

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

SCHOOL OF CHEMICAL SCIENCES
(Academic Flexibility since 2009)



MASTER OF SCIENCE IN CHEMISTRY

(With specialization in Analytical Chemistry)

(Choice Based Credit System, 60:40 Pattern)

w. e. f. June 2019

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

Sr.No	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Core	12	12	12	12
02	Skill based	08	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 Analytical Chemistry, School of Chemical Sciences
Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon
M. Sc. Analytical 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	3	12+0	14	4	0+8	8	1	2	2	22
II	3	12+0	14	4	0+8	8	1	2	2	22
III	3	12+0	12	2	4+6	10	1	2	2	24
IV	3	12+0	12	2	0+12	12	1	2	2	26
Total Credits		48			38			8		94

(T, Theory; P, Practical)

Structure of Curriculum

		First Year				Second Year				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
(A)	Prerequisite and Core Courses									
	Theory	12	03	12	03	12	03	12	03	48
(B)	Skill Based/ Subject Elective Courses									
1	Theory	02	04	02	04	-	-	-	-	04
2	Practical	06	03	06	03	06	01	12	02	30
3	Subject Elective Courses	-	-	-	-	04	01	-	-	04
(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	Practicing Sport Activities	AC-301B	Cyber Security	AC-401B	Current Affairs
		AC-201C	Practicing Yoga	AC-301C	Introduction to Research	AC-401C	Technical Report Writing
		AC-201D	Introduction to Indian Music	AC-301D	Seminar on Review of Research Paper	AC-401D	Intellectual Property Rights (IPR)

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

M. Sc. I Analytical Chemistry
Common Course Structure for the First Year (60+40 Pattern)
(w. e. f. June 2019)

Semester-I

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
CH-101	Core	Inorganic Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-102	Core	Organic Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-103	Core	Physical Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-104	Skill 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

Semester-II

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
CH-201	Core	Inorganic Chemistry-II	04	--	04	40	--	60	--	100	--	04
CH-202	Core	Organic Chemistry-II	04	--	04	40	--	60	--	100	--	04
CH-203	Core	Physical Chemistry-II	04	--	04	40	--	60	--	100	--	04
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

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

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

* All theory courses of both First Years (Semester I and II) in the School are of 60 hrs each including 10-12 hrs of Tutorials / Home Assignments / Class Room Discussion / Seminars / Internal Tests and Assessment.

** Semester practical examination pattern.

*** Students have to choose any one subject from CH-204 i.e. from PC-204/PA-204/IC-204/PH-204/AN-204 for semester II.

Department of Analytical Chemistry
School of Chemical Sciences
Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon
Syllabus for M.Sc. Part-II Analytical Chemistry [Semester III and IV]
[w. e. f. June 2019]

Course Structure for Second Year
Semester-III

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
AN -301	Core	Concepts in Analytical Chemistry	04	--	04	40	--	60	--	100	--	04
AN -302	Core	Analytical Techniques in Chemical Analysis	04	--	04	40	--	60	--	100	--	04
AN -303	Core	Modern Spectroscopic Techniques	04	--	04	40	--	60	--	100	--	04
PC-304	Elective (Choose one out of six PC-304/PA-304/IC-304/OC-304/PH-304/AN-304 :)	Physical Chemistry of Polymers	04	--	04	40	--	60	--	100	--	04
PA-304		Advanced Agrochemicals, Biopesticides and Fertilizers										
IC-304		Pharmaceutical Chemistry										
OC-304		Heterocyclic Chemistry										
PH-304		Physical Chemistry of Polymers										
AN-304		Modern Separation Science										
AN - 305	Skill based	Laboratory Course in Analytical Chemistry-I	--	12	12	--	40	--	60	--	100	06
AC-301(A-D)	Audit Course	Choose one out of five (AC-301(A-D)) (Technology + value added course)	02	--	02	100	--	--	--	100	--	02

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

AC-301 (A):Soft Skills

AC-301 (B): Practicing Sports Activities AC-301 (C):Practicing Yoga AC-301 (D): Introduction to Indian Music

The students appearing for the 3rd semester should select one audit course out of four[AC:301(A-D)]

Semester-IV

Course Code	Course Type	Title of the Course	Contact hours/week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
AN - 401	Core	Advanced Analytical Chemistry	04	--	04	40	--	60	--	100	--	04
AN - 402	Core	Applied Analytical Chemistry	04	--	04	40	--	60	--	100	--	04
AN - 403	Core	Pharmaceutical and Cosmetic Analysis	04	--	04	40	--	60	--	100	--	04
AN - 404	Skill based	Laboratory Course in Analytical Chemistry-II	--	12	12	--	40	--	60	--	100	06
AN - 405	Skill based	A Short Research Project	--	06	06	--	40	--	60	--	100	06
AC-401 (A)/(B)/(C)/(D)	Audit Course	Choose one out of four (AC-401 (A)/(B)/(C)/(D)) (Professional and Social + value added course)	02	--	02	100	--	--	--	100	--	02

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

AC-401 (A): Human Rights,

AC-401(B): Current Affairs,

AC-401 (C): Technical Report Writing,

AC-401(D): Intellectual Property Rights

*Important Notes:

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

** Semester practical examination pattern.

Program at a Glance

Name of the program (Degree)	: M. Sc. (Analytical Chemistry)
Faculty	: Science and Technology
Duration of the Program	: Two years (four semesters)
Medium of Instruction and Examination	: English
Exam Pattern	: 60 : 40 (60 marks University exam and 40 marks continuous internal departmental exam/assessment)
Passing standards (separate head of passing)	: 40% in each exam separately
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)

Program Objectives for M.Sc. Program:

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

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

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

PO No.	PO	Cognitive level
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	Analyse 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

Program Specific Objectives for M.Sc. in Analytical Chemistry program:

- To provide the detail knowledge and skills on Analytical or Applied chemistry.
- To stimulate intellectual development, develops a power of critical analysis and ability to solve a problems.
- To train the students in practical skills for safe handling of chemicals and instruments.

Program Specific Outcomes (PSOs) for M.Sc. in Analytical Chemistry program:

Students who graduate with a Master of Science in Microbiology will:

PSO No.	PSO	Cognitive level
PSO1	Analyse fundamentals of analytical or applied chemistry	4
PSO2	Develop independent learning skill as well as experience of working in analytical laboratory.	6
PSO3	create the students with knowledge and generic skill for the employment in various sectors such R and D, academics as well as professionals.	6

Semester-I

CH-101: Inorganic Chemistry-I

(Core course; Theory; 60 h, 100 Marks and 4 Credits)

Course Objectives:

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

Course Contents (Topics and subtopics)

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

The Ionic solids. Classification of ionic structures, radius ratio rules, calculation of some limiting radius ratio values, close packing, Structures of ionic solids. A cautionary word on radius ratios. Lattice energy. The Born - Haber cycle, Applications of lattice energy. Resonance: resonance energy. Concept of formal charge, criteria for resonating structures. Hydrogen bonding concept and structure of water, alcohols, phenols, types, properties.

Unit V Bioinorganic chemistry

12 h

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

Recommended Books:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry Principles of Structures and Reactivity, 4th edition, New York, NY: Harper Collins College Publishers, 1993.
2. J. D. Lee, Concise Inorganic Chemistry, 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, Advance 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 A] IUPAC Nomenclature of Organic Compounds including Regio- and **12 h**

Stereoisomer's

B] Aromaticity - Huckel's rule and Concept of Aromaticity, Non aromaticity and Antiaromaticity, Annulenes and Heteroannulenes, Fullerenes (C₆₀).

Unit II Nucleophilic substitutions at saturated carbon 12 h

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.

Unit III Electrophilic aromatic substitution 12 h

Mechanism and Orientation in Electrophilic Aromatic Substitution: An Addition-Elimination Mechanism, Ortho, Meta and Para Orientation, Relative Rates of Substitution, The Rate Orientation Relation, Orientation in Multiply Substituted Aromatics, A Pi-complex intermediate.

Electrophilic Aromatic Substitution Reactions— Heteroatom's as the Electrophiles: Nitration, Halogenation, Sulfonation, Diazonium Coupling, Ipso Substitution. Carbon as the Electrophiles: Friedel-Craft Alkylation, Friedel-Craft Acylation.

Nucleophilic Aromatic Substitutions: The Addition-Elimination Mechanism, The Elimination-Addition Mechanism Benzyne, The Aryl Cation Mechanism - Diazonium Salts.

Unit IV Elimination reactions-alkenes and alkynes 12 h

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.

Unit V Electrophilic additions to unsaturated carbon**12 h**

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

Additions to conjugated compounds:

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

Recommended Books:

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

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
CH102.1	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
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CH-103: Physical Chemistry-I
(Core course; Practical; 60 h, 100 Marks and 4 Credits)

Course Objectives:

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

Course Contents (Topics and subtopics)

Unit I	Thermodynamics	12 h
	Laws of thermodynamics, Maxwell relations, thermodynamic equation of state, partial molar quantity and its significance, partial molar volumes, chemical potential, Gibbs-Duhem equation, thermodynamics of mixing- Gibb's free energy of mixing, entropy of mixing, enthalpy of mixing, volume of mixing.	
Unit II	Phase equilibria	12 h
	Phase, components, degree of freedom, the Gibb's phase rule, derivation of phase rule, phase equilibria of one component system (water and carbon dioxide system), phase equilibrium of two component system (two component system solid-liquid equilibria and simple eutectic systems), phase equilibrium of three component system, Clapeyron equation, Clausius-Clapeyron equation, integrated form of Clausius-Clapeyron equation.	
Unit III	Electrochemistry	12 h
	Anomalies of strong electrolytes, Debye-Hückel theory of strong	

electrolytes, relaxation effect (asymmetry effect), electrophoretic effect, activity coefficients of electrolytes, mean ionic activity coefficient, ionic strength of a solution, Debye-Hückel limiting law equation (derivation not expected) and experimental verification of it.

Unit IV Nuclear Chemistry

12 h

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

Unit V Chemical Kinetics

12 h

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

Recommended Books:

1. P. W. Atkins, Physical Chemistry, ELBS, 1998
2. G. M. Barrow, Physical Chemistry, International student edition, 2003.
3. G. W. Castellan, Physical Chemistry, AddisonWesley.
4. W. J. Moore, Physical Chemistry, Orient Longman, 1998.
5. S. Glasstone, D. Van Nostrand, Thermodynamics for Chemist, 1965.
6. S. Glasstone, V. Nostrand An Introduction to Electrochemistry, East-West 1965.
7. J. O'M Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. I and II, 2nd Edition, Plenum, 1977.
8. R. A. Robinson and R. H. Stokes, Electrolytic Solutions, Butterworths, London, 1959.
9. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age Publication Ltd., 1995.

10. G. Friedlander, J. W. Kennedy, E. S. Macias, J. M. Miller, Nuclear and Radiochemistry, John-Wiley, 1981.
11. B. G. Harwey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, 1963.
12. Source book of Atomic Energy, S. Glasstone, van Nostrand, 1967.
13. K. J. Laidler, Chemical Kinetics, McGraw Hill, 1985.
14. J. W. Moore, R. G. Pearson, Kinetics and Mechanism, John Wiley & Sons, 1981
15. G. L. Agrawal, Basic Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
CH103.1	Acquire knowledge on the fundamental and advance concepts of thermodynamics	3
CH103.2	Familiarize with phase rule	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** A. History and importance of safety and health in Laboratory - Moral, legal and financial reasons **06 h**
 B. Different types of Hazards at workplace handling chemicals
 C. Physical, chemical, biological, allergens, hazards pertaining electrical system
 - Effect of hazards on health
 - Where to find Hazard information-Reading Labels
 D. Safety Measures: Safe clothing, hair, dangling jewellery responsible attitude, good House Keeping, use of proper PPE, No food in the laboratories.
- Unit II** Personal Protective and other safety equipment and their uses and demonstration, Different types of safety goggles, apron, masks, different filters for masks, face shield, full body suit, safety shoes, helmet, breathing apparatus suit, safety belt and ear muffs along with inspection methods. Emergency exit, its location and approach path, periodic inspection fire extinguishers, first aid kit, its contents and need for monitoring. Eye wash fountains and safety showers, fire drill, and chemical accident drills, accident free days and incentives to follow safety rules, accident recording and investigation for future controls. **06 h**
- Unit III** Types of fire extinguishers and their method of use **06 h**
 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).
- Unit IV** 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. **06 h**

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

Recommended Books:

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

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
CH104.1	To adapt the rules and regulations of safety practices in the laboratory	6
CH104.2	To develop the experimental skill while performing in the laboratory.	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 Analytical Chemistry: Audit Courses

AC-101: Practicing Cleanliness

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

Course Objectives (COs):

- To make students aware of Clean India Mission and inculcate cleanliness practices among them.

	<ul style="list-style-type: none"> • Awareness program on <ul style="list-style-type: none"> ○ Swachh Bharat Abhiyan (Clean India Mission) ○ Clean Campus Mission ○ Role of youth in Clean India Mission • Cleaning activities inside and surroundings of Department buildings. • Tree plantation and further care of planted trees • Waste (Liquid/Solid/e-waste) Management, Japanese 5-S practices • Planning and execution of collection of Garbage from different sections of University campus • Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance. • Cleanest School/Department and Cleanest Hostel contests • Painting and Essay writing competitions 	
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Course Outcomes (COs):

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

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

Semester-II

CH- 201: Inorganic Chemistry-II

(60 h, 100 Marks and 4 Credits)

Course Objectives:

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

Course Contents (Topics and subtopics)

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

hydrolysis, stereochemistry, isomerisation reactions.

Unit IV Catalysis 12 h

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

Unit V The Structure and Reactivity of molecules 12 h

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

Recommended Books:

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

Chemistry, Universal Book Stall, New Delhi.

9. K. Lal, S.K. Agarwal, Advanced Inorganic Chemistry, Pragati Prakashan, Meerut, 2017.
10. G.S. Manku, Theoretical Principles of Inorganic Chemistry, Tata McGraw-Hill Ed.
11. B. Douglas, D.H. Mc. Daniel, J.J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd edition.
12. R. Sarkar, General and Inorganic Chemistry, Part one, New Central Book Agency, Kolkata.
13. P.K. Bhattacharya, Group Theory and its Chemical applications, Himalaya Publishing House.
14. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, JOHN WILEY & SONS, INC.
15. K. Arora, Concept and Applications of Group Theory, Anmol Publication Pvt. Ltd., New Delhi.
16. W.L.Jolly, Modern Inorganic Chemistry, 2nd edition, Tata McGraw Hill Co.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
CH201.1	illustrate microstates, spectroscopic terms and Orgel and Tanabe-Sugano diagram of inorganic molecules for octahedral and tetrahedral complexes	3
CH201.2	classifies ligand substitution reactions and explains its kinetics and various mechanisms.	2
CH201.3	understand theory and mechanism of catalytic action of catalysts	5
CH201.4	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** **12 h**

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.

Unit II **Rearrangements** **12 h**

Wagner-Meerwein, Pinacol, Wolff, Arndt-Eistert Synthesis, Hofmann, Curtius, Schmidt, Lossen, Beckmann, Baeyer-Villiger, Favorskii, Benzilic acid, Stevens, Wittig, Meisenheimer, Claisen, Cope.

Unit III **Reagents in organic synthesis** **12 h**

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_2H_6 , Peterson's synthesis, Wilkinson's catalyst, Baker's yeast.

Unit IV **Stereochemistry** **12 h**

Stereoisomers, Chirality, Enantiomers, Diastereoisomers, R-S nomenclature, E-Z isomerism, Meso Compounds, Threo and

Erythroisomers. Interconversion of Fischer into Sawhorse and Newman Projections. Conformations and Stereoisomerism of acyclic compounds (ethane, propane, butane) and cyclic compounds (cyclohexane, substituted cyclohexanes).

Unit V

A] U.V. spectroscopy

12 h

Woodward-Fisher rules for conjugated dienes and carbonyl compounds, applications of UV.

B] IR Spectroscopy

Characteristics vibrational frequencies of alkanes, alkenes, aromatic compounds, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, amides, anhydrides, lactones and lactams. Effect of hydrogen bonding and solvent effect on vibrational frequencies, applications of IR.

C] ¹H NMR Spectroscopy

Chemical shift, factors influencing chemical shift, shielding-deshielding, spin-spin coupling (n+1) rule, Pascals triangle, factors affecting on coupling constant.

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

Recommended Books:

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

8. E. L. Eliel, Stereochemistry of Carbon Compounds, McGraw-Hill.
9. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th Edition, New Age International.
10. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
CH202.1	Describe some basic named reactions of organic chemistry	2
CH202.2	Discuss useful rearrangement reactions	2
CH202.3	Understand and apply core study of spectroscopy	3
CH202.4	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	12 h
	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.	

Unit II Macromolecules 12 h

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.

Unit III Microwave Spectroscopy 12 h

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.

Unit IV Infra-red Spectroscopy 12 h

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.

Unit V Photochemistry 12 h

Introduction, photochemical reactions, quantum yield, Jablonski diagram, photosensitization reactions, fluorescence (resonance fluorescence, sensitized fluorescence and quenching of fluorescence), phosphorescence, Stern-Volmer equation.

Recommended Books:

1. R. K. Prasad, Quantum Chemistry, Wiley Eastern Ltd, 1992.
2. Introductory to Quantum Chemistry, A. K. Chandra, Tata McGraw Hill, 1979.
3. I. N. Levine, Allyn and Bacon Quantum Chemistry.
4. M. Hanna, Quantum Mechanics in Chemistry, John Wiley and Sons 1970.
5. P. W. Atkins, Physical Chemistry, ELBS, 1998
6. G. M. Barrow, Physical Chemistry, International student edition, 2003.
7. F.W. Billmeyer Jr., Polymer Chemistry, John-Wiley and sons 1971.
8. D. D. Deshpande, Polymer Chemistry of Macromolecules, Vishal

Publications, 1984.

9. C. N. Banwell, E. M. Mac Cash, Fundamentals of Molecular Spectroscopy, fourth Edition, McGraw Hill.
10. G. M. Barrow. Molecular Spectroscopy,
11. Rohatgi-Mukherjee, Fundamentals of Photochemistry, Wiley-Eastern Ltd., New Delhi, 1978.
12. R. P. Wayne, Principles and Application of Photochemistry, Oxford University Press, 1988.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
CH203.1	Get in-depth knowledge on fundamental and advance concepts of quantum chemistry	4
CH203.2	Know more about Macromolecules	4
CH203.3	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	06 h
	Basic concepts - polymer, monomer and polymerization, functionality and reactivity, Classification of polymers based on - source, chemical nature, thermal response, ultimate form and branched/network structures, homopolymer and copolymer (types)	
Unit II	Mechanisms of polymerisations	06 h
	Mechanisms of chain and step growth polymerizations, ring opening polymerisation, Miscellaneous polymerisations - electrochemical polymerisation, metathesis polymerisation, group transfer polymerisation	
Unit III	Techniques of polymerisations	06 h
	Bulk polymerisation, solution polymerisation, suspension polymerisation, emulsion polymerisation, melt polycondensation, solution polycondensation, and interfacial polycondensation, solid and gas phase polymerisation	
Unit IV	Molecular weights and nomenclature of polymers	06 h
	Degree of polymerisation, various average molecular weights (M_n , M_w , M_v and M_z) and molecular weight distribution (MWD), nomenclature of polymers based on - source, structure, IUPAC	
Unit V	Polymer degradation	06 h
	Polymer degradation and stability, thermal degradation, chain scission, non-chain scission, oxidative and UV stability, chemical and hydrolytic stability, radiation effect, mechano degradation, biodegradation – biodegradable polymers (PLA) and starch additives.	

Recommended Books:

1. V. R. Gowarikar, N. V. Viswanathan and Jayadev Sreedhar, Polymer Science, New Age International (P) Limited, New Delhi, 1988.
2. M. P. Stevens, Polymer Chemistry an Introduction, 2nd Edition, Oxford University Press, New York, 1999.
3. J. R. Fried, Polymer Science and Technology, Eastern Economic

Edition, Printice Hall of India, New Delhi, 2000.

4. C. E. Carraher Jr Introduction to Polymer Chemistry, Special Indian Edition, Taylor and Francis, New Delhi, First reprint, 2010.
5. P. Ghosh, Polymer Science and Technology, Plastics, Rubbers, Blends and Composites, , 3rd Edition, Tata McGraw Hill Education Private Ltd., New Delhi, 2011.
6. ,F. W. Billmayer, Text Book of Polymer Science John Wiley and Sons, New Delhi, 1984.
7. G. Odian, Principles of Polymerisation, 3rd Edition, Odian, John Wiley & Sons (Asia) Pvt. Ltd., Singapore, 2002.
8. P. Bahadur and N. V. Sastry, Principles of Polymer Science, 2nd Edition, Narosa Publishing House, New Delhi, 2012.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
PC204.1	To recall the basic concepts and classification of polymers.	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	06 h
	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,	

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>), bollworm (<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, coccinella) and parasites (<i>Trichogramma</i>) in pest management, pathogens in disease and insect pest management (<i>Bacillus thuringiensis</i> , NPV).	06 h
Unit V	Effects of Pesticides Pesticide residues, toxicity, warning symbols, safety with pesticides, First aid and antidotes.	06 h

Recommended Books:

1. S. K. Handa, Principles of pesticide chemistry. Agrobios (India); 2012.
2. A. Knowles, New developments in crop protection product formulation. T and F Informa UK Ltd. 2005.
3. D. S. Hill, Agricultural insect pests of the tropics and their control. CUP Archive; 1983.
4. S. B. Chattopadhyay Principles and procedures of plant protection. Oxford & IBH Publishing Company, Pvt. Limited; 1991.
5. A. S. Atwal Agricultural Pests of India and South-East Asia. Agricultural pests of India and South-East Asia. 1976. Pradhan S. Insect pests of crops. University of California; 1969.
6. S. Subramanian, S. Subramanian, A. Mohamed, J. Kumar, All about weed control. Kalyani Publishers; 2001.
7. Ó. López, J. Fernandez-Bolanos, editors. Green trends in insect control. Royal Society of Chemistry; 2011.

Course Outcomes (COs):

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

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

IC-204 Basic Concepts of Industrial Chemical Processes

(30 h, 50 Marks and 2 Credits)

Course Objectives:

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

Course Contents (Topics and subtopics)

Unit I	a) Chemical Industry Introduction, Chemical production, Raw materials and their sources b)Parameters of Chemical Industry Plant location, Safety, Construction of plant, Management for productivity and creativity, Training for plant procedure and labour, Chemical processtechnology, Classification of chemical reactions, Batch and continuous operations, Industrial chemical reactions, Conversion, Selectivity and Yield.	06 h
Unit II	Unit Operations Introduction, Unit operations- Conveying, Crystallization, Distillation, Drying, Evaporation, Filtration, Leaching, Liquid-liquid extraction, Membrane separation, Particle size reduction and enlargements, Solid -solid separation.	12 h

Unit III Unit processes**12 h**

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.

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:**12 h**

Introduction, Titration curves, Types of EDTA titrations, Types of Complexometric Titrations (a) Direct Titration (b) Back Titration (c) Replacement titration (d) Indirect Titration (e) Applications of Complexometric Titrations.

Recommended Books:

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

Course Outcomes (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 fields of chemistry.

Course Contents (Topics and subtopics)

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

- 1) Chalcopyrite ore – Estimation of silica by gravimetrically and copper by volumetrically.
- 2) Analysis of Alloy: Brass alloy – Estimation of copper and zinc by volumetrically.
- 3) Preparation and purity determination of Potassium 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
CH205.1	Analyse the alloy concentration and Estimate volumetrically the concentration of Zn and Cu using titration method	4
CH205.2	Determine the lattice energy of various chemical ionic compounds	4
CH205.3	Carry out Fe-Drug Analysis and the volumetric estimation of Fe.	4
CH205.4	Perform experiment for the preparation and purity determination of coordination compounds	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 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 (Analytical Chemistry): Audit Courses

	AC-201(A): Soft Skills (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	<i>Course Objectives (CObs):</i> <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 spontaneously for 5 minutes each on a given topic), Storytelling (Each student narrates a fictional or real-life story for 5 minutes each), Oral review (Each student orally presents a review on a story or a book read by them) Drafting skills: Letter, Report & Resume writing, business letters, reading & listening skills Activity: The teacher should teach the students how to write the letter, report and build resume. The teacher should give proper format and layouts. Each student will write one formal letter, one report and a resume.	8 hrs.

Unit 4	Formal Group Discussion, Personal Interview & Presentation skills Topic comprehension, Content organization, Group speaking etiquettes, driving the discussion & skills. Preparation for personal interview: dress code, greeting the panel, crisp self-introduction, neatness, etiquettes, language tone, handling embarrassing & tricky questions, graceful closing. Activity: Each batch is divided into two groups of 12 to 14 students each. Two rounds of a GD for each group should be conducted and teacher should give them feedback. Mock interview are to be conducted.	4 hrs.
Unit 5	Aptitude and analytical skills Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	8 hrs.
Unit 6	Life skills Time management, critical thinking, sound and practical decision making by dealing with conflicts, stress management, leadership qualities Activity: The teacher can conduct a case study activity to train students for decision making skills. The teacher should conduct a session on stress management and guide students on how to manage stress. The teacher may conduct a stress relieving activity in the class. He/she may counsel students individually to know their problems and guide them on dealing with them effectively.	4 hrs.

Suggested readings:

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 	Morning : 07 to 09 AM OR	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			

6	Handball	<ul style="list-style-type: none"> • Basic Skill of the Game • Major Skill of the Game • Technique & Tactics of the Game • Game Practice 	Evening : 05 to 07 PM	
7	Kabaddi			
8	Kho-Kho			
9	Table-Tennis			
10	Swimming			

Course Outcomes (COs):

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

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

AC-201(C): Practicing Yoga (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	<p>Course Objectives:</p> <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) - UttanPadaasana(Ekpad/Dwipad), Pawanmuktasana, ViparitaraniAsana, Khandarasana, Shavasana ▪ Prone (Viparitshayanthiti) - Vakrahasta, Bhujangasana, SaralhastaBhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana ▪ Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, ArdhChakrasana • Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types • Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (COs):

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

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

AC-201(D): Introduction to Indian Music
(Personality and Cultural Development Related Audit course; Practical; 2 Credits)
(Optional: Campus-level)

	<p>Course Objectives:</p> <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, Aalap etc. Taal and its uses - Treetaal, Daadraa, Zappaal, Kervaa. Information of Badaakhyaal, Chhotaakhyaal (one), Sargam, Lakshangeet (information) Detailed information of Tambora Detailed information of Harmonium and Tablaa. Five filmy songs based on Indian Classical Music (Theory and Presentation) Sound Management - Basic information of Sound Recording (including Practicals) Composition of Music as per the Story Preparing news write-ups of the Seminars, Library Musical Programmes held at the nearest Akashwani, by personal visits.

Course Outcomes (COs):

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

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

Semester -III

AN-301: Concepts in Analytical Chemistry

[60 Lectures]

Objectives:

1. To enlighten student about fundamentals of Analytical Chemistry.
2. To study analytical Techniques Classical and Instrumental methods in detail.
3. To learn the application in various field.

Unit1. A) Analytical Science – A Perspective:

[04 Lectures]

History of Analytical Chemistry, Basic concepts, Classical and Instrumental methods, Factors affecting, choice of analytical methods, Interferences, Sensitivity and detection limit, Future trends in Analysis, Basic concepts, classification of analytical methods, types of instrumental methods.

B) Reference Materials (RMs):

[08 Lectures]

Analytical standards, primary and secondary standards, high purity substances, reference materials, use of RMs in statistical control schemes and in intercomparisons, role of certified reference materials (CRMs), production and requirements, obtaining reference value and certified value.

Unit 2. Sampling and Calibration:

[06 Lectures]

A) Important terms involved in sampling and microanalysis, Methods of sampling, Construction of calibration curves, comparison with single standard, matrix matching, bracketing of standard addition and internal standard methods, calibration of Glassware, buoyancy errors.

B) Systematic approach of solving problems:

[06 Lectures]

pH scale and its significance, pH at elevated temperatures, pH for aqueous solutions of very weak acid and base, pH for salts of weak acid and weak bases, polyprotic acids. Buffer solutions, buffer capacity, applications of buffers, Physiological buffers, buffers for biological and clinical measurements.

Unit 3. Methods for Elemental Analysis:**[12 Lectures]**

Organic samples: Dry and wet ashing methods, Advantages and disadvantages over conventional methods, Special methods, Dissolution of organic samples, Hazards and Safety in laboratory. Inorganic samples: Acids as solvents, fluxes.

Unit 4. Optimization of Experimental Design:**[12 Lectures]**

Accuracy, precision, classification of errors, minimization of errors, significant figures and computation, mean deviation and standard deviation, Detection, reduction and compensation of errors, propagation of intermediate error, confidence level, confidence limit when sigma is known and when sigma is unknown, statistical treatment of random error, properties of Gaussian distribution, Test of significance, F test, Q test (Student T test), Construction and interpretation of graphs, fitting the least squares lines, Chemometrics.

Unit 5. Automated Methods of Analysis:**[12 Lectures]**

Specification and performance of automated methods, Automation strategy, IR process analyzers, Selection of online analyzers, Online Potentiometric analyzers, Optodes and microensors, Process chromatography systems, Automatic Chemical Analysers, Continuous flow methods, Flow injection analysis, Centrifugal analyzers, automatic elemental analyzers, Laboratory Robots.

References:

1. "Principles and Practice of Analytical Chemistry", F. W. Fifield and D. Kealey, 5thEd., Blackwell Science, Chapt. 1, pp 12–13, 331–379, 385–411, 415–458 (Chapt. 7.4) and 463–471, (2000).
2. "Fundamentals of Analytical Chemistry", D. A. Skoog and D. M. West, 4th Ed., CBS College Publishing, New York, Chapt. 1, pp 12–13, (1982).
3. "Introduction to Instrumental Analysis", R. D. Brown, McGraw Hill, Chapt. 2,3 and 4, (1987).
4. "Instrumental Methods of Analysis", H. H. Willard, L. L. Meritt and J. A. Dean, Affiliated East-West Press, Chapt. 1 and 2, (1977).
5. "Principles of Instrumental Analysis", D. A. Skoog, F. James Hollier and T. A. Naiman, Harcourt College Publishers (1998), Harcourt India Pvt. Ltd., Indian Reprint Chapt. 1, pp

- 12–13, (2001). / “Principles of Instrumental Analysis”, D. A. Skoog, F. James Hollier and S. R. Crouch, 6th edn., Thomson Brooks/Cole Publishers (2007).
6. “Sample Pre-treatment and Separation”, R. Anderson, ACOL Series, N.B. Chapman (Ed.), John Wiley & Sons for ACOL, Chapt. 3 and 4, pp 66–118, (1991).
 7. D. A. Skoog, D. M. West and F.J.Holler, Fundamentals of Analytical Chemistry, 2nd Ed., Saunders College Publishing, 1991.
 8. R.A.Day and A. L. Underwood, Quantitative Analysis, 6th Ed., Prentice-Hall of India Pvt.Ltd., 1993.
 9. Gas Chromatography, Open Book Learning Series
 10. Larry Hargis, Analytical Chemistry. Principles and techniques.
 11. Encyclopedia of Analytical Chemistry.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN301.1	memorize the basics concepts of Analytical Chemistry	1
AN301.2	understand various techniques, processes in terms of Analytical Chemistry	2
AN301.3	develop modified procedures of various analysis.	3

AN–302: Analytical Techniques in Chemical Analysis

[60 Lectures]

Objectives:

1. To provide an understanding of chemical methods employed for elemental and compound analysis.
2. To provide experience in some scientific methods employed in analytical chemistry.
3. To develop the graduate with complete theoretical knowledge instrumental Techniques.

Unit 1. A) Inductively coupled plasma atomic emission spectroscopy: [06 Lectures]

Principle, various stages involved in the analysis, instrumentation, applications, advantages and disadvantages.

B) Thermal Methods of Analysis:**[06 Lectures]**

Thermogravimetry [TG], Differential thermal analysis [DTA], Differential Scanning calorimetry [DSC], Thermomechanical analysis [TMA] Instrumentation and application, Thermometric titrations.

Unit 2. Radiochemical Methods of Analysis:**[12 Lectures]**

Neutron activation analysis: Principle, Definition of various terms, various steps involved. Absolute & comparative method, PLNAA pulse N Isotope Dilution analysis: Principle, Direct, reverse double derivative IDA. Radiometric titration: Principle, types and instrumentation. Radio immunoarray: principle and applications.

Unit 3. Polarography, Voltammetry and Ion Selective Electrodes (ISE):**[12 Lectures]**

Polarography: Principles, Factors affecting polarographic wave, pulse polarography, and differential pulse polarography, Voltammetry: Voltammetric principles, Hydrodynamic voltammetry, Stripping voltammetry, Cyclic voltammetry, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes, qualitative and quantitative analysis by these techniques. Types and applications of ISE.

Unit 4. Coulometry:**[12 Lectures]**

Principle of Coulometry, Coulometric Techniques, Coulometer, Coulometric Titrations, Coulometric determinations, Advantages, Instrumentation for coulometric titrators, Different types of coulometry and Applications.

Unit 5. Electrogravimetry:**[12 Lectures]**

Important terms used in electrogravimetric methods, Overpotential, Electrogravimetric methods, Instrumentation, Electrolysis using a mercury Cathode, Spontaneous Electrolysis, Electrography.

References:

1. "Introduction to instrumental analysis" R. D. Braun (1987).

2. "Handbook of Atomic Absorption & Fluorescence Spectrometry by Michael Sargent & Gordon Kirkbright, Viridian Publishing.
3. "Instrumental methods of chemical analysis", H. H. Willard, L. L. Merrit Jr., J. A. Dean and F. A. Settle, 6th Ed (1986).
4. Encyclopedia of Analytical Chemistry (1995).

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN302.1	express theoretical concept of instrumentation.	2
AN302.2	analyze the sample independently.	4
AN302.3	learn how to prepare solutions quantitatively and analysis of the analyte with high accuracy.	4

AN-303: Modern Spectroscopic Techniques

[60 Lectures]

Objectives:

1. The course aims to provide an advanced understanding of the core principles and topics Spectroscopy of their experimental basis.
2. To introduce the students with modern sophisticated techniques in Analytical Chemistry.
3. To learn use of spectroscopic methods for qualitative and quantitative analysis.

Unit 1. Infrared and Raman Spectrometry:

[12 Lectures]

Brief introduction to Spectroscopy, Theory of Infrared Absorption Spectrometry, Instrumentation, Sample handling, FT technique, group frequencies, Vibrational coupling, NIR spectroscopy, New applications, Scattering phenomena, Raman spectroscopy, Qualitative and Quantitative analysis.

Unit 2. A) Nuclear Magnetic Resonance Spectroscopy (NMR):

[06 Lectures]

Theory of NMR- Basic theory, Quantum and classical description of NMR, Relaxation Processes in NMR, Environmental effects on NMR Spectra-[Chemical shift and factors affecting the same, Spin-spin splitting.

B) Electron Spin Resonance Spectroscopy (ESR):**[06Lectures]**

NMR and ESR, Theory of ESR, Experimental technique, ESR:- Principle, Instrumentation, ESR spectra, densities and factors affecting 'g' values, Spin labeling ESR spectroscopy, FTESR, Applications, numericals.

Unit 3. Atomic Absorption Spectrophotometry (AAS):**[12 Lectures]**

Principle-spectral line width, doppler and pressure broadening, Instrument-sources-line and continuous, electrodeless discharge lamps, Hollow cathode lamps, temperature gradients, cells, flames, furnaces, detectors, interferences and modifications in instrumentations, applications, problems discussions.

Unit 4. Molecular Luminescence Spectroscopy:**[12 Lectures]**

Theory of fluorescence and phosphorescence, variable that affects fluorescence and phosphorescence, Instrumentation for measuring fluorescence, phosphorescence, application of fluorescence and phosphorescence.

Unit 5. Photoelectron Spectroscopy:**[12 Lectures]**

Principle of photoelectron spectroscopy, Koopmans Theorem, Types of PES, Photo- ionization process, Chemical shifts in ESCA, Core Binding Energy, Instruments for PES, Techniques of PES, Atomic and molecular photoelectron spectra, Applications of ESCA, Auger Electron Spectroscopy, Instrumentation of Auger Electron Spectroscopy, Applications of ESCA.

Reference:

1. Ewings Analytical Instrument hand book – Cazes, Marcel Dekkar.
2. Analytical Chemistry, Kellneretal, Wiley VCH.
3. Instrumental Techniques for Analytical Chemistry settle – PTR PH.
4. Deans Analytical Chemistry Handbook –Patnaik, Mcgraw Hill Co.Fundamentals of Analytical Chemistry-Skoog D.A and West D.M,Saunders.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN303.1	Apply the recent knowledge about modern sophisticated instruments.	3
AN303.2	carry out chemical analysis using modern sophisticated Instruments.	4
AN303.3	explain theory and application of sophisticated instruments.	4

AN-304: Modern Separation Science

[60 Lectures]

Objectives:

1. To make students well acquainted about various modern separation techniques in analysis.
2. To provide detail knowledge of theoretical concept of various techniques.
3. To furnish knowledge wide applications in the various field.

Unit 1. A) Exclusion (Gel) Chromatography:

[06 Lectures]

Instrumentation, sources of errors, GPC calibration, Column packing, Theory of size of exclusion chromatography, Application of size exclusion chromatography (GPC).

B) Supercritical Fluid Chromatography:

[06 Lectures]

Properties of Supercritical Fluid (SFC) –Instrumentation and operating variables, Comparison with other types of chromatography (HPLC and GLC), Applications

Unit 2. Capillary Electrophoresis and Electro-chromatography:

[12 Lectures]

Over view of Electrophoresis, Capillary Electrophoresis, Applications of Capillary Electrophoresis and Capillary electro-chromatography.

Unit 3. Gas Chromatography:

[12 Lectures]

Principles of gas chromatography, plate theory of gas chromatography, Instrumentation, working of gas chromatography, Evaluation of gas chromatogram, Identification of gas chromatogram, programmed temperature chromatography, flow programming chromatography (FPC), gas-solid chromatography, application of gas chromatography, Problems.

Unit 4 High Performance Liquid Chromatography

[12 Lectures]

Introduction, GC and HPLC, Instrumentation Refractive index detector luminescence detector, ultraviolet detector and electrochemical detector, Quantitative analysis and data display, Derivatization technique in HPLC, Chiral columns, C8 and C18 columns, Applications.

Unit 5. Solvent Extraction Separation:

[12 Lectures]

Principles of solvent extraction, formation of metal complexes, distribution of extractable species, quantitative treatment of extractable equilibrium, Methods of extraction, techniques in extraction, Extraction chromatography, theoretical aspects of extraction chromatography, correlation between solvent extraction and extraction chromatography, techniques in extraction chromatography, chromatographic inert support, stationary phases, use of extraction chromatography for separation of fission products.

References:

1. Principles and Practice of Analytical Chemistry-Fifield F.W. and KealeyD, Blackey Academic.
2. Analytical Chemistry, Kellneretal, Wiley VCH
3. Analytical Chemistry-Christain G.D, Wiley WSE.
4. Deans Analytical Chemistry Handbook – Patnaik, McgrawHill .
5. Fundamentals of Analytical Chemistry-Skoog D.A and West D. M. Saunders

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN304.1	Describe the various separation techniques	2
AN304.2	Distinguish various separation techniques on the basis of principles.	5
AN304.3	establish and modify various separation procedures.	3

AN-004: Laboratory Course in Analytical chemistry–I[100]

Analytical Chemistry Practical–I: (Any 14 experiments)

Objectives:

1. To provide to experimental knowledge the students analytical processes.
2. To furnish knowledge about preparation of solutions, sample preparation etc.
3. How to operate the various instruments to get expertise.

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1. Consumer products (e.g. Inorganic Pigment [e.g. chromium from Zinc chrome]; Pharmaceutical product [magnesium from tablet of “Milk of magnesia” / calcium from calcium-supplementary tablet / aluminium from alum]
 2. Qualitative and quantitative determination of metals (Zn, Cd, and Mn) alone and in mixture by classical and differential pulse polarography.
 3. Thermogravimetry [Determination of percentage of MgCO_3 in Dolomite]
 4. Cyclic voltammetry [Study of cyclic voltammogram of $\text{K}_3[\text{Fe}(\text{CN})_6]$]
 5. Determination of moisture content in food sample using Karl-Fischer Titrator.
 6. Determination of Phosphate in Detergents by Spectrophotometry.
 7. Determination of phosphoric acid in cola beverages by pH titration.
 8. Photometric Titrations: (a) Cu Vs EDTA (b) Fe Vs EDTA using salicylic acid.
 9. Determination of saponification value and iodine, saponification, acid value of an oil.
 10. Determination of chloride and sulfate with an adsorption indicator.
 11. Determination of total salts by cation exchange.
 12. Agricultural analysis of, Soil sample, animal feeds, soil micronutrients.
 13. Estimation of sulphadiazine/ sulphonamide.
 14. Chromatographic separation of sugars, amino acids by paper, T.L.C. and Ion exchange methods (both qualitative and quantitative method) separation organic compounds by column chromatography.
 15. Estimation of milk powder for Ca, Fe and P content.
 16. Determination of chemical oxygen demand (COD) of polluted water samples.
 17. Determination of percentage purity of commercial washing soda by potentiometric titration.
 18. Determination of calcium in egg shell by flame photometric method.
 19. Determination of potassium in soil by flame photometric method (Lithium internal standard method).

20. Estimation of vitamin B2 in drug sample by fluorometry.
21. Determination of percentage purity of electrolytic copper by electrogravimetry.
22. Determination of organic amines by potentiometric titration in glacial acetic acid.
23. Determination of pKa value of an indicator.
24. Determination of sulfate nephelometrically.
25. Analysis of copper by extractive photometry using diethyl dithiocarbamate.

References

1. A. I. Vogel, A Textbook of Quantitative Inorganic analysis, 2nd Ed., ELBS Ed.
2. A. I. Vogel, A Textbook of Practical Organic Chemistry, 4th Ed., ELBS Ed.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN004.1	Practice practical by performing various basic techniques using instrumental analytical procedures.	3
AN004.2	Develop with skilled experimental hand.	6
AN004.3	Distinguish between classical and modern procedures of analysis.	5

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

AC-301(A): Computer Skills		
(Technology + Value added Audit course; Practical; 2 Credits)		
(Optional: Campus + Program level)		
Course Objectives (CObs): <ul style="list-style-type: none"> To inculcate different daily useful computer skills among students. 		
Unit 1	Elements of Information Technology <p>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</p>	2 L
Unit 2	Office Automation-Text Processing <p>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, Move and Resize Tables, Moving the order of the column and/or rows inside a table, Table Properties 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.</p>	5 L
Unit 3	Office Automation-Worksheet Data Processing <p>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,</p>	5 L

	Deleting Rows, Columns, and Cells 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 effectively.	3

AC-301(B): Cyber Security

(Technology + Value added Audit course; Practical; 2 Credits)

(Optional: Campus + Program level)

Course Objectives (CObs):

- To make students aware of different daily useful cyber security skills/rules.

Unit 1	Networking Concepts Overview Basics of Communication Systems, Transmission Media, ISO/OSI and TCP/IP models, Network types: Local Area Networks, Wide Area Networks, Internetworking, Packet Formats, Wireless Networks: Wireless concepts, Advantages of Wireless, Wireless network architecture, Reasons to use wireless, Internet	3 L
Unit 2	Security Concepts Information Security Overview, Information Security Services, Types of Attacks, Goals for Security, E-commerce Security, Computer Forensics, Steganography. Importance of Physical Security, Biometric security & its types, Risk associated with improper physical access, Physical Security equipments. Passwords: Define passwords, Types of passwords, Passwords Storage – Windows & Linux.	7 L
Unit 3	Security Threats and vulnerabilities Overview of Security threats, Hacking Techniques, Password Cracking, Types of password attacks, Insecure Network connections, Wi-Fi attacks & countermeasures, Information Warfare and Surveillance. Cyber crime: e-mail related cyber crimes, Social network related cyber crimes, Desktop related cyber crimes, Social Engineering related cyber crimes, Network related cyber crimes, Cyber terrorism, Banking crimes	7 L
Unit 4	Cryptography Understanding cryptography, Goals of cryptography, Types of cryptography, Applications of Cryptography, Use of Hash function in cryptography, Digital signature in cryptography, Public Key infrastructure	5 L
Unit 5	System & Network Security	3 L

	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.	
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: <ol style="list-style-type: none"> 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: 978-1522952190ISBN-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 (CObs):

- To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant research paper.

Seminar Activity:

- Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journals from ACS, RSC, Elsevier, Springer etc. to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities.
- Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation.

Course Outcomes (COs):

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

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

SEMESTER -IV

AN-401: Advanced Analytical Chemistry

[60 Lectures]

Objectives:

1. To furnish knowledge about most recent and highly sophisticated instruments.
2. To earn knowledge about recent and advanced techniques such as X-ray Hyphenated Techniques , Laser Based Techniques. Imaging Techniques etc.
3. To furnish knowledge about various spectroscopies such Mossbauer Spectroscopy, Atomic Emission Spectrometry (AES)etc.

Unit 1. Fundamentals of X-ray Diffraction:

[12 Lectures]

X-Ray Fluorescence method: Principle, Characteristics X-ray emission, Instrumentation, X-ray tube, Radioactive sources. Wavelength dispersive instruments. Energy dispersive instruments. Analytical Applications-Qualitative Analysis-Quantitative Analysis, Theory of X-ray diffraction, diffraction of X-rays by crystals, determination of crystal Structure (powder as well as single crystals), Instrumentation, determination of lattice parameters, X-ray intensity calculations and application of X-rays.

Unit 2. Mossbauer Spectroscopy:

[12 Lectures]

Introduction to Mossbauer effect, recoilless emission & absorption of X-rays, Instrumentation, Spectral parameters of Mossbauer spectra such as Isomer shift, Quadruple splitting and Hyperfine interactions, application of Mossbauer effect to the investigations of compounds of iron and tin. Sources electrical discharge, dc/ac arcs, sparks laser microprobe, qualitative and quantitative analysis, problems discussion.

Unit 3. Atomic Emission Spectrometry (AES):

[12 Lectures]

Inductively coupled plasma-ICP / AES and Flame emission spectroscopy (FES).

Unit 4. A) Laser Based Techniques:

[06 Lectures]

Atomic fluorescent spectrometry (AFS), resonant ionization spectroscopy (RIS), Laser enhanced ionization (LEI). Principle-types of transition, tunable laser, Classification of medium pumping and

controlling mechanisms, Instrumentation detailing of various gaseous, liquid and solid sources, cell, Monochromators, Detectors.

B) Hyphenated Techniques:

[06 Lectures]

GC–MS, LC–MS, Total ion current (TIC) chromatogram, MS–MS (Tandem) Spectrometry, ICP–MS.

Unit 5. Imaging Techniques:

[12 Lectures]

MRI: Magnetic resonance imaging (MRI)–Principle, Instrumentation, Magnetic resonance angiography, ^1H -NMR of relevant diamagnetic and paramagnetic compounds, Contrast agents and Clinical applications.

CT Scan- Principle, Instrumentation and Application.

References:

1. Elements of X–ray diffraction, B.D Cullity, Addison Wisley, 1967.
2. Diffraction Method, Wormald, Oxford University, Press, 1973
3. Standard Method of Chemical Analysis IIIA, 6th Ed.
4. Neutron Scattering in Chemistry, Baun, G.E. Butleworth, London, 1971.
5. Mossbauer Spectroscopy, Greenwood N.N., Gibbs T.C., Chapman Hall, 1971.
6. Chemical Application of Mossbaur Spectroscopy, Goldanski V.I &Harber .H., Academic Press 1968.
7. Spectroscopy in Inorganic Compounds CNR Rao & Ferraro G.R., Academic Press, 1970.
8. Basic Principles of Spectroscopy Cheney R.Mac Grows Hill, 1971.
9. Thermal Method, Wendlandt, W.W. John, Wiley, 1986.
10. Principles of Instrumental analysis, Skoog, IIIrd Ed., Sounders, 1985.
- 11.MRI: Basic principles and applications”, M. A. Brown, R. C. Semelka, 1995

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN401.1	Understand the principles of theoretical aspect working spectroscopies	2
AN401.2	Explain the principles and theoretical aspect of working imaging technique.	2
AN401.3	Describe the various Hyphenated Techniques.	2

AN-402: Applied Analytical Chemistry

[60 Lectures]

Objectives:

1. To furnish knowledge about most recent trends in Applied Analytical chemistry.
2. To earn knowledge about recent and advanced analysis of soil, Agrochemicals, Analysis of Soil etc.
3. To furnish knowledge about various applications in Metallurgy, Food Chemistry etc.

Unit 1. Metallurgy:

[12 Lectures]

Ores and minerals, dressing of ore, Methods of metal dressing (hand picking, magnetic separation, centrifuge, froth flotation Etc), Pollution due to metallurgical process (Metal dressing, calcinations, smelting), Alloying: Definition, Purposeful development of alloy, Carat of Gold (precious material) and its method of analysis, Techniques of purification: Zone refining, Analysis of high purity materials like silicon, Vacuum fusion and extraction techniques.

Unit 2. Food Chemistry:

[12 Lectures]

Definition and importance, Water in food, Water activity and shelf life of food, Carbohydrates—chemical reactions, Functional properties of Sugars and Polysaccharides in foods, Lipids: Classification and use of lipids in foods, Physical and Chemical properties, Effects of processing on functional properties and nutritive value, Protein and amino acids— Physical and Chemical properties, Distribution, amount and functions of proteins in foods, functional properties, Effect of processing—loss of vitamins and minerals due to processing. Pigments in food, Food Flavors, Browning reaction in foods, Enzymes in foods and food industry, Bio-deterioration of foods, Food contaminants (Adulterants), Additives and toxicants.

Unit 3. Analysis of Agrochemicals:

[12 Lectures]

Sampling, Extraction, Clean Up, Analysis of pesticides, Application of chemical as well as Bioassay methods for analysis of pesticide residue, Analysis of DDT, Malathion, BHC from dust residue.

Unit 4. Analysis of Soil:

[12 Lectures]

Method of soil analysis, soil fertility its determination, determination of inorganic constituents of plant materials, Chemical analysis as measure of soil fertility, analysis of Fertilizers.

Unit 5. Analysis of oils, fats, soaps and detergents

[12 Lectures]

Analysis of oils, fats, soaps and detergents Introduction to natural fats and oils, Analysis of oils and fats: Softening point, Congent point, Titre point, cloud point, Iodine, Saponification, acid, hydroxyl; Introduction to soaps, analysis of soap (saponifiable, unsaponifiable) and for unsaponified matter in soaps, Estimation of free alkali and phenol in soap. Classification of detergents (in Brief): Analysis of active ingredients from detergents (methylene blue and Hyamine-1622 method); Estimation of CMC, Chlorides, total phosphates etc.

References:

1. Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, 1995
2. Standard methods of Chemical Analysis”, Vol. 2, (Part A & B), F. J. Welcher, 5th edn., Von Nostrand & Robert E. Krieger Publishing Co. New York, (1975 and 2000)

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN402.1	Understand the principles of theoretical aspect and reaction of analysis	2
AN402.2	Modify analysis procedures with better results	3
AN402.3	analyze of oils, fats, soaps and detergents, soil, food etc.	4

AN-403: Pharmaceutical and Cosmetic Analysis

[60 Lectures]

Objectives:

1. To furnish knowledge about Pharmaceutical and Cosmetic Analysis.
2. To earn knowledge about methods of Standardization and Quality Control.
3. To furnish knowledge Assay and Tests for Drugs, cosmetics, clinical.

Unit 1. Pharmaceutical Industry: a review

[12 Lectures]

Definition and classification of drugs and medicines, introduction to pharmaceutical

formulations, classification of dosage forms, Sources of impurities in pharmaceutical chemicals and raw materials.

Unit 2. Official Methods of Standardization and Quality Control: [12 Lectures]

Introduction to drugs, their classification, sources of impurities in pharmaceutical raw materials such as chemical, atmospheric and microbial contaminants etc. Limit tests, limit tests for impurities like, Pb, As, Fe, moisture, chlorides, sulfates, Boron, free halogen, selenium etc. Analysis of some commonly used drugs like sulfa drugs, antihistamines, barbiturates, vitamins (A, B6, C, E, K) etc.

Unit 3. Assay and Tests for Drugs: [12 Lectures]

Assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies.

Unit 4. Analysis of Cosmetics: [12 Lectures]

- A. **Cosmetics:** Introduction, classification of cosmetics, Raw material etc.
- B. **Analysis of cosmetics:** Composition of creams and lotions: Determination of water, propylene glycol nonvolatile matter and ash content. Determination of borates carbonates sulphate, phosphate, chloride, titanium and Zinc oxide.
- C. **Analysis of face powder:** Estimation of boric acid, Mg, Ca, Zn, Fe, Al, and Ba. Analysis of ingredients

Unit 5. Clinical chemistry [12 Lectures]

Scope of Clinical chemistry: Philosophy of clinical analysis, Practical aspects of analysis: sample types, collection of specimens (samples) like blood, urine, faeces; Cleaning of glass apparatus; Storage of clinical samples.

General techniques for analysis: Brief principle and applications of following techniques: colorimetric, spectrophotometric, turbidimetric, fluorimetric, flame photometry, auto-analysis, paper electrophoresis, gel-electrophoresis, chromatography; Units of expressing biochemical values.

References:

1. Analytical Biochemistry, D, J. Homes and H. Peck, Longman (1983)
2. Bioanalytical Chemistry, S. R. Mikkelesen and E. Corton, John Wiley and sons 2004
3. Analysis of food and beverages, George Charalanbous, Accademic press 1978.
4. Harry's Cosmetology, Longman scientific co.
5. Formulation and Function of cosmetics, Sa Jellineck.
6. Cosmetic Technology, Saggarin.
7. Modern cosmetics, E. Thomessen Wiley Interscience.
8. Encyclopedia of industrial chemical analysis, Snell et al Inter science.
9. Govt. of India publications of food drug cosmetic act and rules.
10. Hand book of drug law, Mehta Univ. Book agency Ahmadabad.
11. Chemical analysis of drugs, Higuchi, Interscience, 1995.
12. Connors Text book of pharmaceuticals Analysis, J Wiley, 2001.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN403.1	Understand the principles of theoretical aspect and reaction of Pharmaceutical and Cosmetic analysis.	2
AN403.2	Modify procedures assay and tests for drugs, cosmetics, clinical with better results.	3
AN403.3	Carry out assay and tests for Drugs, cosmetics, clinical indecently.	5

AN-005: Laboratory Course in Analytical chemistry-II [100]**Analytical Chemistry Practical-I: (Any 15 experiments)****Objectives:**

1. To provide to experimental knowledge the students various sample analysis.
2. To furnish knowledge about preparation of stock solutions, sample preparation and Suitable procedure for accuracy and precision.
3. Handling different types of sophisticated instruments.

1. Pharmaceutical Analysis-Dissolution test, Disintegration test, Weight Variation test, Test for

- uniformity of content.
2. Estimation of following functional groups Phenolic/amino group, ester group, amide group
 3. Fertilizer analysis for N, P, K.
 4. Analysis of vitamin–A in food products.
 5. Analysis of vitamin–C in juices and squashes.
 6. Estimation of mercury in skin ointment.
 7. Chemical analysis of chill/turmeric powder.
 8. Potentiometric Titrations: (a) FAS Vs $K_2Cr_2O_7$ (b) FAS Vs $KMnO_4$.
 9. Determination of strength of acetic acid in commercial vinegar sample conductometrically.
 10. Molecular weight of polymer from Viscosity measurements
 11. (Experiments in physical chemistry–J. M. Wilson and others page no. 202)
 12. Differential potentiometric titration
 13. (Experiments in physical chemistry–J. M. Wilson and others page no. 272)
 14. TGA for a mixture of $CuSO_4$ and $NaCl$, find out the percentage of each constituent in the Mixture.
 15. Estimation of Zn and Cd from their mixture by polarographic technique
 16. Quantitative analysis of mixture by gas Chromatography [e. g. Chloroform and carbon Tetrachloride / methanol and ethanol]
 17. Table work for IR-spectra, NMR, UV–Visible spectra.
 18. Estimation of cholesterol in egg yolk.
 19. Estimation of lactose in milk iodometrically and Isolation of casein from given milk sample.
 20. Determination of exchange capacity of a cation or anion exchange resin.
 21. Separation of dichromate and permanganate ion using an alumina column.
 22. Determination of number of theoretical plates of a C18 HPLC column.
 23. Separation and estimation of a mixture of acetophenone, benzene and toluene by using C18 column with acetonitrile: water (60:40) mobile phase
 24. Simultaneous determination of copper and bismuth in a mixture using EDTAspectrophotometrically.
 25. Determination of composition of the complex by Job's continuous variation method and stability constant study.
 26. Determination of HCl and H_2SO_4 by conductometric titration with $NaOH$ and $BaCl_2$.
 27. Spectrophotometric determination of pH of a buffer mixture.

Each experiment includes standardization of the reagents, calibration of the instrument with known reagents and analysis of an unknown.

References

1. A. I. Vogel, A textbook of Quantitative Inorganic analysis, 2ndEd., ELBS Ed.
2. A. I. Vogel, A textbook of Practical Organic Chemistry, 4thEd., ELBS Ed.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN005.1	Perform practical using basic techniques of instrumental analytical procedures.	4
AN005.2	Develop with skilled experimental hand.	6
AN005.3	Distinguish between classical and modern procedures of analysis	5

AN-006: Project Work

[100 Marks]

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

Course Objectives (COs):

- To provide to knowledge literature survey about research work.
- Students will learn to carry out reaction/ analysis independently
- To develop the student with analytical skill to established the relation between the outcomes and experiment carried out.

Course Outcomes (COs):

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

CO No.	CO	Cognitive level
AN006.1	Search various published research papers/ articles with concerned research topics.	2
AN006.2	Develop with skilled experimental hand and in characterization/ analysis of research outcomes.	6
AN006.3	apply knowledge to carry out major research project in industries/academics	3

M.Sc. Part II Semester IV: Audit Courses

	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 hrs.
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 hrs.
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 hrs.
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 hrs.
Suggested readings: <ol style="list-style-type: none"> Human rights education – YCMOU, Nasik Value education – SCERT, Pune Human rights reference handbook – Lucille whare 		

Course Outcomes (COs):

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

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

AC-401(B): Current Affairs (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)			
Course Objectives (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 	08
Unit 2	Awards and recognitions	<ul style="list-style-type: none"> National & International Awards and recognitions Books and authors 	07
Unit 3	Science & Technology	<ul style="list-style-type: none"> Software, Automobile, Space Research New inventions and discoveries 	07
Unit 4	Environment & Sports	<ul style="list-style-type: none"> Summit & conference, Ecology & Climate, Organization. National & International Games, Olympics, commonwealth etc. 	08
Suggested readings (Use recent years' data and current literature): <ol style="list-style-type: none"> India 2019, by Publications Division Government of India Manorama Year Book by Philip Mathew, India 2019, Rajiv Maharshi Quick General Knowledge 2018 with Current Affairs Update, Disha Experts 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 (CObs): <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	6 h

	formats for referencing, Ways of communicating a research paper.	
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: <ol style="list-style-type: none"> 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
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:

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=iwI8Iyo90mM>
<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
