theory and explain the structures based on it	5

CH-202: Organic Chemistry-II (60 h, 100 Marks and 4 Credits)

Course Objectives:

- The course offers to study the importance of stereochemistry and organic spectroscopy for structure elucidation with respect to laboratory and industrial applications.

- This course also offers to learn various name reactions, rearrangement and reagents used in organic chemistry.
- This course helps to understand the principles behind UV, IR, and NMR spectroscopy.

Course Contents (Topics and subtopics)

Unit I	Selective name reactions Stork 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 Erythro isomers. 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, Pascal's triangle, factors affecting on coupling constant. Joint Problems based on UV, IR & ¹H NMR. Recommended Books: 1. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, II nd 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.	12 h

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
202.1	Describe some basic named reactions of organic chemistry	2
202.2	Discuss useful rearrangement reactions	2
202.3	Understand and apply core study of spectroscopy	3
202.4	Use of stereochemistry and reagents in organic synthesis.	4

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	12 h

Unit IV	<p>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.</p> <p>Infra-red Spectroscopy</p> <p>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.</p>	12 h
Unit V	<p>Photochemistry</p> <p>Introduction, photochemical reactions, quantum yield, Jablonski diagram, photosensitization reactions fluorescence (resonance fluorescence, sensitized fluorescence and quenching of fluorescence), phosphorescence, Stern-Volmer equation.</p> <p>Recommended Books:</p> <ol style="list-style-type: none"> 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. 	12 h

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
C203.1	Get in-depth knowledge on fundamental and advance concepts of quantum chemistry	4
C203.2	Know more about Macromolecules	4
C203.3	Describe theoretical aspect of spectroscopy, which is helpful in development of theoretical research in physical chemistry.	4

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 polymerisation and learn different techniques of polymerisation.
- 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 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)	06 h
Unit II	Mechanisms of polymerisations Mechanisms of chain and step growth polymerizations, ring opening polymerisation, Miscellaneous polymerisations - electrochemical polymerisation, metathesis polymerisation, group transfer polymerisation	06 h
Unit III	Techniques of polymerisations Bulk polymerisation, solution polymerisation, suspension polymerisation, emulsion polymerisation, melt polycondensation, solution polycondensation, and interfacial polycondensation, solid and gas phase polymerisation	06 h
Unit IV	Molecular weights and nomenclature of polymers 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	06 h
Unit V	Polymer degradation 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.	06 h

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.	1
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.ChattopadhyayPrinciples and procedures of plant protection. Oxford & IBH Publishing Company, Pvt. Limited; 1991.
5. A. S. AtwalAgricultural 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	Get in-depth knowledge on fundamental and advance concepts of basic mathematics course, which is essential for chemical sciences.	4
PH204.2	This knowledge is also required for solving various mathematical equations that need to be solved in several physical chemistry courses.	4
PH204.3	Apply the knowledge to explore applications of chemical mathematics to student will be able to solve numerical problems in physical 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: 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.	12 h
Unit II	Errors, statistics and sampling: 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.	12 h
Unit III	Ultra purity and ultra trace analysis: Ultra purity and ultra trace analysis, laboratory dosing, purification of reagents, Preconcentration Techniques, , contamination control during analytical operation.	12 h
Unit IV	Basic analytical process: Separation methods, Precipitation, solvent extraction and chromatographic methods. Activation analysis, basic principles, fast neutron activation analysis, radiochemical methods in activation analysis.	12 h
Unit V	Complexometric equilibria: 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.	12 h

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 (COs):

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

CO No.	CO	Cognitive level
AN204.1	To differentiate the fundamental methods of chemical analysis	4
AN204.2	To apply the basic analytical processes in chemical analysis	3

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 field of chemistry.

Course Contents (Topics and subtopics)

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

- 1) Chalcopryite 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 trioxalato chromate (III).
- 4) Preparation and purity determination of Nitro penta-ammino 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
CH204.1	Analyse the alloy concentration and Estimate volumetrically the concentration of Zn and Cu using titration method	4
CH204.2	Determine the lattice energy of various chemical ionic compounds	4
CH204.3	Carry out Fe-Drug Analysis and the volumetric estimation of Fe.	4
CH204.4	Perform experiment for the preparation and purity determination of coordination compounds	6

CH-206: Laboratory Course in Organic Chemistry-II (50 Marks and 2 Credits)

Course Objectives:

- This course is designed to develop the experimental skills in organic chemistry.
- This course offers to prepare organic compounds in single stage.
- This course also offers to interpret IR and NMR the 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
CH 206.1	Solve the experimental problems in laboratory or industrial sectors related with organic chemistry.	6
CH 206.2	Prepare and purify the organic compounds	6
CH 206.3	Determine the structure of organic compound from spectroscopic data.	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	Know more about Safety requirements and lab skills	4
CH 207.3	Practice learned each instrument.	3

M.Sc. Part I Semester II:

Audit Courses - Choose one out of four (AC-201 (A)/(B)/(C)/(D)
(Personality and Cultural Development Related)

AC-201(A): Soft Skills

AC-201(B): Practicing Sports Activities

AC-201(C): Practicing Yoga

AC-201(D): Introduction to Indian Music

	AC-201(A): Soft Skills (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives (COs): <ul style="list-style-type: none"> 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	8 hrs.

	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.	
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:

1. Basics of Communication In English: Francis Sounderaj, MacMillan India Ltd.
2. English for Business Communication: Simon Sweeney, Cambridge University Press
3. An Introduction to Professional English and Soft Skills: Das, Cambridge University Press
4. Quantitative Aptitude: R.S. Agrawal

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): <ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 (COs):

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

CONo.	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: <ul style="list-style-type: none"> To motivate students towards yoga and provide them required training.
	<ul style="list-style-type: none"> Yog: Meaning, Definition & Introduction, Objectives Primary Introduction of Ashtanga Yoga Preparation of Yogabhyas Omkar Sadhana, Prayer, Guru Vandana SukshmaVyayamas Suryanamaskar (12 Postures) Asanas : <ul style="list-style-type: none"> Sitting (Baithaksthiti) - Vajrasana, Padmasana, Vakrasana, Ardha-Pashchimotanasana Supine (Shayanthiti) - UttanPadaasan(Ekpad/Dwipad), Pawanmuktasana, ViparitaraniAasan, Khandarasan, Shavasana Prone (Viparitshayanthiti) - Vakrahasta, Bhujangasana, SaralhastaBhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana Standing (Dhandstithi) - 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: <ul style="list-style-type: none"> To motivate students towards Indian music and provide them minimum required training.
	<ul style="list-style-type: none"> Definition and brief about generation of Swar, Saptak, Thaata, Raaga, Aavartan, Meend, Khatka, Murkee, Taal, Aalaap etc. Taal and its uses - Treetaal, Daadaraa, 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.
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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

M.Sc. Part II Semester III

IC-301: Unit Processes in Chemical Industries

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- To prepare the graduate to become a professional with understanding of basics of unit processes in chemical industries.
- To familiarise the graduate with basic concepts and objectives behind various unit processes of different chemical industries.
- To educate the graduate with manufacturing of different chemicals.

Course Contents (Topics and subtopics)

Unit I	a) Amination by Reduction:[06 h] Introduction and definition, Methods of reduction, Metal and acid Reductions, Metal and alkali reductions, Amination by aminolysis, aminating agents, physical and chemical factors affecting aminolysis, manufacture of aniline by reduction of nitrobenzene, p-phenylenediamine, aniline by continuous ammonolysis. b) Alkylation: [06 h] Introduction and types of Alkylation, alkylating agents, factors controlling alkylation, equipment for alkylation, alkylation methods for i) Alkyl-aryl sulphonates, ii) Ethylbenzene, iii) Dimethylaniline.	[12 h]
Unit II	Hydrolysis: Definition and scope, hydrolyzing agents, materials susceptible to hydrolysis, kinetics, thermodynamics and mechanisms of hydrolysis, Equipment for hydrolysis, Technical operations involving hydrolysis.	[12 h]
Unit III	a) Oxidation: [06 h] Liquid and vapour phase oxidations, apparatus for Oxidation, technical oxidation of acetaldehyde, iso-propyl alcohol, naphthalene, and naphthalene sulphonic acid. b) Esterification: [06 h] Esterification of organic acids and derivatives, esters by addition, to unsaturated systems, interesterification of lard, technical preparation of ethyl acetate, cellulose acetate, nitroglycerol, polyethyl ether.	[12 h]

Unit IV	a) Hydrogenation: [06 h] [12 h] Catalytic hydrogenation, Apparatus, Industrial processes, Hydrogenation of fatty oils, Synthesis of methanol. b) Nitration: [06 h] Introduction, Nitrating reagents, Aromatic nitration, Nitration of paraffinic hydrocarbons, nitrate esters, N-nitro-compounds, process equipment for technical nitration, Mixed acid nitration, Typical Industrial nitration processes.
Unit V	Sulfonation and Sulfation: [12 h] Introduction, sulfonating and sulfating reagents and their principle applications. Chemical and physical features in sulfonation and sulfation, mechanisms, the desulfonation reaction, working up procedures, Industrial equipment and techniques, Transition from batch to continuous processing. Recommended Books <ol style="list-style-type: none"> 1. Unit Processes in Organic Synthesis- P. H. Groggins, Tata McGraw-Hill, 5th Edition, New Delhi, 2010. 2. Dryden's Outline of Chemical Technology, M. Gopal Rao, Marshall Sittig East-West Press Pvt. Ltd., 3rd Edition, 2014. 3. Chemical Process Industries- B. Shreve., Tata McGraw Hill, New Delhi, 2012. 4. Comprehensive Industrial Chemistry, P. G. More, Pragati Edition, Meerut, 2010.

Course Outcomes

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

CO No.	CO	Cognitive level
IC301.1	Distinguish between unit processes and unit operations of chemical industries.	5
IC301.2	Apply the knowledge on newer techniques in industrially important products with the help of various unit processes.	3
IC301.3	Expertise in operating procedures, hazard analysis, and safe work practices.	5

IC-302: Synthetic Methods in Organic Synthesis

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- To prepare the graduate to understand synthesis plans of industrially important heterocyclic compounds with the help of various name reactions.
- To prepare the graduate to know methods of isolation of products from natural resources.
- To prepare the graduate with proficiency in green chemistry and industrial hazards management.

Course Contents (Topics and subtopics)

Unit I	Organic Name Reactions: Suzuki Coupling, Wittig-Horner Reaction, Sonogashira Coupling, Rosenmund Reduction, Pechmann Condensation, Olefin Metathesis, Knoevenagel Condensation, Heck Reaction, Diazotization, Wacker oxidation, Mukaiyama esterification, Hiyama coupling, Pauson-Khand reaction, Negishi coupling, Monsanto acetic acid synthesis, Kumada coupling.	[12 h]
Unit II	a) Natural Products: [06 h] Chemistry of natural products such as alkaloids, steroids, terpenes. Total Synthesis of Carpanone (O. L. Chapman), Vitamin B12 (R. B. Woodward), Monensin (W. C. Still), Menthol (Takasago). b) Isolation of Natural Products of Commercial Importance: [06 h] Methods of Isolation of Natural Products, Isolation of Nicotine from tobacco waste, Citral from lemon grass, extraction of Neem oil and eucalyptus oil.	[12 h]
Unit III	a) Heterocyclic Chemistry: [06 h] Synthesis and reactions of Pyridine (Hantzsch Synthesis), Quinoline (Bischler-Napieralski Synthesis), Pyrrole, Furan, Thiophene (Paal-Knorr Synthesis), Benzofuran, Indole (Fischer), Imidazole. b) Designing Organic Synthesis: [06 h] Common terms used in retro synthetic analysis, One group disconnection, Two group disconnections, Illogical two group disconnections.	[12 h]
Unit IV	Industrial Hazards and management: Chemical and Process Hazards: Toxicity, Flammability, Corrosively, Explosion, Ignition, Pressure, Temperature, Noise, Industrial safety, Hazardous Waste and Management.	[12 h]
Unit V	Green Chemistry: Introduction, Principles, Alternative reagents (PTC, crown ethers, cryptands), solvents (ionic liquids, eutectics, and supercritical fluids), environmentally benign approaches: Sonochemistry, Polymer supported reactions, Microwave mediated reactions, Solvent free and solid supported reactions, ball milling/grinding methods for synthesis.	[12 h]
Recommended Books <ol style="list-style-type: none"> 1. Advance Organic Chemistry - Jerry March, John Willey and Sons, 2007. 2. Modern Methods of Organic Synthesis, , W. Carruthers and I. Coldham, Cambridge University Press, 4th Edition U.K.; New York, 2004. 3. Designing Organic Synthesis- Stuart Warren, John Willey and Sons, 1991. 4. Modern Synthetic Reagents- H. O. House. Benjamin-Cummings Publishing Co. 2nd edition, 1972. 5. Organic Chemistry- S. H. Pine, McGraw-Hill, New York, 5th edition, 2007. 6. Organic Chemistry-, Robert T Morrison and Robert N Boyd, Englewood Cliffs, N. J.: Prentice Hall, 1992. 7. Reaction Mechanism and Reagents in Organic Chemistry, G. R. Chatwal, Himalaya Publishing House, 2017. 8. Green Chemistry: Theory & Practice P. T. Anastas and J. C. Warner, TPB, 2012. 9. Green Chemistry: Frontiers in Benign Chemical Synthesis P. T. Anastas and T. C. Williamson, Oxford University Press, 1999. 10. Organic Synthesis: Special Techniques V. K. Ahluwalia and Renu Aggarwal, CRC Press, 2001. 		

11. Green Chemistry. J. N. Gurtu, and A. Gurtu, Pragati Prakashan, 2014.
12. Green Chemistry. R. Sanghi, and M. M. Srivastava, Narosa, 2004.
13. Classics in total synthesis. K. C. Nicoloue and E. J. Sorensen, Wiley VCH, 1996.

Course Outcomes

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

CO No.	CO	Cognitive level
IC302.1	Summarize utility of different name reactions and methods for the preparation of heterocyclic compounds.	2
IC302.2	Identify the ways of isolation of constituent from their corresponding natural sources.	1
IC302.3	Detect importance of green chemistry and the possible industrial hazards in their management.	3

IC 303 : Industrial Polymers and Paint Technology

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- Prepare the graduate with basic background on polymerisation techniques and various ways to classify polymers.
- Prepare the graduate with ways of preparation, properties, and applications of industrially important thermoplastics and thermosetting polymers.
- Prepare the graduate with information about constituents of paints, role of polymers in paint as well as properties and basics of paint manufacturing.

Course Contents (Topics and subtopics)

Unit I	A. Basic Concepts of Polymers (06 h)	[12 h]
	History, Trends, and General Polymer Background, Concept of functionality and reactivity, Degree of polymerization, Classification of polymers (Homopolymers, co-polymers, linear polymers, branched polymers, cross linked or three dimensional polymers, block co-polymers, organic- inorganic polymers, natural and synthetic polymers, chain and step growth polymers, thermoplastic and thermoset, based on applications - fibers, foams, adhesives and elastomers, based on performance – commodity and engineering polymers, isotactic polymer, syndiotactic polymer, atacti polymer)	
Unit II:	General Chemistry, Technology of Production, Properties and Applications of	[12 h]

Chain growth polymers

- a. Polyethylene (HDPE, MDPE, LDPE, LLDPE, HMWPE, UHMWPE, EVA, crosslinked PE, chlorinated PE),
- b. Polypropylene (PP),
- c. Polyisobutylene (PIB)),
- d. Acrylics (PMMA & PAN)
- e. Polyvinyles (PVC, PVDC & CPVC),
- f. Polystyrene & copolymer (HIPS, SBR, SAN & ABS)
- g. Poly(vinyl acetate)

Unit III: General Chemistry, Technology of Production, Properties and Applications of [12 h]**Step growth polymers**

- a. Phenol formaldehyde (PF- novolak and resol)
- b. Urea formaldehyde (UF)
- c. Melamine formaldehyde (MF)
- e. Polyamides:- Nylon-6, Nylon-12, Nylon-46, Nylon-66, Nylon-612

Unit IV: A. Paints – Introduction of paint - Wet paint, constituents of paints, classification [12 h]

of paints, applications of paints, Dry film properties of paints-adhesion, hardness, toughness and durability, flexibility, loss of decorative properties due to weathering, ease of repair and surface renovation-solvent resistance, how paints dry-drying without chemical reaction, drying by chemical reaction

B. Pigmentation of paints:- pigment properties, - tinting strength, light fastness, bleeding characteristics, hiding power, refractive index, particle size, particle shape, specific gravity, chemical resistivity, and thermal stability, Types of pigments (classification)- natural/ synthetic pigments, organic/inorganic pigments, pigment selection

Unit V: A. Manufacture of Paints (05 h) [12 h]

Principles, source of added value, production strategy, manufacturing process for varnishes/paints/coating powders, equipment for pigment dispersion – high speed disperser, sand or bead mill, triple roll mill, ball mill, titrator

B. Important Resins or Modifications of Resins for Paints and Coatings (07 h)

- a. Epoxy Resins (BPA based resin, curing agents & flame-retardant epoxy resins)
- b. Unsaturated polyester resins

Recommended Books

1. Polymer Chemistry - M. P. Stevens, 2nd Ed., Oxford University Press, New York, 1999.
2. Poly. Synthesis - Stanley R. Sandler, Wolf Karo, Vol. 1, Academic Press, Inc., California, 1994.
3. Introduction to Polymer Chemistry - R.B. Seymour, Marcel Dekker, 6th Ed.,

Florida, 2003.

4. Polymer Chemistry-properties and applications, Andrew Peacock, Allison Calhoun, Hanser Publishers, Munich, 2006.
5. Polymer Science and Technology of Plastics and Rubbers, Premamoy Ghosh, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1996.
6. Encyclopaedia of Chemical Technology, Kirk and Othmer, John Wiley & Sons, 2000
7. Plastics Materials, J. Brydson, Butterworths, 8th Edn., London, 1999.
8. Polymer Chemistry, Ayodhya Singh, Campus Books, New Delhi , 2006.
9. Organic Polymer Chemistry, V. Jain, IVY Publishing House, New Delhi, 2003.
10. Outlines of Paint Technology, W. M Morgan 3rd edn CBS Publishers, 2000.
11. Introduction to Paint Chemistry and Principles of Paint Technology, By J. Bentley and G. P. a. Turner, 4th Edn, Chapman & Hall, London, UK, 1998
12. Paints, Coatings and solvents, Dieter Stoye, Werner Freitag, Wiley-VCH Verlag GmbH, Weinheim, 1998.
13. Organic Coatings: Properties and Evaluation, Felix Konstandt, Chemical Publishing Co., New York, 1985.

Course Outcomes

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

CO No.	CO	Cognitive level
IC303.1	Use the knowledge of synthesizing industrial polymers and use information about their industrially important applications.	3
IC303.2	Distinguish plastics as thermoplastics and thermosets.	4
IC303.3	Distinguish between polymerization techniques viz. bulk, solution, suspension, emulsion, and interfacial polymerizations.	4
IC303.4	Plan possibility in using polymers and pigments in paints and familiarize with paint manufacturing steps and processes.	5

IC-304: Pharmaceutical Chemistry

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- To prepare the graduate to understand concept of pharmaceutical industries and drugs.
- To provide information on relations of chemical structure and bioactivity (SAR and QSAR), assay of drugs, metabolism, and mode of action of drugs.

- To enable the graduate to classify drugs according to their actions.

Course Contents (Topics and subtopics)

Unit I	Introduction to pharmaceutical chemistry Brief history, Drugs, Classification of drugs, Characteristic of good drugs, Therapeutic index, Bactericidal and Bacteriostatic drugs. Biological and Medical terms used in pharmaceutical chemistry, pharmacokinetics, Receptor, Affinity, Intrinsic activity, Bio-isosters, chemotherapy, pharmacodynamics, pharmacokinetics, Formulation of Drugs.	[12 h]
Unit II	Theories of drugs action Relation of chemical structure and chemical reactivity (SAR and QSAR), Assay of drugs, Metabolism of drugs, Mode of action, Meaning of following terms with examples- Antipyretics, Analgesics, Anti-inflammatory drugs, Antidiabetes, Leprosy, Antacids, Sedatives, Hypnotics, Cardiovascular drugs, Anthelmintic, Antibiotics, vitamins, hormones Chemical contraceptives.	[12 h]
Unit III	Cancer therapy Nature of cancer, terminology, theories of cancers, Causes and treatment of cancer, surgery, photo-radiation, radiation, immunotherapy, chemotherapy, combination therapy, adjuvant therapy. Antineoplastic drugs: mercaptopurine, 6-thioguanine, 5-fluorouracil, allopurinol, methotrexate. Alkylating agents. DNA intercalating agents, effect of alkylating agents on DNA. Antimitotic agents. Other compounds.	[12 h]
Unit IV	a) Anti-AIDS: [08 h] Introduction, Mechanism of HIV multiplication, Pathogenicity of HIV diagnosis-ELISA Anti-AIDS drugs, transmission, and prevention of HIV. b) Cardiovascular drugs: [04 h] Introduction, synthesis of amyl nitrate, methyldopa, sorbitrate.	[12 h]
Unit V	a) Anti-diabetic drugs: [02 h] Introduction, Synthesis of sequence of A and B chain of Insulin, Glibenclamide, Metformin. b) Vaccine and Antisera: [02 h] Vaccine-Types of Vaccines Antisera – Antitoxic, Antibacterial, Antiviral sera c) Vitamins: [03 h] Types of Vitamins, Synthesis of Vitamin A, E and H. d) Clinical Chemistry and Drug analysis: [05 h] Composition of blood collection, and preparation of samples. Clinical analysis: serum electrolyte, blood glucose, blood urea nitrogen, uric acid, albumin, globulin, acidic and alkaline phosphates. Narcotics and dangerous drug, drug analysis by chromatography/spectrophotometry.	[12 h]

Recommended Books

1. Medicinal Chemistry G. R. Chatwal, Himalaya Publishing House, New Delhi, 2010.
2. Principles of Medicinal Chemistry W. D. Foye's, T. L. Lemke, and D. A. Williams, Wolter and Kluwer (India) Pvt. Ltd., (4th edition), 1996
3. Organic chemistry of drug design and drug action, Richard B. Silverman, Mark W. Holladay, Academic Press, 1992

4. Synthetic Drug G. R. Chatwal, Himalaya Publishing House, 2016
5. Handbook of Industrial Chemicals (Vol.-I) K. M. Shah, Edutech Publishing Co. 2013.
6. Principles of Medicinal Chemistry Vol. I, K. G. Bothara, S. S. Kadam and K. R. Mahadik, Nirali Prakashan, 2010.
7. A Text Book of Medicinal Chemistry P. Parimo, CBS, 2011.
8. A Text Book of Pharmaceutical Formulations. B. M. Mittal, Vallabh Prakashan, 1997.
9. Fundamentals of analytical chemistry. D. A. Skoog, D. M. West, W. B. Saunders and F. J. Holler, Nelson Education, 2013.

Course Outcomes

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

CO No.	CO	Cognitive level
IC304.1	Summarize fundamental terms involved in pharmaceutical industry.	2
IC304.2	Express structure property relationship of various molecules for their probable applications as a drug.	6
IC304.3	Discuss the severe diseases like cancer, AIDS, and cardiovascular disorders.	2

IC-305: Laboratory Course in Industrial Chemistry- I

(Minimum 14 practical, 100 Marks and 6 Credits)

Course Objectives:

- To prepare the graduate with practical hands-on analysis of industrially important chemicals.
- To train the graduate with synthesis and purification of various industrially important chemicals.
- To prepare the graduate with practical skills to industrial jobs / entrepreneurial skills

Practical's included:

1. Spectroscopic Analysis:

UV-visible, IR, NMR and MS structure determination on the basis of data.

2. Synthesis of Organic compounds

a) Inorganic preparations and analysis (any three)

Zinc sulphate, Calcium carbonate, Ferrous sulphate, Boric acid, Zinc stearate, Plaster of Paris.

b) Organic one step preparations (any three)

- i) Preparation of benzoic acid by nitric acid oxidation
- ii) Preparation of benzoic acid by KMnO_4
- iii) Preparation of phenyl hydroxyl amine
- iv) Preparation of P-nitroanilide by nitration
- v) Preparation of anisole from phenol using DMS or methyl iodide

c) Organic two steps preparations (any three)

- i) Acetanilide – p-Bromoacetanilide – p-Bromoaniline

- ii) Phenyl hydrazine – Acetophenone phenyl hydrazine – 2-Phenyl indole
- iii) Acetophenone – Acetophenone oxime – Acetanilide
- iv) Cyclohexanone – Cyclohexanone oxime – Caprolactum
- v) Aniline – Diazoaminobenzene – p-Aminoazobenzene
- vi) Benzophenone – Benzopinacol – Benzopinacolone

d) Drug Preparation (any two)

Preparation of methyl salicylate, benzimidazole, sulphanilic acid, aspirin

3. Analysis of drugs (any five)

- i) Sulpha drugs- Sulphadiazine, Sulphaoxazole, Sulphaacetamide
- ii) APC tablet,
- iii) Iodometric assay- Analigl, Acetarsol.
- iv) Gravimetric analysis- Piperazine adipate/hydrate/ Phosphate
- v) Phenol estimation- Cyclobarbitone tablets
- vi) Determination of Water by KF method- Rifamycin Sodium,
- vii) Spectroscopic analysis of drugs- UV- Visible/ IR/ NMR.

4. Analysis of Water

- i) Determination of DO, SS, Hardness, BOD, COD.
- ii) Estimation of Chlorine and heavy metals by chemicals as well as Instruments.

5. Estimation of functional groups (any two)

-COOH, -OH, -NH₂, -CHO, R-CO-R', Ar-OH.

Recommended Books

1. A textbook of Practical Organic Chemistry – A. I. Vogel – ELBS with Longman, 5th Ed., 1989.
2. Laboratory Manual of Organic Chemistry- R. K. Bansal – Wiley Eastern 3rd Ed., 1994.
3. Advanced Practical Organic Chemistry – N. K. Vishnoi- Vikas 2nd, 1996
4. Application of Absorption Spectroscopy of Organic Compounds- J. R. Dyer – Prentice Hall, 1978
5. Spectroscopic Methods in Organic Chemistry – D.H. Williams Flemming – McGraw Hill, 1989
6. Organic Spectroscopy- P. S. Kalsi New Age International, 2007.
7. Instrumental Methods of Analysis – by Dr. G.R. Chatwal and Sham Anand, 2011.
8. Unit Processes in Organic Synthesis- P. H. Groggins, Tata McGraw-Hill, 5th Edition, New Delhi, 2010.
9. Chemical Technology – Dryden by M. Rao and M. Marshall, East west press, 1997.
10. Chemical Technology – Shah and Pandey, Sangam Books Limited, 2000
11. Synthetic Drugs- G .R. Chatwal, Himalaya Publishing House Ltd. 2016.
12. Pharmaceutical Drug Analysis- Ashutosh Kar, New Age International (P) Ltd, 2005.

Course Outcomes

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

CO No.	CO	Cognitive level
IC305.1	Prepare industrially important chemicals by various synthetic routes.	5
IC305.2	Use the skills to produce industrial chemicals.	3
IC305.3	Build knowledge for the synthesis of industrially important compounds.	3

M.Sc. Part II Semester III

Audit Courses - Choose one out of four (AC-201 (A)/(B)/(C)/(D)
(Personality and Cultural Development Related)

AC-301A	Computer Skills
AC-301B	Cyber Security
AC-301C	Introduction to Research
AC-301D	Seminar on Review of Research Paper

AC-301(A): Computer Skills		
(Technology + Value added Audit course; Practical; 2 Credits)		
(Optional: Campus + Program level)		
Course Objectives (CObs): <ul style="list-style-type: none"> 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	5 L

	3.4 Charting: Chart Types, drawing charts, Ranges, formatting charts	
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 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.	6 L
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	3

	effectively.	
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AC-301(B): Cyber Security (Technology + Value added Audit course; Practical; 2 Credits) (Optional: Campus + Program level)		
Course Objectives (CObs): <ul style="list-style-type: none"> 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:

1. 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):	
<ul style="list-style-type: none"> To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant research paper. 	
Seminar Activity:	
<ul style="list-style-type: none"> 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

M.Sc. Part II Semester IV

IC-401: Applied Industrial Chemistry-I

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- To understand basic concepts of applied industrial products and high energy materials.
- To learn journey of dyes, oils, and cosmetics perfumery in modern civilizations.
- To know various methods to apply fermentation and petrochemical techniques.

Course Contents (Topics and subtopics)

Unit I	a) Dyes Industries: [06 h] Introduction, Classification of Dyes, Colour and Contribution – Valence Bond Theory, M. O. Theory, Witt's Theory, Synthesis of Fast Red A, Naphthol Blue Black 6B, Naphthol Green B, Rosaniline, Alizarin pyronene- G. b) Fermentation Industries: [06 h] Introduction, Outline of Fermentation, Basic requirement of Fermentation, Manufacture of chloramphenicol, acetic acid, butanol, ethyl acetate, oxalic acid,	[12 h]
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	and citric acid.	
Unit II	Oils and Oleo Chemicals Industries Introduction, Properties and classification of oils, extraction, and purification of oils; Fatty acids- Introduction, nomenclature and applications of fatty acids; Soap- Introduction, classification, uses and manufacturing process of soap(s), Manufacture of detergents.	[12 h]
Unit III	a) Cosmetics Industries: [06 h] Introduction, manufacturing process of powder, cream and lotion, lipstick and nail polish, shampoo and hair dyes, tooth paste. b) Perfumery Industries: [06 h] Compounds used for different perfumes, Essential oils, Preparation of phenyl ethanol, Yara-Yara, β -ionone, musk ketone, musk ambrette, musk xylene, phenyl acetic acid and its' esters, benzyl acetate, synthetic musk, jasmine.	[12 h]
Unit IV	a) Petrochemicals: [06 h] Petroleum refining, outline of chemicals derived from ethylene, xylene, and naphthalene. b) Biofuels: [06 h] Introduction, Types of biofuels (bioethanol, biodiesel), Raw materials for synthesis of biofuels, Properties of biofuels, biofuels and environment, biofuels and economic, standard specification of biofuels uses of biofuels, Modification of vegetables of oils as biodiesel.	[12 h]
Unit V	High Energy Materials (HEMs) Introduction, definitions of explosives, propellants and energetic polymers, Classification of Explosives – high explosive, low explosive, melt cast explosive, thermally stable explosive, energetic binder, energetic plasticizer, energetic oxidizer, thermochemistry of explosives.	[12 h]
Recommended Books		
<ol style="list-style-type: none"> 1. Shrieves Chemical Process Industries –George T. Austin, Tata McGraw Hill publication, 2011. 2. Chemical Technology – Dryden by M. Rao and M. Marshall, East west press, 1997. 3. Chemical Technology – Shah and Pandey, Sangam Books Limited, 2000 4. Synthetic Dyes – G. R. Chatwal Himalaya publication house, 2009. 5. Organic Chemistry Vol. III – S. M. Mukharji, S. P. Singh, R P. Kapoor, New age International publication, 2017. 6. Paint Technology – W. M. Morgan 3rd edition, CBS publication, 2017. 7. Plants Oils as fuels: Present Science and Future Developments- N. Martini and J. S. Sebeli, 1998 8. Biofuels: Air Pollution and Health- Kirk R. Smith, 1987. 9. Biofuels and Industrial Products from Jatropha- M. Mittelbach, 1997. 10. Formulary of Cosmetic Preparations – M. Ash and I. Ash. 1977. 11. Formulary of Paints and Other Coatings – M. Ash and I. Ash. Chemical Publishing Company, 2000 12. Perfumery Technology- B. Billot and F. V. Wells, 1981. 13. High Energy Materials, Propellants, Explosives and Pyrotechnics- Jai Prakash Agrawal, 2010. 		

Course Outcomes

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

CO No.	CO	Cognitive level
IC401.1	Recognize importance of dyes as well as fermentation methods.	2
IC401.2	Express the content and techniques of processing perfumery and cosmetic products.	2
IC401.3	Write importance and various applications of biofuels as well as petrochemicals in modern era.	3
IC401.4	Explain chemical & physical properties and applications of high energy materials.	2

IC-402: Agrochemicals Industries

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- To provide knowledge about chemistry and importance of agrochemicals.
- To furnish the knowledge of properties and applications of various agrochemicals.
- To learn the manufacturing processes of different agrochemicals.

Course Contents (Topics and subtopics)

Unit I	Agrochemicals: [06 h] Introduction, Classification, Role of agrochemicals in agriculture. Pesticides- Classification, Nomenclature, formulation, toxicity, Principles of pest control, IPM. Chemistry of Pesticides: [06 h] Introduction to biological classes of pesticides, Structure, Chemical name, Physical properties, Chemical properties, Synthesis, Degradation and metabolism, Formulations, Mode of action, Uses, Toxicity.	[12 h]
Unit II	Chemistry of Pesticides a) Insecticides: Cypermethrin, Phorate, Propoxur. b) Acaricides: Dichlorvos, Phosphamidon, c) Fungicides: Captan, Copper oxy chloride, d) Rodenticides: Warfarin, Zinc Phosphide. e) Nematicides: Aldicarb, Terbufos. f) Fumigants: Ethylene dibromide, Methyl bromide. g) Repellants (DEET) and attractants. h) Molluscicides: Metaldehyde i) Herbicides (2, 4-D, Dicamba, Propanil, Maleic hydrazide) and Plant growth regulators, (Chloramequat chloride, Daminozide, Ethephone, IAA). Manufacturing processes of some pesticides: Lindane (BHC), Dimethyl phthalate, Parathion, Phorate, Ethylene oxide, 2, 4-D, Copper sulphate.	[12 h]

Unit III	Pesticide formulations Introduction, Inert ingredients, Necessity of formulations, a) Dry formulations: Diluents, Carriers, Important properties/factors affecting quality and stability of pesticides formulations- particle size, bulk density, flowability, sorptivity, compatibility, Synergists, adjuvants; Stability and shelf life of formulations. Dusts (D/DP), Granules (G), Wettable powders (WP/WDP), Manufacturing processes. b) Liquid formulations: Solution/ oil Concentrates, Emulsifiable Concentrates (EC), Solvents, Adjuvants, factors affecting quality and stability and shelf life of formulations. c) Other formulations: Fumigants, Smoke generators, Liquidators, Oils, creams and gels, Bait, Seed dressings, Aerosols, ULV.	[12 h]
Unit IV	Advanced Pesticide formulations User friendly/ Safe and high performance formulations, i) Aqueous concentrates (AC), ii) Dustless Dusts (DL), Microgranules (MG), iii) Emulsion Concentrates (EW), Microemulsion (ME), Gels (GL), iv) Suspension Concentrates/ Flowables (SC/ SF), Water Dispersible Granules (WDG) or Dry Flowables (DF), Water soluble package, v) Controlled Release Formulations (CRF), Encapsulated Granules (CG), vi) Suspo- Emulsions /Emulsions Flowables (SE), Capsule Suspension (CS), β - cyclodextrin (CD) inclusion complexes, Ultra low volumes (ULV), Next Generation Formulations (NGF).	[12 h]
Unit V	Fertilizers Introduction, Classification, Principles, and methods of fertilizers applications. Synthetic fertilizers: Introduction, Manufacture and uses of nitrogenous fertilizers- Urea, Phosphatic fertilizers- triple super phosphate, Potassic fertilizers- potassium chloride, Complex/compound fertilizers- nitro phosphate, Mixed fertilizers – method of preparation and formulation. Fluid fertilizers- Introduction, Manufacturing of nitrogenous and mixed fluids. Recommended Books <ol style="list-style-type: none"> 1. Chemistry of Insecticides and Fungicides – U. S. Sree Ramulu, Oxford and IBM Pub., 1979 2. Pesticides Formulations – Van Wade. Velkenburg, 1973. 3. Agro based Industries and Pesticides formulations – S. B. Shrivastava and V. K. Agrawal, Small Industry Research Institute 4. Analytical Methods of Pesticides and Plant Growth Regulators and Food Additives Vol. I –IV – Gunter and Zweig, 1968. 5. Pesticides Synthesis – Mavy, Kohn, Menn, 1979. 6. Chemical Technology – Dryden by M. Rao and M. Marshall, East west press, 1997 7. Manures and Fertilizers – K. S. Yawalkar, J. P. Agrawal, S. Bokde, 1967. 8. Fluid Fertilizers – D. A. Palgrave, 1993. 9. Commercial Fertilizers – G. H. Collings, 2002. 	[12 h]

Course Outcomes

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

CO No.	CO	Cognitive level
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IC402.1	Discuss the properties and applications of advanced agrochemicals.	2
IC402.2	Explain in detail about different formulations and application of agrochemicals.	3
IC402.3	Generalize with commercial manufacturing ways of agrochemicals.	2

IC-403: Applied Industrial Chemistry-II

(60 h, 100 Marks and 4 Credits)

Course Objectives:

- To make the graduate familiar with chemistry, technology, and production of industrially important products like paper, leather, sugary, glass, and ceramics.
- To prepare the graduate with knowledge of preparation, properties, and applications of high-performance chemicals used in an electronic industries.
- To prepare the graduate with knowledge on role of hydrogen, nitrogen, oxygen, carbon dioxide, and liquefied gases.

Course Contents (Topics and subtopics)

Unit I	Paper and pulp industries: [06 h] Introduction, types of pulping, types and quality of paper, lignin and lignans. Leather Industry: [06 h] Introduction, Constituents of animal skin, manufacture and preparation of hide, cleaning, soaking, limiting and degreasing, finishing and sharing, tanning: leather, vegetable, chrome, tanning effluents: pollution and control.	[12 h]
Unit II	Metallurgy Introduction, production status of minerals in the World, mineral processing, manufacture and applications of metal alloys and salts, technique for reusing low grade minerals, iron and steel (iron, steel alloy, tool steel and stainless steel), copper and its alloy, zinc, nickel and aluminum.	[12 h]
Unit III	Glass and ceramics Industries Introduction, raw materials, soda glass, borosilicate glass, lead glass, colored glass, ceramic raw materials, clays, pottery, zeolites, fly ash, ceramic tiles.	[12 h]
Unit IV	Electronic Industries Introduction, ferrite and magnetic materials, Curie temperature, phosphorous for various uses, luminous paint, high purity silicon-zone refining method, germanium, gallium, indium and arsenic.	[12 h]
Unit V	Sugar industry-based chemicals: [08 h] Introduction of sugar industry, manufacturing process of sugar, manufacture processes of oxalic acid, citric acid, ethanol, furfural from sugar byproduct. Industrial gases: [04 h] Introduction, hydrogen, nitrogen, oxygen, carbon dioxide, and liquefied gases.	[12 h]

Recommended Books

1. Extraction metallurgy. J. D. Gilchrist, Pergamon press, Oxford ; New York :

Pergamon Press, 1989.

2. Foundation of steel and iron metallurgy. W. H. Denis, 1967.
3. Industrial chemistry. R. W. Thomas and P. Farago, 1973
4. Modern electroplating. 5th edition, F. A. Lowinbein, 2014.
5. Electroplating for engineering: A Handbook. 3rd Edn. V. N. Reinbold, Springer US, 1996.
6. Leather processing and Tanning technology: A handbook. NIIR Board of Consultants and Engineers, Niir Project Consultancy Services, 2011.
7. Tanning Chemistry: The Science of Leather. Anthony D. Covington, 2015.
8. Comprehensive Industrial Chemistry- P. G. More, Pragati Prakashan 2018.

Course Outcomes

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

CO No.	CO	Cognitive level
IC403.1	Discuss paper making and leather tanning procedures undergoing in industries.	2
IC403.2	Recall about newer techniques involved in metallurgy and applications.	1
IC403.3	Identify the properties of chemicals and their applications in electronic industries.	2
IC403.4	Summarize applicability of sugar based industrially important chemicals or additives.	5

IC-404: Laboratory Course in Industrial Chemistry- II

(Minimum 14 practical, 100 Marks and 6 Credits)

Course Objectives:

- To provide practical training on chemical processing as well as develop learning techniques for synthesizing organic and inorganic chemicals.
- To provide hands on training to carry out scientific laboratory procedures.
- To provide the knowledge of formulation and analysis of agrochemicals and other industrial products.

Practical's included

- I **A. Spectroscopic Analysis:** UV-Vis, NMR, IR, Mass spectral interpretations
- B. Instrumental Analysis:** DSC, TGA, DTA, SEM, TEM, XRD.
- II **Synthesis of Chemical Compounds**
- A. Preparation of agrochemicals (any five)**
- 1-/2- Naphthoxy acetic acid, 2- Chlorophenoxy acetic acid, Maleic hydrazide, Phthallyl hydrazide, Dimethyl phthalate, Coumarin.
- B. Preparation of dyes (any three)**
- Sudan- I, Yellow chrome, Orange chrome, Prussian blue.
- C. Organic two steps preparations (any three)**

1. Benzoin – Benzil – Benzilic acid
2. Acetanilide – p-Nitroacetanilide – p-Nitroaniline
3. p-Nitrotoluene – p-Nitrobenzoic acid – p-Aminobenzoic acid
4. o-Hydroxy acetophenone – o-Benzoyloxy acetophenone – o-Hydroxy benzoyl methane
5. p-Toluidine – 4-Acetomido-3-bromotoluene – 4-Bromotoluene
6. p-Nitrotoluene – p-Nitrobenzylidene diacetate – p-Nitrobenzaldehyde

D. Preparation and characterization of polymers and paints (any three)

1. Preparation of Urea formaldehyde resin
2. Preparation of Phenol formaldehyde resin – novolak and resol
3. Preparation of alkyd resin
4. Preparation of epoxy resin
5. Preparation of varnish
6. Formulation of distemper, primer, undercoat, and topcoat
7. Characterization of surface coating viscosity, gloss, impact resistance, cross cut adhesion, Scratch resistance
8. Preparation of nylon 66.

III Analysis of Agrochemicals (any three)

Copper sulphate, Copper oxy chloride, Bleaching powder, Phosphamidon, Nuvan, Lindane.

IV Analysis of Polymers and Oils

1. Determination of iodine/ acid/ Sap values.
2. Estimation of FFA of oils.

V Analysis of Soaps

VI Use of Reagents in Organic Synthesis (any three)

LiAlH_4 , NaBH_4 , SeO_2 , B_2H_6 , Grignard reagent, Lead tetra acetate, KMnO_4 , DMS or alkyl halide, NaIO_4 , PPA, AlCl_3 , DMF/ POCl_3 .

Recommended Books

1. Methods of pesticides analysis- U. S. Sree Ramulu, Oxford- IBH, 2003.
2. Pesticide Plant Regulators and Food Additives, Vol I to IV- Gunter Zweig- Academic press, 1967.
3. A textbook of Practical Organic Chemistry – A. I. Vogel – ELBS with Longman, 5th Ed. 1989.
4. Laboratory Manual of Organic Chemistry- R. K. Bansal – Wiley Eastern 3rd Ed., 1994.
5. Advanced Practical Organic Chemistry – N. K. Vishnoi- Vikas 2nd, (1996)
6. Application of Absorption Spectroscopy of Organic Compounds- J. R. Dyer – Prentice Hall, 1978
7. Spectroscopic Methods in Organic Chemistry – D .H. Williams and I Fleming – McGraw Hill, 4th Ed., 1989.
8. Environmental Chemistry – A. K. De 2007.
9. Organic Chemistry- P. S. Kalsi, 2016.
10. Instrumental Methods of Analysis – by Dr. G.R. Chatwal and Sham Anand, 2011.
11. Chemical Technology – Dryden by M. Rao and M. Marshall, East west

- press, 1997.
12. Chemical Technology – Shah and Pandey, Sangam Books Limited, 2000.
 13. Unit Processes in organic synthesis, McGraw Hill Education, P. H. Grogginess.
 14. Synthetic dyes-G. R. Chatwal Himalaya publication house, 2009.
 15. Paint Technology – W. M. Morgan 3rd edition, CBS publication, 2017.
 16. Experiments in Polymer Science, D. G. Hundiware, V. D. Athawale, U. R. Kapadi, V. V. Gite, New Age International Pvt. Ltd., New Delhi, 2009.

Course Outcomes

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

CO No.	CO	Cognitive level
IC404.1	Prepare the formulations of agrochemicals.	6
IC404.2	Complete analysis of the pesticide and formulations as well.	3
IC404.3	Able to prepare selected polymers in the laboratory.	6

IC 405: Short Research Project (100 Marks and 6 Credits)

Course Objectives:

- The short research project for M. Sc. Chemistry (with specialization in Industrial Chemistry) is constructed to get familiarize with designing of industrially important products.
- Train the students for relevant literature survey.
- The project should provide hands on training to the students on various instruments and analytical techniques.

Course Outcomes

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

CO No.	CO	Cognitive level
IC 405.1	Design and execute the plan of research on desire thrust area independently.	6
IC 405.2	Surveying the literature pertaining to the area of research or demand.	4
IC 405.3	Operate the require equipment according to the thrust area.	5
IC 405.4	Prepare the detail project report on the completed research work and its presentation.	3
IC 405.5	Acquire knowledge for better outcome of research (publications, patents, reports).	2

M.Sc. Part II Semester IV: Audit Courses

Audit Courses - Choose one out of four (AC-401/402/403/404
Professional and Social + Value Added Audit course; Practical; 2 Credits)

(Optional: Campus-level)

AC-401: Human Rights

AC-402: Current Affairs

AC-403: Technical Report Writing

AC-404: Intellectual Property Rights

	AC-401(A): Human Rights (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives (CObs): <ul style="list-style-type: none">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 h.
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 h
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 h
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 h
Suggested readings: <ol style="list-style-type: none">Human rights education – YCMOU, NasikValue education – SCERT, PuneHuman 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 (CObs): <ul style="list-style-type: none">To make students updated about current affairs of India and world.		
	Title	Content	Hours
Unit 1	Politics & Economy	<ul style="list-style-type: none">National & International Political Activity, Organization.Economy & Business, Corporate world	8 h
Unit 2	Awards and recognitions	<ul style="list-style-type: none">National & International Awards and recognitionsBooks and authors	7 h

Unit 3	Science & Technology	<ul style="list-style-type: none"> • Software, Automobile, Space Research • New inventions and discoveries 	7 h
Unit 4	Environment & Sports	<ul style="list-style-type: none"> • Summit & conference, Ecology & Climate, Organization. • National & International Games, Olympics, commonwealth etc. 	8 h

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): <ul style="list-style-type: none"> • 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 h.
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 h
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 h
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 h
Unit 5	Miscellaneous Reports Writing research proposals, Writings project proposals, Lecture notes, Progress reports, Utilization reports, Scientific reports etc.	6 h

Suggested readings:

1. Academic Research & Report Writing By Dr. Samir Roy ,National Institute of Technical Teachers Training and Research, Kolkata
2. https://onlinecourses.swayam2.ac.in/ntr21_ed23/preview
3. <https://www.youtube.com/watch?v=Xp2PVO3do34>
4. <https://www.theiet.org/media/5182/technical-report-writing.pdf>
5. http://www2.hawaii.edu/~sugihara/courses/HCU2016s_TC/notes/TechWriting1.html
6. A Step-by-Step Guide to Writing Academic Papers, by Anne Whitaker September 2009
7. 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
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AC401C.1	<ul style="list-style-type: none"> • Able to write reports on various activities including academic and research effectively and efficiently. 	3
AC401C.2	<ul style="list-style-type: none"> • 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 (COs): <ul style="list-style-type: none"> • 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 h
Unit 3	Structure of IPR Offices in India, Fees of patenting in India, Restoration of Patents,	3 h
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 h
Unit 5	Infringement of patent Infringement of patent Rights and Offences, Actions against Infringement and Remedies and Relief	4 h
Unit 6	Discussion on Case studies - Trade secret, Geographical indication	4 h
Unit 7	Discussion on case studies – Trade mark, Compulsory Licence	4 h
Unit 8	Discussion on - Career in Intellectual Property Rights	3 h
Suggested readings: <ol style="list-style-type: none"> 8. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct. 9. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub. 10. National Portal of India. http://www.archive.india.gov.in 11. Office of the Controller General of Patents, Design & Trademarks; Government of India. http://www.ipindia.nic.in/ 12. World Intellectual Property Organisation. http://www.wipo.int 13. World Trade Organisation. http://www.wto.org 14. https://www.youtube.com/watch?v=2YEr9hpuAfA&t=12s 15. Patent Act 1970 - https://www.youtube.com/watch?v=9r3OneOW6YE 16. Career in IP https://www.youtube.com/watch?v=iwI8lyo90mM https://www.youtube.com/watch?v=vdJm7pY2JoU 17. Infringement of patent https://www.youtube.com/watch?v=6y5j7HoixhU https://www.youtube.com/watch?v=7ihGrOxxe88 18. Geographical indication https://www.youtube.com/watch?v=7k5rCsnlMSI 19. 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	Able to know patent rights and ownership of patents.	3
