'A' Grade
NAAC Re-Accredited
(3rd Cycle)

KAVAYITRI BAHINABAI CHAUDHARI
NORTH MAHARASHTRA UNIVERSITY, JALGAON

Academic Curriculum
(For Affiliated Colleges of KBC NMU)

M. Sc. Part-1
CHEMISTRY
(Semester I and II)

Choice Based Credit System (60:40 Pattern)
(Outcome Based Curriculum)
As Per U.G.C. Guidelines

To Be Implemented From

Academic Year 2021-22

SYLLABUS

M. Sc. Part-1
CHEMISTRY (Semester I and II)

Summary of Distribution of Credits under CBCS Scheme
[at affiliated colleges w.e.f. academic year 2021-22]

Sr. No.	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Core	**12**	**12**	**12**	**08**
02	Core Skill Based	**02**	**20**	**-**	**12**
03	Elective	**-**	**-**	**04**	**04**
04	Project	**-**	**-**	**-**	**06**
05	Audit	**02**	**02**	**02**	**02**
06	Total Credits	**16**	**34**	**18**	**32**

Subject Type	Core	Core Skill Based	Elective	Project	Audit	Total
Credits	**44**	**34**	**08**	**06**	**08**	**100**

Total Credits = 100

Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon

M. Sc. Part-1 Chemistry (Sem-I and II)
[at affiliated colleges w.e.f. academic year 2021-22]

Choice Based Credit System (Outcome Based Curriculum)

Course credit scheme

Semester	(A) Core Courses			(B) Core Skill Based / Elective Course			(C) Audit Course (No weightage in CGPA)			Total Credits (A+B+C)
	No. of Courses	Credits (T)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (Practical)	Total Credits	
I	3	12	**12**	1	2 + 0	02	1	2	2	**16**
II	3	12	**12**	4	2 + 18	20	1	2	2	**34**
III	3	12	**12**	1	4 + 0	04	1	2	2	**18**
IV	2	08	**08**	4	4 + 18	22	1	2	2	**32**
Total Credits	**44**			**48**			**8**			**100**

(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	
	Prerequisite and Core Courses									
(A)	Theory	14	4	14	4	12	3	08	2	48
	Practical	-	-	18	3	-	-	18	3	36
(B)	**Core Skill Based / Subject Elective Courses**									
1	Theory /Practical	-	-	-	-	4	1	4	1	08
(C)	**Audit Course (No weightage in CGPA calculations)**									
1	Practicing Cleanliness	2	1							2
2	Personality and Cultural Development Related Course			2	1					2
3	Technology Related + Value Added Course					2	1			2
4	Professional and Social + Value Added Course							2	1	2
	Total Credit Value	16	5	34	8	18	5	32	7	100

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) **Personality and Cultural Development**		**Semester III** (Choose One) **Technology + Value Added Course**		**Semester IV**(Choose One) **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	Molecular Docking	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)

Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon

Syllabus under CBCS for M. Sc. Part-I Chemistry
Syllabus Structure (w.e.f. 2021-22)
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-110	Core	Physical Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-130	Core	Inorganic Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-150	Core	Organic Chemistry-I	04	--	04	40	--	60	--	100	--	04
CH-190	Core Skill Based	Industrial Safety and Good Laboratory Practices	02	--	02	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-210	Core	Physical Chemistry-II	04	--	04	40	--	60	--	100	--	04
CH-230	Core	Inorganic Chemistry-II	04	--	04	40	--	60	--	100	--	04
CH-250	Core	Organic Chemistry-II	04	--	04	40	--	60	--	100	--	04
CH-290	Core Skill Based	Instrumentation and Analysis	02	--	02	20	--	30	--	50	--	02
*CH-P-1	Core Skill Based	Physical Chemistry Practical-I	--	06	06	--	40	--	60	--	100	06
*CH-I-1	Core Skill Based	Inorganic Chemistry Practical-I	--	06	06	--	40	--	60	--	100	06
*CH-O-1	Core Skill Based	Organic Chemistry Practical-I	--	06	06	--	40	--	60	--	100	06
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

*** To be started from Semester-I & evaluated at the end of Semester-II**

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

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

Syllabus for M.Sc. Part-I Chemistry

(Semester - I & II)

Course Structure for First Year

Course Code	Course Type	Title of the Course
Semester – I		
CH-110	Core	Physical Chemistry-I
CH-130	Core	Inorganic Chemistry-I
CH-150	Core	Organic Chemistry-I
CH-190	Core Skill Based	Industrial Safety and Good Laboratory Practices
AC-101	Audit Course	Practicing Cleanliness
Semester – II		
CH-210	Core	Physical Chemistry-II
CH-230	Core	Inorganic Chemistry-II
CH-250	Core	Organic Chemistry-II
CH-290	Core Skill Based	Instrumentation and Analysis
CH-P-1	Core Skill Based	Physical Chemistry Practical-I
CH-I-1	Core Skill Based	Inorganic Chemistry Practical-I
CH-O-1	Core Skill Based	Organic Chemistry Practical-I
AC-201 (A)/ (B)/(C)/(D)	**Audit Course**	Choose one out of four (AC-201 A/B/C/D) (Personality and Cultural Development Related) AC-201 (A): Soft Skills AC-201 (B): Practicing Sports Activities AC-201 (C): Practicing Yoga AC-201 (D): Introduction to Indian Music

Important Notes:

1. Each theory course prescribed for M. Sc. should be covered in 4 lectures, each of 60 minutes duration per week per course including lectures, tutorials, seminars, classroom discussions etc. (Total 60 hrs. / theory course)

2. Each practical course will require 06 hours of laboratory work per week and will be extended over two semesters. All three practical courses will be examined at the end of the academic year. (Total 180 hrs. / practical course)

3. There should not be more than 10 students in a batch for M. Sc. Practical course.

4. For theory course, the question paper (Internal/External) should include numerical, short answer, long answer, MCQ questions, problem solving approach to test understanding of the subject.

5. In the 60 lectures theory course about 10 lectures will include tutorials, student seminars, classroom discussions and tests.

6. The marks for each paper are distributed as external examination 60 marks and internal examination 40 marks. For internal assessment of each theory and practical course, 2 written tests will be taken.

7. The 75 % attendance of students is compulsory.

8. Students should visit at least five chemical industries in the first year of M. Sc. and submit the observations/report to the Department.

Semester-wise Course Structure of M.Sc. Organic Chemistry

Program at a Glance

Name of the program (Degree)	: M. Sc. (Organic Chemistry)
Faculty	: Science and Technology
Duration of the Program	: Two years (four semesters)
Medium of Instruction and Examination	: English
Exam Pattern	: 60 : 40 Pattern (60 marks University exam and 40 marks continuous internal departmental exam/assessment)
Passing standards	: 40% in each exam separately (separate head of passing)
Evaluation mode	: CGPA
Total Credits of the program	: 100 (44 core credits including 6 credits of project/dissertation, 34 skill enhancement credits, 08 subject elective credits and 08 audit credits)

CH-110: Physical Chemistry - I

(60 L, 100 Marks and 4 Credits)

Course Objectives:

1. To learn the principals and foundations of quantum chemistry.
2. To get oriented towards the basic theory underlying the chemical bond.
3. To acquire knowledge about the different possible equilibrium in nuclear decay processes.
4. To learn the basic concepts about the interaction of high energy radiations with matter.
5. To learn the theory and concepts behind the electrochemical processes and ionic equilibria.

Unit No.	Name of the unit	Lectures
1	**Essentials of Quantum Chemistry** Recapitulation of basic concepts of quantum chemistry, Schrodinger equation, normalization with examples, Hermitian operator and its theorems, postulates of quantum mechanics, free particle, particle in one dimensional box and its application for excitation energies in linear conjugated systems, two and three dimensional box, wavefunction and probability density plots, degeneracy, simple harmonic oscillator, energy eigenvalues, Ψ and Ψ^2 plots, even and odd functions, rigid rotator, spherical polar coordinates, separation of variables and energy values. Hydrogen atom Schrodinger wave equation (derivation not expected), radiation distribution functions, dependence of spherical harmonics of angles (shape of orbitals only introduction), and related numerical. **Ref. 2, 3, 4, 6, 8**	**12**
2	**Chemical Bonding** Variation principle, approximation, LCAO-MO, H_2^+ molecular ion, importance of coulomb and exchange integrals, Born-Oppenheimer approximation and the approximated Hamiltonian, VBT to H_2 molecule (derivation not expected) Comparison between MOT and VBT, valence electron approximation, HMO theory and its application to ethylene and butadiene. **Ref. 2, 3, 4, 6, 8**	**12**
3	**Nuclear Chemistry** Parent-daughter decay-growth relationships: daughter nucleus stable, general expression for activity of daughter, parent shorter and longer lived than daughter, parent and daughter of nearly the same half-life, secular and transient equilibrium. Applications of radioactivity: Typical reactions involved in the preparation of radio isotopes (^{22}Na, ^{32}P), Szilard - Chalmer's reaction, Isotope dilution and neutron activation analysis, and related numerical **Ref. 5, 8**	**12**
4	**Radiation Chemistry** Elements of radiation chemistry: primary effects of interaction of radiation with matter, LET, Bremsstrahlung. Interaction of gamma radiation with matter: photoelectric effect, Compton scattering and pair production, units of measuring radiation absorption. Radiation dosimetry: units of dose, Fricke and Ceric sulphate dosimeters, conversion of measured dose values and related numerical.	**12**

	Ref. 5, 8	
5	**Electrochemistry** Strong electrolytes, ionic strength, activity and activity coefficients of strong electrolytes, Debye Huckel theory of conductivity (derivations not expected), ionic atmosphere, relaxation and electrophoretic effects, DHO equation (mathematical derivation not expected), its validity and deviations, Debye-Huckel theory of activity coefficients: Debye-Huckel limiting law (derivation expected), its testing and deviations. Transport number: definition and its relation to ionic mobility, Moving boundary and Hittorf's theoretical and experimental method and related numerical **Ref. 1, 6, 7, 8**	**12**

References:

1. P. W. Atkins, J. D. Paula, Physical Chemistry, Oxford University Press
2. Donald McQuerry , Quantum Chemistry, Viva Books
3. R. K. Prasad, Quantum Chemistry, New Age International
4. I. Levine, Quantum Chemistry, Pearson Education
5. H. J. Arnikar, Essentials of Nuclear Chemistry
6. D. A. McQuerry & J. D. Simon, Physical Chemistry Molecular Approach, Viva Books
7. S. H. Maron and C. F. Prutton, Principles of Physical Chemistry, Oxford and IBH Publishing Co.
8. Dr. L. S. Patil, Physical Chemistry I, Shree Book Co. Mumbai

Course Outcomes (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Apply the quantum mechanical principles to simple systems of chemical interests	**3**
2	Differentiate between the nature of chemical bond concept from MOT and VBT	**2**
3	To identify and write the different types of equilibriums in a given nuclear decay process	**4**
4	To explain the concept of Radiation dose measurement and its practical applications	**2**
5	To be able to calculate the ionic strength and activity coefficients by using the basic concepts underlying.	**5**

CH-130: Inorganic Chemistry - I

(60 L, 100 Marks and 4 Credits)

Course Objectives:

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

Unit No.	Name of the unit	Lectures
1	**Molecular Symmetry and Applications** Molecular term symbol for homonuclear diatomic molecules H_2,B_2,C_2,N_2,$O_2$and F_2 molecules Linear tri-atomic molecules – BeH_2, CO_2. Trigonal planar molecule- BF_3, Tetrahedral Molecule – CH_4, Trigonal pyramidal molecule NH_3, Angular Tri-atomic molecules H_2O, NO_2.	12
2	**Organometallic compounds of transition metals** Organometallic compounds, molecule orbital theory and 18 electron rule, counting electrons in complexes, alkyl and aryl complexes, alkene complexes, metal π complexes- metal carbonyl and metal nitrosyls.	12
3	**Chemistry of non-transition elements** Hydrides-classification, electron deficient, precise and rich hydrides. Study of PH_3, SbH_3, AsH_3, Selenides, Tellurides. Synthesis, properties and structures of alkali and alkaline earth metal compounds, Synthesis and reactivity of inorganic polymer of Si and P.	12
4	**Molecular symmetry** Symmetry elements and operations, symmetry planes, reflections, inversion centre, proper / improper axes of rotation, equivalent symmetry elements and atoms, symmetry elements and optical isomerism, Classification of point groups and procedure to determine the point group, with at least one example of each point group.	12
5	**Transition Metal Carbonyls and Related Compounds** Introduction, preparation and properties of transition metal carbonyls, structure of transition metal carbonyls, carbonyl hydrides, carbonylate anions and cations, carbonyl halides, phosphine and phosphorous trihalide complexes, dinitrogen complexes, nitric oxide complexes, cyano complexes.	12

References:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry Principles of Structures and R eactivity, 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. Shrivers, P.W. Atkins and C.H. Langfor, Inorganic Chemistry, CH Langford, 1990.
6. B.R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Shoban Lal Nagin Chand and Co., 2005.
7. H. B. Gray, Electrons and Chemical Bonding. W. A. Benjamin, Inc., New York, 1965.
8. H. J. Emeleus and A.G. Sharpe, Modern Aspects of Inorganic Chemistry, Universal Book S tall, 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 Chemistr, 2nd edition.
12. R. Sarkar, General and Inorganic Chemistry, Part one, New Central Book Agency, Kolkat.
13. P. K. Bhattacharya, Group Theory and its Chemical applications, Himalaya Publishing Ho use.
14. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advance Inorganic Chemistr, Si xth Edition, John Wiley & Sons, Inc.

Course Outcomes (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Apply the fundamental knowledge about the synthesis, structure, bonding and properties of some selected main group elements which are very important in different fields.	**3**
2	Apply fundamental knowledge about molecular symmetry, MOT, organometallic compounds, ionic solids and bioinorganic compounds.	**3**
3	Explain various concepts and theories of various topics from inorganic chemistry.	**2**

CH-150: Organic Chemistry – I

(60 L, 100 Marks and 4 Credits)

Course Objectives: To make the students conversant with the

1. Study of basic concepts of organic chemistry.
2. Study of reaction intermediates.
3. Study of the different classes, mechanism & stereochemistry of reactions.

Unit No.	Name of the Units	Lectures
1	**Aromaticity** Huckel's (4n+2) and 4n rules. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, azulenes, tropolones, fulvenes, sydnones, annulenes, aromatic ions and Fullerene (C60). **Ref. 3. Page No. 40-67** **Ref. 5, 7, 9 Relevant pages**	**04**
2	**Reactive Intermediates and Concerted Reactions** **(Carbocations, Carbanions, Carbene, Nitrene, and Arynes)** Organic reactive intermediates and their structure, methods of generation, structure, stability and important reactions involving carbocations, carbanions, nitrenes, carbenes, arynes. **Ref. 3. Page No. 165-186, 195-202** **Ref. 4, 5, 6 Relevant pages**	**10**
3	**A. Nucleophilic Substitution reaction** **Aliphatic nucleophilic substitution** a) S_N1, S_N2 and S_N^i mechanism and stereochemistry (regioselectivity and stereospecificity of substitution reaction). b) Nucleophilic substitution at an allylic, aliphatic and vinylic carbon. c) Effect of substrate structure, nucleophile, leaving group and solvent on rate of $S_N1$and S_N2 reactions, ambident nucleophile. **Aromatic nucleophilic substitution** S_NAr, S_N1, Benzyne and S_NR1 reactions, effect of substrate structure, leaving group, solvent and attacking nucleophile. **B. The neighbouring group mechanism** The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Non-classical carbocations, phenonium ions, norbornyl system. **Ref. 2. Page No. 406-443.** **Ref. 3. Page No. 255-262, 265-272, 286-289, 298-320** **Ref. 4, 5, 7, 8, 10 Relevant pages**	**14**
4	**Electrophilic Substitution reaction** a) Arenium ion mechanism, orientation and reactivity, energy profile diagram, ortho, para, ipso attack, orientation in other ring systems, six and five membered heterocycles with one hetero atom. b) Important reactions like Friedel crafts alkylation and acylation, nitration, halogenation, formylation, chloromethylation, sulphonation, diazo coupling.	**12**

	Ref. 1. Page No. 447-562 **Ref. 2, 3, 4, 5, 7, 8 Relevant pages**	
5	**Addition reaction** a) Addition to carbon-carbon multiple bonds and carbon heteroatom multiple bonds- Mechanism and stereochemical aspects of addition reaction involving electrophile. b) Structural effects and reactivity: Halogenations, Hydrohalogenation, Hydration, Hydroxylation, Hydroboration, Epoxidation, Carbene addition, Hydrogenation, Ozonolysis. **Ref. 1. Page No. 517-557** **Ref.3, 8, 9, 10 Relevant pages**	**10**
6	**Elimination reaction** a) E1, E2, E1CB mechanisms, Stereo chemistry of elimination, Elimination versus substitution, anti and syn elimination. b) Dehydrohalogenation, Dehalogenation, Dehydration, Hoffmann and Saytzeff's elimination, Pyrolytic elimination. **Ref. 1. Page No. 466-501** **Ref.3, 4, 8, 9, 10 Relevant pages**	**10**

References:

1. Organic chemistry, Fifth edition by Staney H. Pine.
2. Organic Chemistry – by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford).
3. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Forth Edition by Jerry March.
4. A Guide book to Reaction Mechanism in Organic Chemistry–Peter Sykes.
5. Advance Organic Chemistry (Part A and B) –by A. Carey and R.J. Sundherg.
6. Modern methods of organic synthesis – W. Carruthers (Cambridge) .
7. Organic Chemistry: A Brief Course by Robert C. Atkins, Francis A Carey.
8. Organic Reactions & their Mechanisms- P. S. Kalsi.
9. Organic Chemistry- Morrison & Boyd.
10. Stereochemistry conformations and mechanism by P.S. Kalsi

Course Outcomes (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Apply the fundamental concepts of organic reaction mechanism in theoretical and practical work, may be in academic, research laboratories, and industries.	**3**
2	Understand the importance and types of organic reactions and their applications.	**2**
3	Acquire knowledge of important characteristics of organic compounds.	**4**

CH-190: Industrial Safety and Good Laboratory Practices

(30 L, 50 Marks and 2 Credits)

Course Objectives: To make the students conversant with the

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

Unit No.	Name of the Units	Lectures
1	**Hazards and Safety measures** A) History and importance of safety and health in Laboratory - Moral, legal and financial reasons B) Different types of Hazards at workplace handling chemicals - Physical, chemical, biological, allergens, hazards pertaining electrical system - Effect of hazards on health - Where to find Hazard Information - Reading Labels C) Safety Measures: Safe clothing, hair, dangling jewelry, proper responsible attitude, good housekeeping, use of proper PPE, no food in the laboratories.	**06**
2	**Basic of laboratory safety** 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**
3	**Introduction to industrial safety** Types of fire extinguishers and their method of use, Material Safety Data Sheets (MSDS), Globally Harmonized System (GHS) Signs (http://www.calstatela.ed/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).	**06**
4	**Laboratory and chemical waste management** 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**
5	**Good Laboratory Practices (GLP)** Good Laboratory Practices (GLP)**,** introduction and principles of GLP, performance of laboratory studies and calibration using Standard Operating Procedures (SOPs), instrument validation, reagent certification, laboratory notebook maintenance to contemporary standards, maintenance of laboratory records based on instrument and reagent certification, introduction to ISO and NABL accreditation.	**06**

References:

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 (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Understand the importance of laboratory safety.	**1**
2	Aware and follow healthy laboratory practices.	**2**
3	Acquire the knowledge about personal protective equipment.	**4**

AC-101: Practicing Cleanliness (Compulsory; College-level Audit Course; Practical; 2 Credits)		
Course Objectives (CObs): • To make students aware of Clean India Mission and inculcate cleanliness practices among them.		

	• Awareness program on
	  o Swachh Bharat Abhiyan (Clean India Mission)
	  o Clean Campus Mission
	  o Role of youth in Clean India Mission
	• Cleaning activities inside and surroundings of Department buildings.
	• Tree plantation and further care of planted trees
	• Waste (Liquid/Solid/e-waste) Management, Japanese 5-S practices
	• Planning and execution of collection of Garbage from different sections of University campus
	• Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance.
	• Cleanest School/Department and Cleanest Hostel contests
	• Painting and Essay writing competitions	

Course Outcomes (CO):

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

No.	CO	Cognitive level
1	Identify need at of cleanliness at home/office and other public places.	**2**
2	Plan and observe cleanliness programs at home and other places.	**4**
3	Practice cleanliness practices in day-to-day life.	**3**

CH - 210: Physical Chemistry - II
(60 L, 100 Marks and 4 Credits)

Course Objectives:

1. To orient and acquaint the PG students towards the fundamental and advanced aspects of thermodynamics and statistical thermodynamics.
2. To acquire knowledge about kinetics of complex reactions and fast reactions.
3. To evoke the fundamental concepts of YR, electronic and Raman spectroscopy and understand the advance concept involved in it.

Unit No.	Name of the Units	Lectures
1	**Thermodynamics** Introduction, enthalpy of a system, molar heat capacities, relation between Cp and Cv, Joule-Thomson effect, third law of thermodynamics, concept and importance of absolute entropy, standard entropy and residual entropy, Maxwell relations (derivation expected), 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 and related numerical **Ref: 2, 8, 13, 14**	**12**
2	**Statistical thermodynamics** Introduction, Concept of Boltzmann Ensemble, Thermodynamic probability, Sterling approximation, Boltzmann distribution law, partition function and its significance, energy and entropy in terms of partition function, separation of partition functions, translational partition function, translation energy and entropy from it, rotational partition function, rotational energy and entropy from it, vibrational partition function, vibrational energy and entropy from it and related numerical. **Ref:1, 2, 8, 13, 14**	**12**
3	**Chemical kinetics** Introduction, complex reactions, reactions approaching equilibrium (opposing reactions), consecutive elementary reactions (sequential reactions), parallel reactions and its kinetics, elucidation of mechanism of complex reactions: rate determining step of the reaction and steady state approximation, pre-equilibria, Michaelis-Menten mechanism of enzyme catalysis, chain reactions and its characteristics, steps involved in chain reactions with suitable example. Explosion, Types of explosion, explosion limits and related numerical. Fast reactions, techniques for the study of fast reactions: flow methods and flash photolysis. **Ref: 2, 8, 13, 14.**	**12**
4	**Infra-red Spectroscopy** Introduction, the vibrating diatomic molecule, the energy of a diatomic molecule, the simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating rotator: Born-Oppenheimer approximation, breakdown of Born-Oppenheimer approximation, the vibrations of polyatomic molecules, fundamental vibrations and their symmetry (water molecule and carbon dioxide molecule) and related numerical. **Ref: 8, 11, 14**	**12**

5	**Electronic and Raman spectroscopy** (a) Electronic spectroscopy: Electronic vibrational spectra, intensity of vibrational electronic spectra, Franck-Condon principle, rotational fine structure, Fortrat diagram, dissociation energy, pre-dissociation. (b) Raman Spectroscopy: Introduction, Rayleigh and Raman scattering, quantum theory of Raman effect, classical theory of the Raman effect: Molecular polarizability, Raman activity of vibrations (water molecule and carbon dioxide molecule), rule of mutual exclusion. and related numericals. **Ref: 8, 11, 14.**	**12**

References:

1. Maron, S. H. and Prutton, C. F. (2012) Principles of Physical Chemistry (4th Edition), Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Atkins, P. W. (1998) Physical Chemistry, ELBS.
3. Barrow, G. M. (2003) Physical Chemistry, International Student Edition.
4. Moore, W. J. (1998) Physical Chemistry, Orient Longman.
5. McQuarrie, D. A. And Simon, J. D. (2006) Physical Chemistry- A Molecular Approach, Viva Books Ovt. Ltd., New Delhi.
6. Nash, L. K. (1968) Elementary Statistical Thermodynamics, Addition-Wesley, Reading.
7. Gupta, M. C. (1990) Statistical Thermodynamics, M. C. Gupta, Wiley Eastern Ltd.
8. Laidler, K. J. (1965) Chemical Kinetics, Second Edition.
9. Frost, A. A. and Pearson, R. G. Kinetics and Mechanism, Second Edition.
10. Agrawal, G. L. Basic Chemical Kinetics by Tata McGraw-Hill Publishing Company Ltd., New Delhi.
11. Banwell, C. N. and McCash, E. M. (1996) Fundamentals of Molecular Spectroscopy, McGraw Hill International (UK).
12. Bahl, B. S., Bahl, A., Tuli, G. D. (2005) Essentials of Physical Chemistry by Chand and Co Ltd., New Delhi.
13. Puri, B. R., Sharma, L. R. and Pathania M. S. (2007) Principles of Physical Chemistry (42nd Edition), , Vishal Publishing Co., Jalandhar.
14. Dr. L. S. Patil, Physical Chemistry II, Shree Book Co. Mumbai.

Course Outcomes (CO):

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

No.	CO	Cognitive level
1	Students will gain an understanding of Joule-Thomson effect, third law of thermodynamics, absolute entropy, standard entropy and residual entropy and partial molar quantity and its significance.	**2**
2	Students should understand the importance of statistical thermodynamics and concept of partition functions.	**2**
3	Students should able to understand core study of chemical kinetics and spectroscopy.	**2**

CH - 230: Inorganic Chemistry - II (60 L, 100 Marks and 4 Credits)		
Course Objectives: 1. This course offers to impart the basic knowledge about spectroscopy of inorganic compounds 2. This course also offers to study the reaction mechanism in transition metal complexes. 3. This course helps to understand catalysis and structure reactivity of molecules.		
Unit No.	***Name of the Units***	***Lectures***
1	**The Ionic bond** Structures of ionic solids, radius ratio rules, calculation of limiting radius ratio Values of coordination no.3, 4, 6, close packing, classification of ionic structures – Ionic compounds of the type AX (ZnS, NaCl, CsCl), Ionic compounds of the type AX_2 (CaF_2, TiO_2, SiO_2); Layer structures (CdI_2, [NiAs]) Structures containing polyatomic ions.	**12**
2	**Electronic Spectra** Energy levels in an atom, coupling of orbital angular momenta, coupling of spin angular momenta, spin orbit coupling. Determining the ground state terms – Hund's rule, Hole formulation, Derivation of the terms for a P2 & P3 configuration, calculation of the number of microstates, Electronic spectra of transition metal complexes – Laporte 'orbital' selection rule, spin selection rule, splitting of electronic energy levels and spectroscopic states.	**12**
3	**Reaction mechanism in transition metal complexes** Ligand substitution reaction, classification of mechanism, substitution of square planer complexes, nucleophilicity of entering group, shape of activated complexes, K1 pathway, substitution in octahedral complexes, rate law and their interpretation, activation of octahedral complexes, base hydrolysis, stereochemistry, isomerization reactions.	**12**
4	**Catalysis** Catalysis, description of catalyst, properties of catalyst, types of catalyst, catalytic steps in organotransition metal catalyst, hydrogenation of alkenes, hydroformylation, Monsanto acetic acid synthesis, Wacker oxidation of alkenes, alkene polymerization, heterogeneous catalysis, nature of heterogeneous catalyst, examples of heterogeneous catalysts (hydrogenation, oxidation).	**12**
5	**Preparation & Application of Complexes** Preparation of complexes, Application of complexes in analytical chemistry, complexometric titration, Application of complexes in metallurgy, Application of complexes in industry, Application of complexes in medical field. Presence of metal complexes in biological system (Haemoglobin, Chlorophyll, Vitamin-B_{12})	**12**

References:

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. Shrivers, P.W. Atkins and C.H. Lang for, 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 (CO):

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

No.	CO	Cognitive level
1	Understand the concept of microstates, spectroscopic terms and orgel diagram of inorganic compounds.	**2**
2	Gain knowledge about magnetic properties and charged transfer spectra of transition metal complexes.	**2**
3	Students are able to analyze structure reactivity and reaction mechanisms of metal complexes.	**4**

CH - 250: Organic Chemistry - II
(60 L, 100 Marks and 4 Credits)

Course Objectives:

1. This course also offers to learn various name reactions, rearrangement and reagents used in organic chemistry.
2. The course offers to study the importance of stereochemistry and organic spectroscopy for structure elucidation with respect to laboratory and industrial applications.
3. This course helps to understand the principles behind UV, IR, ^{1}HNMR, ^{13}CNMR and Mass spectroscopy.

Unit No.	Name of the Units	Lectures
1	**Rearrangements** Wagner-Meerwein (with Demjanov), Pinacol, Wolff, Arndt-Eistert Synthesis, Hofmann, Curtius, Schmidt, Lossen, Beckmann, Baeyer-Villiger, Favorskii, Benzilic acid, Stevens, Wittig, Claisen, Cope, oxy-cope, Meisenheimer, Sommelet-Hauser, Dienone-phenol, Ciamician-Dennsted, Fries (with photo Fries) rearrangements	12
2	**Selective Name Reactions** Aldol Condensation, Henry reaction, Perkin reaction, Stobbe Condensation, Dieckmann Condensation, Benzoin Condensation, Reimer-Tiemann reaction, Reformatsky reaction, Darzens reaction, Michael reaction, Mannich reaction, Shapiro reaction, Bomford-Stevens reaction, Nef reaction, Baylis Hilman reaction, Cannizaro reaction, Knovengeal reaction, Sharpless reaction, Barton reaction, Hofmann Loffler-Freytag reaction, Vilsmeir-Haack reaction	14
3	**Reagents in Organic Synthesis** **A] Oxidizing Reagent:** CrO_3, $Na_2/K_2Cr_2O_7$, Collins reagent, PDC (Cornforth reagent), PCC (Corey's reagent), $KMnO_4$, MnO_2, SeO_2, $Pb(OAc)_4$, Pd-C, OsO_4, Peracid, (m-CPBA), O_3, H_2O_2, $NaIO_4$, HIO_4, $Al(O\text{-}i\text{-}R)_3$ (Oppenauer oxidation), Swern oxidation, DDQ, NBS and B_2H_6 **B] Reducing Reagent:** $LiAlH_4$, $NaBH_4$, $NaCNBH_3$, MPV reduction, Na/liquor NH_3, Na/alcohol, H_2/Pd-C, H_2/Pd-$BaCO_3$, DIBALH and Wolff Kishner reduction, Zn-Hg/H_2O/HCl, Zn(Cu), Baker's yeast, LDC (Gilman's reagent), LDA (Lithium diisopropylamide), DCC (dicyclohexylcarbodimide), Woodward and Prevost hydroxylation and Baker's yeast.	14
4	**Stereochemistry** Stereochemical principles (stereoisomers, chirality, optical activity, enantiomers, diastereoisomers, epimer, anomer), R-S nomenclature, Meso Compounds, E-Z nomenclature, Threo and Erythro nomenclature. optical activity in biphenyls, spiranes, allenes, Racimic modification and racimation, optical purity, pro-stereoisomerism (Homomorphic, Homotopic, Heterotopic, enantiotropic, diastrophic-atoms, groups and faces). Interconversion of Fischer, Newman and Sawhorse Projections, stereospecific and stereoselective reactions Conformational analysis of cyclic (cyclohexane, mono-substituted cyclohexane) and acyclic compounds (ethane, propane, butane).	14

5	**Spectroscopy:** Instrumentation, Sample Preparation for UV, IR, NMR (^{1}H and ^{13}C), Mass Spectrometry. Joint problems based on UV, IR, NMR (^{1}H and ^{13}C), Mass.	**06**

References:

1. S. H. Pine – Organic Chemistry, 5th Edition, McGraw-Hill.
2. P. S. Kalsi – Organic Reactions and Their Mechanisms
3. J. Clayden, N. Greeves, S. Warren – Organic Chemistry, IInd Edition, Oxford University Press.
4. Peter Sykes-A Guidebook to Mechanism in Organic Chemistry
5. W Carruthers and Iain Coldham – Modern Methods of Organic Synthesis
6. P. S. Kalsi –Stereochemistry: Conformation and Mechanism, 8th Edition, New Age International.
7. F. A. Carey, R. J. Sundberg – Advanced Organic Chemistry Part-B: Reactions and Synthesis, 5th Edition, Springer.
8. D. Nasipuri – Stereochemistry of Organic Compounds: Principles and Applications, Revised 2ndEdition, New Age International.
9. E. L. Eliel – Stereochemistry of Carbon Compounds, McGraw-Hill.
10. P. S. Kalsi – Spectroscopy of Organic Compounds, 6th Edition, New Age International.
11. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan – Introduction to Spectroscopy.
12. R. M. Silverstein, F. X. Webster – Spectrometric Identification of Org. Compounds.

Course Outcomes (CO):

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

No.	CO	Cognitive level
1	Students will learn the basic name reactions and rearrangement reactions.	**2**
2	Students will understand the applications of reagents in organic synthesis.	**2**
3	Students will apply the basic knowledge about core study of spectroscopy and stereochemistry	**3**

CH - 290: Instrumentation and Analysis
(30 L, 50 Marks and 2 Credits)

Course Objectives:

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

Unit No.	Name of the Units	Lectures
1	**Errors, statistics and sampling:** Accuracy and precision, Error, types of error, systematic and random errors, minimization 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 and sampling statistics.	06
2	**Voltammetry:** Excitation signals Linear-sweep Voltammetry- voltammetric instruments, voltammetric electrodes, voltammograms, hydrodynamic voltammetry and voltammetric detectors.	06
3	**Electrogravimetric Analysis:** Theory of electrogravimetric analysis, terms used in electrogravimetric analysis, completeness of deposition, Electrolytic separation of metals, character of the deposit, electrolytic separation of metals with controlled cathode potential, apparatus and determination of copper (constant current procedure).	06
4	**Ultra-purity and ultra-trace analysis:** Ultra-purity and ultra-trace analysis, laboratory dosing, purification of reagents, Preconcentration Techniques and contamination control during analytical operation.	06
5	**Chemical Aspects to Nanomaterials:** Nanoscience and nanotechnology, effect of making into small size, general theme of classification of nanomaterial, application of nanomaterials, characterization of nanomaterials using XRD, SEM-EDAX, and TEM.	06

References:

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.
4. Vogel's Text Book of Quantitative Chemical analysis (Sixth Edition) By- J.
5. Mendham, R.C. Denny, J.D. Barnes, M.J.K. Thomas (Pearson Education- Low Price Edition)

Course Outcomes (CO):

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

No.	CO	Cognitive level
1	Explain various theoretical concepts of analytical chemistry.	**2**
2	Build up ability to solve the numerical problems.	**3**
3	Apply theoretical principles, working of various classical and modern instrumentation techniques.	**3**

AC-201(A): Soft Skills **(Personality and Cultural Development Related Audit course; Practical; 2 Credits)**		
	Course Objectives (CObs): • To develop soft skills and communication skills amongst the students.	
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 h**
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 h**
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 h**
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 GD for each group should be conducted and teacher should give them feedback. Mock interviews to be conducted.	**4 h**
5	**Aptitude and analytical skills** Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	**8 h**
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 h**

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 (CO):

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

No.	CO	Cognitive level
1	Grasp soft skills and communication skills.	**2**
2	Apply life skills to manage the situations.	**4**

CH-P-1: Physical Chemistry Practical-I
(180 Hrs., 100 Marks and 6 Credits)

Course Objectives: The practical course is designed

1. To understand the basic principles of different techniques used in laboratory and provide hands on training on various instruments.
2. To understand the standardization of instruments to make appropriate measurements, analyze the data and report the results.
3. To understand the basic principles of different techniques used in laboratory.
4. to develop the experimental skills in physical chemistry
5. To acquire the knowledge about verification of theoretical aspects.
6. To understand the standardization of instruments like colorimeter, polarimeter etc. and their application.

Students should perform minimum of twenty (20) experiments.
It is expected to perform at least two experiments from each technique.

INSTRUMENTAL

Conductometry

1. Determine the conductance of strong electrolyte (KCl/NaCl/$AgNO_3$/HCl) at various concentrations and verify the applicability of DHO equation.
2. Determine the amount of trichloroacetic acid, monochloroacetic acid and acetic acid in the given by conductometric titration against sodium hydroxide solution.
3. Determine the solubility of sparingly soluble salt ($BaSO_4$) at different temperatures conductometrically and determination of ΔG, ΔH and ΔS of the solution.
4. Study the second order velocity constant of hydrolysis of ethyl acetate by sodium hydroxide using conductance measurement.
5. Determination of critical micellar concentration (CMC) of sodium lauryl sulphate from the measurement of conductivities at different concentrations.
6. To determine the concentration of Fe^{2+} ions by titrating with potassium dichromate solution conductometrically.

Potentiometry

1. To determine the stability constant of a complex ion $[Ag_2(S_2O_3)]^{-3}$ potentiometrically.
2. To determine standard free energy change ΔG^0 and equilibrium constant for the reaction $Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$ potentiometrically.
3. To determine the activity coefficient of an electrolyte (HCl) by potentiometry.
4. To determine the amount of each halide in a mixture of halides containing a) KI and KBr/KCl or b) KI / KBr and KCl potentiometrically.
5. To titrate ferrous ammonium sulphate solution with potassium dichromate solution potentiometrically using bimetallic electrode pair.
6. To determine the transport number of Ag^+ and NO_3^- ion.

pH metry

1. Determination of Hammette constant of a given substituted benzoic acid by pH measurements.
2. To determine acidic and basic dissociation constant of amino acid and the iso-electric point of the acid.
3. To determine the three dissociation constants of polybasic acid such as H_3PO_4 by pH measurements.
4. Determine the effect of KCl on the pH of HCL solution.

Colorimetry / Spectrophotometry

1. To determine the pKa and Ka of given indicator by colorimetry / spectrophotometry
2. To determine the empirical formula of Ferric salicylate complex by Job's method and verify by slope ratio method.
3. Determine the amount of Cu (II) and Fe (III) in a mixture by titrating it against standard EDTA solution spectrophotometrically.
4. Determination of iron in water using a colorimeter.
5. Simultaneous determination of $Cr_2O_7^{2-}$ and MnO_4^- ions or Co^{2+} and Ni^{2+} in the solution by spectrophotometry.
6. Record the UV spectrum of Benzene, Pyridine and Pyrimidine in methanol. Compare and discuss the various transition involved in terms of MO theory.

Polarimetry

1. Polarimetric determination of the specific rotation of camphor in benzene and carbon tetrachloride.
2. Determine the percentage of two optically active substances (d-glucose and d-tartaric acid) in a mixture polarimetrically.

Refractometry

To measure refractometrically average polarizability of some of the common solvents.

NON-INSTRUMENTAL

Chemical Kinetics

1. To determine the rate constant for depolymerization of diacetone alcohol catalysed by sodium hydroxide using dilatometer.
2. Study the kinetics of reaction between potassium persulphate and potassium iodide.
   a) Determine the rate constant.
   b) Study the influence of ionic strength on the rate constant.
3. To determine energy of activation of the hydrolysis of methyl acetate in presence of hydrochloric acid (Calculations and graphs expected from excel programming)
4. Determine the colorimetrically the order and energy of activation for decomposition of violate coloured complex of ceric ion and N-phenylanthranilic acid.

Other Non-instrumental experiments

1. Determined the transport number of H^+ and Cl^- ions by moving boundary method.
2. To obtain solubility curve for liquid say water-acetic acid-chloroform system
3. Investigate the adsorption of acetic acid in aqueous solution by using activated charcoal and verify Freundlich's adsorption isotherm.
4. Determination of partial molar volume of ethanol in dilute aqueous solutions.
5. To study the effect of addition of an electrolyte (KCl/NaCl /NH_4Cl/Na_2SO_4 / K_2SO_4) on solubility of an organic acid (benzoic acid or salicylic acid).

Cryoscopy:-

To determine the mean activity coefficient of an electrolyte (NaCl) in dilute solution by cryoscopic measurement.

References:

1. Findley's Practical Physical Chemistry (9^{th} edition), Edited by B. P. Levitt (Longman Group Ltd).
2. Systematic Experimental Physical Chemistry (2^{nd} edition), By S. W. Rajbhoj and Dr. T. K. Chondekar (Anjali Publication, Aurangabad).
3. Advanced Practical Physical Chemistry (26^{th} edition), By J. B. Yadav (Goel Publishing House, Meerut).
4. Experimental Physical Chemistry, By V. D. Athawale, P. Mathur (New Age international Ltd, New Delhi)
5. Advanced Practical in Physical Chemistry (13^{th} edition or latest) By Dr. Pande, Dr. Mrs. Datar, Dr. Mrs Bhadane, Manali Publication, Pune.
6. University Practical Chemistry by P. C. Kamboj, Vishal Publishing Co. Jalandhar, Panjab.
7. Practical Physical Chemistry, By A. M. James and F. F. Prichard, Longman Group Ltd.
8. Advanced Physical Chemistry Experiments by Dr. J. N. Gurtu and Amit Gurtu, Pragati Prakashan Meerut.

Course Outcomes (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Students will understand the preparation for each experiment.	**2**
2	Setup and standardize the potentiometer, P^H meter and conductometer.	**3**
3	Identify thermodynamics and kinetics of simple systems.	**4**
4	To know Safety requirements and lab skills to perform physico-chemical experiments.	**2**
5	To apply the principles and techniques to different systems.	**3**

CH-I-1: Inorganic Chemistry Practical-I
(180 Hrs., 100 Marks and 6 Credits)

Course Objectives: The practical course is designed

1. To understand the basic principles of different techniques used in laboratory analysis.
2. To provide hands on training on various techniques of analysis.
3. Develop the ability to analyze drug samples
4. To make appropriate measurements, analyze the data and report the results.

Students should perform minimum of twenty (20) experiments.

Analysis of ore (minimum two)

a. Pyrolusite ore - Estimation of silica gravimetrically and Manganese volumetrically.
b. Haematite - Estimation of copper volumetrically and Iron gravimetrically.
c. Chromite ore – Estimation of Iron gravimetrically and chromium volumetrically.

Analysis of binary mixtures by gravimetric and volumetric method (minimum five)

a) Copper- Nickel
b) Copper -Magnesium
b) Copper-Zinc
c) Iron-Magnesium
d) Nickel-Zinc
e) Lead-Tin

Drug Analysis (minimum one)

a. Determination of iron from given drug sample.
b. Determination of Calcium from given Calcium tablet.

Thermochemistry (minimum two salts)

To determine the lattice energy of binary salts (NaCl, KCl, $CaCl_2$).

Preparation of the following complexes and determination of its purity (minimum four)

a) Potassium trioxalatoferrate(III)trihydate
b) Tris(acetylacetonato)iron(III)
c) Potassium di aqua bis(oxalato) chromate (III)
d) Prussian Blue (Potassium Ferric Ferro cyanide)
e) Chloropenta-amminecobalt (III) chloride

Chromatography (minimum two)

a) Determination of the Rf value of Pb, Cu, Cd ions by using paper chromatographic technique.
b) Determination of the Rf value of Fe, Al, Cr ions by using paper chromatographic technique.
c) Determination of the Rf value of Ba, Sr, Ca ions by using paper chromatographic technique.

Instrumental method of Analysis (minimum four experiment)

a) To determine the strength of given mixture of carbonate and bicarbonate by pH metric method
b) To determine Ca in the given solution by flame photometrically, by calibration curve Method**.**

c) Spectrophotometry (**any one**)

1. Estimation of phosphate from waste water by calibration curve method
2. Estimation of Manganese from steel.

d) To determine the amount of copper present by iodometric method (potentiometrically)

e) Estimation of Boric acid using NH_4OH by conductometric method.

References:

1. A Text book of Quantitative Analysis by A.I.Vogel , 4**th** edition
2. Advanced Practical Inorganic Chemistry By Gurdeep Raj Goel Publishing House.
3. Post Graduate Practical Chemistry (Part – 1) by H.N. Patel, S.P. Turakhia,S.S. Kelkar, S.R. Puniyani, Himalaya Publishing House.
4. Applied Analytical Chemistry: Vermani.
5. University Practical Chemistry by P.C.Kamboj
6. Commercial Methods of Analysis: Shell &Biffen

Course Outcomes (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Students will understand the process of ore analysis.	**2**
2	Students able to apply their knowledge for binary mixture separation of inorganic compounds using quantitative analysis	**3**
3	Students can analyze contents present in drug	**4**
4	Students able to evaluate the lattice energy of binary salt	**6**
5	Students are able to synthesize and evaluate the complex and also able to determination of complex purity.	**5**
6	Students understand the techniques of chromatography and its application in analysis.	**2**
7	Students able to handle and perform the instrumental analysis techniques.	**3**

CH-O-1: Organic Chemistry Practical-I
(180 Hrs., 100 Marks and 6 Credits)

Course Objectives: The practical course is designed

1. To make students aware of how to perform organic compounds in laboratory.
2. The course includes synthesis of some derivatives and organic compounds, which will help them while working in research laboratory in future.
3. This course will help them in industry or while doing research in medicinal chemistry for Drug development.
4. To make student aware of green chemistry and role of green chemistry in pollution reduction and pollution control.
5. The students learn how to avoid solvents and do solvent free reaction.
6. Also, the work-up procedure in many experiments is made more eco-friendly to environment.

Introduction to Laboratory Safety (Minimum 2 Practical)

- Meaning of safety signs on container of chemicals, safety handling of chemicals
- Handling of glassware's and care to be taken, handling of organic flammable as well as toxic solvents in laboratory,
- Use of Personal Protective Equipment (PPE) (safety goggles, shoes and gloves)
- Fire extinguisher and its use,
- Chemical Spills/Clean up: action to be taken in accidental cases e.g. cleaning of acid spill over, use eye wash station and bath station in emergency, etc. (compulsory)
- Behaviour: No food or drink policy; include information about where food and drink are allowed (if such a space exists). Explicitly state that disruptive or destructive behaviour will not be tolerated.

Single Stage Preparation Monitored by TLC (Minimum 6)

1. Acetophenone to Benzalacetophenone.
2. Resorcinol to 7-hydroxy, 4-methyl coumarin.
3. Camphor to Borneol.
4. Benzophenone to Benzhydrol.
5. Acetoacetic ester to Pyrazolone.
6. Paramino Benzoic Acid to Parachloro Benzoic Acid.
7. 2-methoxy naphthalene to 1- formyl-2-methoxy napthalene.
8. Gycine to Benzoylglycine.
9. p- nitrotoluene to p- nitrobenzoic acid.
10. Fischer Indole Synthesis-Reaction of phenyl hydrazine and cyclohexanone
11. Knoevenagel condensation reaction-Reaction of aldehyde and malononitrile.
12. Anthracene to Anthraquinone
13. Benzaldehyde to Cinnamic acid
14. Anisole to 2,4-Dinitroanisole

Purification Techniques (Minimum 8 Demonstration/Experiments)

1. Purification of two organic solids by recrystallization using solvents other than water
2. Purification of two organic liquids by upward/downward/traditional distillation technique
3. Column Chromatography technique should be performed for any one of the above

preparations

4. Purification by Sublimation Method
5. Thin Layer Chromatography technique for identification of two different compounds present in mixtures
6. Solvent extraction using Soxhlet extractor.
7. Solvent extraction by separatory funnel
8. Steam distillation.

Use of Chemistry software's like, ISI draw, Chem Draw, Chem Sketch (Minimum 4)

2. Draw the structure of simple aliphatic and aromatic compounds, heterocyclic compounds with different substituent. (Minimum Ten Compounds).
3. IUPAC name and predict the NMR Signals.
4. Sketch Design reaction mechanism scheme of any two addition and two substitution reactions.
5. Literature Search and references.

Preparation of Derivatives: (Minimum 6)

1. Acetyl
2. Benzoyl
3. Semicarbazone,
4. Amide
5. Aryloxyacetic acid,
6. Ester
7. Oxime

Introduction to Green Chemistry

Concept of green chemistry, twelve principals of green chemistry, applications of green chemistry for sustainable development, Atom economy.

Green Chemistry Preparations (Minimum 4)

1. Bromination of acetanilide using Cerric ammonium nitrate.
2. Preparation of Benzilic Acid using NaOH /KOH under Solvent-free Conditions.
3. Photo reduction of benzophenone to benzopinacol in presence of sun light using isopropanol and acetic acid.
4. Nitration of salicylic acid
5. Preparation of 1, 1-bis-2-naphthol under grinding at room temperature.
6. Alternative Green Procedure for Preparation of a Derivative for Carboxylic Acid.
7. Alternative Green Procedures for Organic Qualitative Analysis - Detection of N, S, Cl, Br, I.

Interpretation of UV, FT-IR and ^{1}H-NMR spectrum of above synthesized compounds. (Minimum 10 Compounds)

References:

1. A text book of practical organic chemistry- A. I. Vogel.

2. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Aggarwal
3. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST
4. R. K. Bansal, Laboratory Manual of Organic Chemistry, New Age International Publisher

Course Outcomes (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Students understand the important of safety techniques and handling of chemicals.	**2**
2	Students are made aware of carrying out different types of reactions and their workup methods.	**2**
3	Students able to perform purification techniques in organic chemistry like recrystallization, distillation, steam distillation and extraction.	**3**
4	This practical course is designed to make student aware of green chemistry and role of green chemistry in pollution reduction.	**5**
5	Students are able to apply their knowledge for development of experiment involve green chemistry.	**6**

AC-201(B): Practicing Sports Activities
(Personality and Cultural Development Related Audit course; Practical; 2 Credits)

Course Objectives (CObs):

- To motivate students towards sports and provide them required training.

SR NO.	NAME OF THE SPORT/GAME (Select ONE of the Following)	SYLLABUS OF THE COURSE	TIMING (02 Hours in a Week)	SEMESTER
1	Volleyball	• General Fitness • Basic Fitness • Specific Fitness • History of the Game • Basic Skill of the Game • Major Skill of the Game • Technique & Tactics of the Game • Game Practice	Morning : 07 to 09 AM OR Evening : 05 to 07 PM	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			
6	Handball			
7	Kabaddi			
8	Kho-Kho			
9	Table-Tennis			
10	Swimming			

Course Outcomes (CO):

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

No.	CO	Cognitive level
1	Play any sports on the ground.	**2**
2	Become healthier and fit.	**3**

AC-201(C): Practicing Yoga

(Personality and Cultural Development Related Audit course; Practical; 2 Credits)

Course Objectives:

- To motivate students towards yoga and provide them required training.

- Yog: Meaning, Definition & Introduction, Objectives
- Primary Introduction of Ashtanga Yoga
- Preparation of Yogabhyas
- Omkar Sadhana, Prayer, Guru Vandana
- Sukshma Vyayamas
- Suryanamaskar (12 Postures)
- Asanas :
  - Sitting (Baithaksthiti) - Vajrasana, Padmasan, Vakrasan, Ardha-Pashchimotanasanan
  - Supine (Shayansthiti) - Uttan Padaasan(Ekpad/Dwipad), Pavanmuktasana, Viparitakarani Aasan, Khandarasan, Shavasana
  - Prone (Viparitshayansthiti) - Vakrahasta, Bhujangasana, Saralhasta Bhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana
  - Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, Ardh Chakrasana
- Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types
- Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (CO):

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

No.	CO	Cognitive level
1	Perform different yoga.	**2**
2	Perform different asanas.	**3**

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

Course Outcomes (CO):

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

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