Kavayitri Bahinabai Chaudhari

North Maharashtra University

Jalgaon

Academic Curriculum

M.Sc. Part - I

Subject: Chemistry

(Semester I and II)

Based on NEP-2020

(Outcome Based Curriculum)

As Per U.G.C. Guidelines

NATIONAL EDUCATION POLICY 2020

Prepared
By
BoS Chairman,
Members of Board of Studies and
The Experienced Teachers in Chemistry,
KBCNMU, Jalgaon

To Be Implemented From
Academic Year 2023-24

Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon

SYLLABUS

M.Sc. Part-I CHEMISTRY

(Semester I and II)

Based on NEP-2020
(Outcome Based Curriculum)
As Per U.G.C. Guidelines

Summary of Distribution of Credits as under CBCS Scheme

[For affiliated colleges, w. e. f. academic year 2023-24]

Course credit scheme

Semester	(A) Core Courses			(B) Elective Course			Total Credits (A+B)
	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	
I	6	12+06	**18**	1	04+00	**04**	**22**
II	6	12+06	**18**	1	04+00	**04**	**22**
Total Credits			**36**			**08**	**44**

(T:Theory; P:Practical)

Structure of Curriculum

		First Year				Total Credit Value
		Semester I		Semester II		
		Credit	Course	Credit	Course	
(A)	**Discipline Specific Courses / Core Courses**					
	Theory	12	03	12	03	24
	Practical	06	03	06	03	12
	Total (A)					**36**
(B)	**Discipline Specific Elective / Elective Courses**					
	Theory	04	01	04	01	08
	Practical	00	00	00	00	00
	Total (B)					**08**
Total (A+B)		**22**	**07**	**22**	**07**	**44**

	Semester-I	Semester-II	Total
Minimum Papers	7	7	**16**
Minimum Marks	220	220	**440**
Maximum Marks	550	550	**1100**
Total Credits	22	22	**44**

Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon

Syllabus under NEP-2020 for M. Sc. Part-I Chemistry Syllabus Structure (w.e.f.2023-24)

M.Sc. (level 6.0) Sem-I

(Name of Courses for–Major, Minor, GE, VSEC, IKS courses)

Sr No	Course Category	Name of the course (Title of the Paper)		Total Credit	Hours/Semester	Teaching Scheme (hrs/week)		Evaluation Scheme		
						Theory	Practical	CIE(CA)	ESE(UA)	Duration of Examination (Hrs)
						T	P			
1	DSC	DSC-25	Advanced Physical Chemistry-I	4	60	4	-	40	60	3
		DSC-26	Chemistry Practical-I (Physical Chemistry)	2	60	-	4	20	30	6
		DSC-27	Advanced Organic Chemistry-I	4	60	4	-	40	60	3
		DSC-28	Chemistry Practical-II (Organic Chemistry)	2	60	-	4	20	30	6
		DSC-29	Chemistry Practical-III (Inorganic Chemistry)	2	60	-	4	20	30	6
2	DSE	DSE-5	A) Advanced Inorganic Chemistry-I	4	60	4	-	40	60	3
			B) Advanced Analytical Chemistry-I	4	60	4	-	40	60	3
3	Research	RM	Research Methodology	4	60	4	-	40	60	3
			Total	**22**		**16**	**12**	**220**	**330**	

DSC: Discipline Specific Course, DSE: Discipline Specific Elective
RM: Research Methodology CIE: Continuous Internal Evaluation
ESE: End Semester Evaluation

Important points:

i. For theory courses one credit is equivalent to 15 lectures of 60 minutes each and for practical courses one credit is equivalent to 30 lectures of 60 minutes each.

ii. There will be 12 practical sessions per semester of 4 hours each.

iii. Total weeks for teaching and internal evaluation are 15. Out of the 15 weeks, 12 weeks are for teaching and 03 weeks for internal evaluation (Theory as well as Practical).

M. Sc. (level 6.0) Sem-II

(Name of Courses for–Major, Minor, GE, VSEC, IKS courses)

Sr No	Course Category	Name of the course (Title of the Paper)		Total Credit	Hours /Semester	Teaching Scheme (hrs/week)		Evaluation Scheme		
						Theory	Practical	CIE(CA)	ESE (UA)	Duration of Examination (Hrs)
						T	P			
1	DSC	DSC-30	Advanced Physical Chemistry-II	4	60	4	-	40	60	3
		DSC-31	Chemistry Practical-IV (Physical Chemistry)	2	60	-	4	20	30	6
		DSC-32	Advanced Organic Chemistry-II	4	60	4	-	40	60	3
		DSC-33	Chemistry Practical-V (Organic Chemistry)	2	60	-	4	20	30	6
		DSC-34	Chemistry Practical-VI (Inorganic Chemistry)	2	60	-	4	20	30	6
2	DSE	DSE-6	A) Advanced Inorganic Chemistry-II	4	60	4	-	40	60	3
			B) Industrial Safety and Good laboratory Practices	4	60	4	-	40	60	3
3	OJT/Int	OJT/Int	On Job Training or Internship	4	120	-	8	40	60	3
			Total	**22**		**12**	**16**	**220**	**330**	

DSC: Discipline Specific Course, DSE: Discipline Specific Elective
RM: Research Methodology CIE: Continuous Internal Evaluation
ESE: End Semester Evaluation

Important points:

i. For theory courses one credit is equivalent to 15 lectures of 60 minutes each and for practical courses one credit is equivalent to 30 lectures of 60 minutes each.

ii. There will be 12 practical sessions per semester of 4 hours each.

iii. Total weeks for teaching and internal evaluation are 15. Out of the 15 weeks, 12 weeks are for teaching and 03 weeks for internal evaluation (Theory as well as Practical).

iv. **Exit Option**: PG Diploma after one Year of PG Programme (44 Credits)

Syllabus for M.Sc. Part-I Chemistry

(Semester - I & II)

Course Structure for First Year

Course Code	Course Code	Course Type	Title of the Course
Semester –I			
DSC-25	CH-411	Core	Advanced Physical Chemistry-I
DSC-26	CH-412	Core	Chemistry Practical-I (Physical Chemistry)
DSC-27	CH-413	Core	Advanced Organic Chemistry-I
DSC-28	CH-414	Core	Chemistry Practical-II (Organic Chemistry)
DSC-29	CH-415	Core	Chemistry Practical-III (Inorganic Chemistry)
DSE-5	CH-416A	Elective	Advanced Inorganic Chemistry-I
	CH-416B	Elective	Advanced Analytical Chemistry-I
RM	RM-417	RM	Research Methodology
Semester– II			
DSC-30	CH-421	Core	Advanced Physical Chemistry-II
DSC-31	CH-422	Core	Chemistry Practical-IV (Physical Chemistry)
DSC-32	CH-423	Core	Advanced Organic Chemistry-II
DSC-33	CH-424	Core	Chemistry Practical-V (Organic Chemistry)
DSC-34	CH-425	Core	Chemistry Practical-VI (Inorganic Chemistry)
DSE-6	CH-426A	Elective	Advanced Inorganic Chemistry-II
	CH-426B	Elective	Industrial Safety and Good laboratory Practices
OJT/Int	CH-427	OJT/Int	On Job Training or Internship

DSC: Discipline Specific Course, DSE: Discipline Specific Elective
RM: Research Methodology, OJT: On Job Training

Important Notes:

1. One credit is equivalent to 15 hour of teaching (lecture or tutorial) or 30 hours of practical or field work or community engagement and service per semester.
2. Total weeks for teaching and internal evaluation are 15. Out of the 15 weeks, 12 weeks are for teaching and 03 weeks for internal evaluation (Theory as well as Practical).
3. Each theory course prescribed for M. Sc. should be covered in number of lecture lectures equivalent to the credit (2 hours for 2 Credit course, total 30 hours and 4 hours for 4 credit course, 60 hours), each per week per course including lectures, tutorials, seminars, class room discussions etc.
4. Each practical course will require 04 hours of laboratory work per week for each semesters (Total 60 hours/practical course of 2 credit)
5. In the 60 lectures of theory course about 10 lectures will include tutorials, student seminars, classroom discussions and tests.
6. From DSE courses any one course is to be selected in each semester.
7. There should not be more than10 students in a batch for M. Sc. Practical course.
8. 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.
9. 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.
10. The minimum marks required for passing the theory and practical course are 24 marks in External examination (out of 60) and 16 marks in Internal examination (out of 40) and 12 marks in External examination (out of 30) and 08 marks Internal examination (out of 20).
11. The external evaluation of M.Sc. practical course should be done by Internal and External examiner jointly at the end of each semester
12. The 75% attendance of students is compulsory.
13. Students should visit at least one chemical industry in the first year of M. Sc. And submit the observations/report to the Department.
14. Exit Option: PG Diploma after one Year of PG Programme with 44 Credits.

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

Program at a Glance

Name of the program (Degree)	:M. Sc. (Chemistry)
Faculty	:Science and Technology
Duration of the Program	:Two years (four semesters)
Medium of Instruction and Examination	: English
Exam Pattern	:60:40 Pattern
Passing standards	: 40% in each exam separately (Separate head of passing)
Evaluation mode	:CGPA
Total Credits of the program	: 88 Credits

Semester-I

DSC-25

CH-411 : Advanced Physical Chemistry–I

(60L, 100 Marks and 4 Credits)

Course Objectives:

1. To learn the principals and foundations of quantum chemistry.
2. To acquire knowledge about the different possible equilibrium in nuclear decay processes.
3. To learn the theory and concepts behind the electrochemical processes and ionic equilibria.
4. To acquire knowledge about kinetics of complex reactions and fast reactions.
5. To orient and acquaint the PG students towards the statistical thermodynamics.

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, free particle, particle in one dimensional box and its application for excitation energies in linear conjugated systems, two and three dimensional box :wave function and probability density plots, degeneracy, energy equation for simple harmonic oscillator, rigid rotator, spherical polar coordinates. Hydrogen atom Schrodinger wave equation (derivation not expected), and related numerical. **Ref. 2,3,4,6**	**12**
2	**Nuclear& Radiation 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 same the same half life, secular and transient equilibrium. Applications of radioactivity: Szilard - Chalmer's reaction, Isotope dilution and neutron activation analysis and related numerical Radiation dosimetry: units of dose, Fricke and Ceric sulphate dosimeters, and conversion of measured dose values and related numerical. **Ref.5, 9**	**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 steps involved in chain reactions with suitable example and related numerical. Fast reactions, techniques for the study of fast reactions: flow methods and flash photolysis. **Ref:1, 6, 8, 12, 13**	**12**
4	**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,	**12**

	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, 9**	
5	**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 and related numerical. **Ref: 1,7, 9, 10, 11**	**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 & C. F. Prutton, Principles of Physical Chemistry, Oxford & IBH Publishing Co.
8. K.J. Laidler, (1965) Chemical Kinetics, Second Edition
9. B.R. Puri, L.R Sharma and M.S. Pathania (2007) Principles of Physical Chemistry (42nd Edition) , Vishal Publishing Co., Jalandhar
10. L.K Nash (1968)Elementary Statistical Thermodynamics, Addition-Wesley, Reading.
11. M. C. Gupta, (1990) Statistical Thermodynamics, Wiley Eastern Ltd.
12. A.A. Frost and R.G. Pearson, Kinetics and Mechanism, Second Edition.
13. G.L. Agrawal, Basic Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
14. Dr. L. S. Patil, Physical Chemistry I, Shree Book Co. Mumbai
15. Dr. L. S. Patil, Physical Chemistry II, 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	To identify different equilibrium processes, explain the concept of radiation dose measurement and its practical applications	**3**
3	Students should able to understand core study of chemical kinetics and spectroscopy.	**2**
4	To be able to calculate the ionic strength and activity coefficients by using the basic concepts underlying.	**5**
5	Students should understand the importance of statistical thermodynamics and concept of partition functions.	**2**

DSC-27
CH-413 : Advanced 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	**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**
2	**Nucleophilic Substitution reaction** **A. Aromatic nucleophilic substitution** SNAr, SN^1, Benzyne and SNR^1 reactions, effect of substrate structure, leaving group, solvent and attacking nucleophile. **B. The neighboring group mechanism** The neighboring group mechanism, neighboring 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	**12**
3	**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. Ref. 1. Page No. 447-562 Ref. 2, 3, 4, 5, 7, 8 Relevant pages	**12**
4	**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**

5	**Elimination reaction** a) E_1, E_2, E_1CB mechanisms, Stereo chemistry of elimination, Elimination versus substitution, anti and syn elimination. b) Dehydrohalogenation, Dehalogenation, Dehydration, Hoffmann and Saytzeff's elimination, Pyrolytic elimination, decarboxylative elimination. Ref. 1. Page No. 466-501 Ref.3, 4, 8, 9, 10 Relevant pages	**10**
6	**Aromaticity** Huckle's 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 (C_{60}) including NMR characteristics of aromatic systems. Ref. 3. Page No. 40-67 Ref. 5, 7, 9 Relevant pages	**06**

References:

1. Organic Chemistry, Staney H. Pine, Fifth edition,.
2. Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothes (Oxford).
3. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Jerry March, Fourth Edition.
4. A Guide Book to Reaction Mechanism in Organic Chemistry–Peter Sykes.
5. Advance Organic Chemistry (Part A and B), A. Carey and R.J. Sundberg.
6. Modern Methods of Organic Synthesis, W. Carruthers (Cambridge) .
7. Organic Chemistry: A Brief Course, Robert C. Atkins, Francis A Carey.
8. Organic Reactions & their Mechanisms- P. S. Kalsi.
9. Organic Chemistry- Morrison & Boyd.
10. Stereochemistry Conformations and Mechanism, P.S. Kalsi

Course Outcomes (CO):

After successful completion of the course students are expected to achieve

No.	CO	Cognitive level
1	Develop knowledge of substitution (electrophilic, nucleophilic) addition and elimination reactions	5
2	Differentiate between various organic reactive intermediates and their reactions	4
3	Students can understand the carbon-carbon multiple bonds and carbon heteroatom multiple bonds- Mechanism and stereochemical aspects	4
4	Differentiate between the concept of aromaticity and anti aromaticity	**4**

DSE-5

CH-416-A : Advanced Inorganic Chemistry-I

(60L, 100 Marks and 4 Credits)

Course Objectives:

1. The course helps to build up a conceptual framework for understanding the principles and theories for chemical bonding and properties of inorganic compounds.
2. The course helps to furnishes the basic concepts of group theory and its applications for various inorganic compounds
3. The course furnishes knowledge of Organometallic compounds of some important transition metals and their applications.
4. The course offers information lying on synthesis, structure, bonding, reactivity and properties of some selected non transition elements.
5. The course aims at providing a good understanding of metal cluster compounds with respect to their *synthesis, structure and properties etc.*

Unit No.	Name of the Unit	Lectures
1	**Molecular Orbital Theory** a) Molecular term symbol for homonuclear diatomic molecules - H_2, B_2, C_2, N_2, O_2 and F_2 molecules, b) Linear tri-atomic molecules - BeH_2, CO_2 c) Trigonal planar molecule- BF_3, d) Tetrahedral Molecule - CH_4, e) Trigonal pyramidal molecule -NH_3, f) Angular Tri-atomic molecules - H_2O, NO_2.	12
2	**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
3	**Organometallic compounds of transition metals** Organometallic compounds, molecule orbital theory and 18 electron rule, counting electrons in organometallic complexes, alkyl and aryl complexes, alkene complexes, Allyl and butadiene complexes, complexes containing delocalized cyclic system	12
4	**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
5	**Metal Clusters** Introduction, Metal clusters, Carbonyl clusters, Low nuclearity carbonyl clusters, High nuclearity carbonyl clusters (HNCC), Electron counting scheme of HNCC's, Halide type clusters	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 edition.
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 Ho use.
14. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, John Wiley & Sons, Inc.

Course Outcomes(CO):

After successful completion of the course students are expected to

No.	Course Outcomes (CO)	Cognitive level
1	On the basis of MOT Student should able a) to determine term symbols of elements of First and second row period homonuclear diatomic molecules b) to know structure, bonding (BMO, ABMO and NBMO), properties, MO electronic configuration and construction of MO energy level diagram various molecules.	**5**
2	Student should imagine molecules in 3 dimensions and a) to understand the concept of symmetry and able to pass various symmetry elements through the molecule b) to understand the concept of point group and apply it to molecules c) to understand product of symmetry operations.	**4**
3	Student should a) know and apply EAN rule to organometallic compounds. b) know alkyl and aryl complexes, alkene complexes, Allyl and butadiene complexes, complexes containing delocalized cyclic system (sandwich compounds) c) know catalytic reaction involving organometallic compounds and mechanism of these reactions	**5**

4	Student should understand a) Hydrides of P, Sb, As, etc b) Selenides, Tellurides. c) Synthesis, properties and structures of alkali and alkaline earth metal compounds d) synthesis and reactivity of inorganic polymer of Si and P.	**4**
5	Student should able to know a) Metal clusters b) Carbonyl clusters and their types (HNCC and LNCC), apply electron counting scheme to HNCC's c) Halide cluster.	**3**

DSE-5

CH-416-B : Advanced Analytical Chemistry-I

(60L, 100 Marks and 4 Credits)

Course Objectives:

1. This course covers both fundamental and practical aspects of chemical analysis.
2. The student will earn 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.	10
2	**Fluorescence and Phosphorescence** Fluorescence, Photoluminescent Theory, Electron Transitions During Photoluminescence, Factors That Affect Photoluminescence, Luminescent Apparatus, Optical Excitative Sources, Wavelength selectors, Cells, Detector and Readout, Photoluminescent spectra, Photoluminescent Analysis, Analysis of Nonluminescing Compounds, Determination of Mixtures, Phosphorescence.	10
3	**Voltammetry:** Excitation signals Linear-sweep Voltammetry- Voltammetric Instruments, Voltammetric Electrodes, Voltammograms, Hydrodynamic voltammetry, Voltammetric Detectors	10
4	**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, Determination of copper (constant current procedure)	10

5	**Ultra purity and ultra trace analysis:** Ultra purity and ultra trace analysis, laboratory dosing, purification of reagents, Preconcentration Techniques, contamination control during analytical operation.	**10**
6	**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.	**10**

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", 4thEd., CBS College, Publishing,NewYork.
4. Vogel's Text Book of Quantitative Chemical analysis (Sixth Edition) By-J. Mendham, R.C.Denny, J.D.Barnes, M.J.K.Thomas (Pearson Education-LowPriceEdition)

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**

RM-417 :Research Methodology for Sciences

M.Sc. Part-I: Semester-I

(60 L, 100 Marks and 4 Credits)

Course Objectives:

To make the students familiar with the,

CO-1. To learn the basics of science, scientific research its importance.

CO-2. To learn the Ethics and plagiarism precautions to be taken while doing research.

CO-3. To understand the detailed referencing and literature review procedure before beginning the research.

CO-4 To understand the process of writing research papers, research project report and research proposal.

CO-5 To learn various advanced tools useful for the science and aware about the laboratory safety.

Unit	Course Contents (Topics and subtopics)	Lecture
1	**Science and Scientific Research** What is Science? Characteristics of Science, Technology and techno-science, Meaning of Research, Characteristics and types of research, Importance of research activities, Principles of quality research work, Problems in research, Scientific attitude and temper, Qualities of good researcher, Scientific community, Non-science and Pseudoscience, Scientific realism.	12
	Ref. 1: 1-24 and 49-54; Ref. 2: 1-71; Ref. 3: 1-21.	
2	**Design and Criteria of Scientific Research** Introduction, Research planning and design, Selection of research topic, Criteria for good research problem, Source of research Idea, Principles of good research, Criteria of good research, Guidelines for research skill and awareness, Research validity and reliability, Arte fact and bias in research. **Scientific methodology:** Rules and principles of scientific methods, Research methods versus methodology, Hypothesis and testing of hypothesis. Research ethics: Principles and values. Plagiarism: its types and how to avoid it.	12
	Ref. 1: Pages: 1-24, 55-92 and 233-262; Ref. 3: 24-52.	
3	**Literature Survey** Literature review, Approaching the literature, Scholarly literature, Data	12

	provenance and evaluation, Intellectual property. **Sources of information:** Primary, Secondary, Tertiary sources, Patents, Journals (Print and e-journal),Type of Journals, Conference Proceedings. Journal Impact Factor, Citation index, *h*-index. **Understanding of literature:** Reading A Scientific Paper, Abstracts, Current titles, Reviews, Monographs, Books, Current contents, Cross referencing, Indian patent database. **Tools for Digital Literature Survey:** Scientific data bases, e-journals, INFLIBNET, Shod sindhu, Shodh ganga, Google/Google Scholar, Research Gate, PubMed, finding and citing Information.	
	Ref. 1: 148-180; Ref. 4: 299-317; Ref. 5: 1569-1603	
4	**Scientific Writing** Introduction to scientific writing, writing science laboratory Notebook. **Writing Research Paper:** Title, Abstracts, Keywords, Introduction, Material and Methods, Results and discussion, Conclusion, Acknowledgement, References and Supplementary data. Difference between research communication and Review article, Reply to Referee comments for science research paper. Preparation of Poster and Oral Presentation **Writing Proposals:** Research grant and its various components	**12**
	Ref. 1: 180-229; Ref. 6: 29-43; Ref. 7: Relevant Pages	
5	**Advanced Scientific Tools and Laboratory Safety** **A) Advanced Tools:** Tools for citing and referencing: Mendeley, Zotero, Endnote etc. **Styles of referencing:** Referencing from reputed publishing houses National and International. **Online searching Databases**: *SciFinder*, *Scopus*, *Web of Science*, *ACM Digital Library*, *ProQuest Biological Sciences (All the databases only introduction).* **B) Laboratory Safety** Laboratory safety, Laboratory manual, Lab as a safe place: habits, Cause of accidents and What to do in case of an accident, Personal protective	**12**

	equipment, Emergency equipment for general purpose. Laboratory ventilation. **C) Introduction to Intellectual Property** Introduction, Role of IP in the economic and cultural development of the Society, IP Governance, IP as a Global Indicator of Innovation, Origin of IP, History of IP in India (Introduction: Patents, Copyrights and Related Rights, Trademarks, Geographical Indications, Trade Secrets, Semiconductor Integrated Circuits and Layout Designs, Plant Varieties, Traditional Knowledge, Industrial Designs, Biodiversity Conservation). Categories of Intellectual Property, Conditions for Obtaining a Patent Protection.	
	Ref. 8, and9: Relevant Pages, Ref. 10: 1-44 and Relevant Pages **Ref. 11 onwards: Relevant Pages and Links**	
	References: 1. Research Methodology for Scientific Research, K. Prathapan, I.K. International Pvt. Ltd., New Delhi – 110002, (2019). 2. Research Methodology: The Aims, Practices and Ethics of Science, Peter Pruzan, Springer International Publishing (2016). 3. Research Methodology: Methods and Techniques, 3rd edition, Kothari, C.R. Published by New Age International (P) Ltd., Publishers (2004). 4. Teaching to Avoid Plagiarism How To Promote Good Source, Diane Pecorari, Use-Open University Press (2013). 5. APPENDIX A: The Literature of Organic Chemistry March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Seventh Edition, by Michael B. Smith and Jerry March Copyright John Wiley & Sons, Inc. (2013). 6. Joaquín Isac-García, José A. Dobado, Francisco G. Calvo-Flores, Henar Martínez-García - Experimental Organic Chemistry laboratory manual, Academic Press (2016) 7. A Practical Guide to Scientific Writing in Chemistry Scientific Papers, Research Grants and Book Proposals Tyowua, A. T., CRC Press is an imprint of Taylor & Francis Group, LLC (2023). 8. Chemical Information for Chemists: A Primer, edited by Currano, J. N., Roth, D. L. Publisher The Royal Society of Chemistry (2014). 9. Handbook of Safety in Science Laboratories Education Bureau Kowloon Tong Education Services Centre, Hong Kong (2013). 10. Intellectual Property A Primer for Academia,Tewari, R., Bhardwaj, M.Publication Bureau, Panjab University, Chandigarh, © Panjab University, Chandigarh, ISBN: 81-85322-92-9, (2021). 11. A Manual for Referencing Styles in Research, M. H. Alvi (2016)	

12. https://academic.oup.com/pages/authoring/books/preparing-your-manuscript/referencing-styles
13. https://revvitysignals.com/products/research/chemdraw
14. LaTeX Beginner's Guide, Stefan Kottwitz, Packt Publishing, http://static.latexstudio.net/wp-content/uploads/2015/03/LaTeX_Beginners_Guide.pdf
15. Falagas, M.E., Pitsouni, E.I., Malietzis, G.A. and Pappas, G. (2008), Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. The FASEB Journal, 22: 338-342. https://doi.org/10.1096/fj.07-9492LSF
16. Plagiarism, Citation and Referencing: Issues and Styles, A Manual for Referencing Styles in Research, Mohsin Hassan Alvi, DOI: 10.13140/RG.2.1.5149.6408 http://bit.ly/46nFwYi
17. Citation tools: Easing up the researchers' efforts, Dhiraj Kumar, Gyankosh: The Journal of Lib. & Info. Management Vol 4 No. 2 Jul-Dec, 2013
18. Citation Management:How to use citation managers such as EndNoteand Zotero.
URL:https://guides.lib.uchicago.edu/citationmanagement
19. https://pubs.acs.org/doi/full/10.1021/acsguide.40303
20. https://edu.rsc.org/resources/how-to-reference-using-the-rsc-style/1664.article
21. https://www.springer.com/gp/authors-editors/journal-author/journal-author-helpdesk/preparation/1276
22. https://service.elsevier.com/app/answers/detail/a_id/28224/supporthub/publishing/
23. EndNote: A comprehensive guide to the reference management software EndNote. URL: https://aut.ac.nz.libguides.com/endnote
24. Zotero: Learn how to use the reference management software Zotero. URL: https://aut.ac.nz.libguides.com/zotero
25. Mendeley: Learn how to use the reference management programme Mendeley. URL: https://aut.ac.nz.libguides.com/mendeley
26. Grammarly User Guide, https://bpb-ap se2.wpmucdn.com/blogs.auckland.ac.nz/dist/3/316/files/2020/02/Grammarly-Manual-Feb-2020-1.pdf
27. Online Resources: Publishers, Chemical Societies, Electronic Journals etc.: https://www-jmg.ch.cam.ac.uk/data/c2k/cj/
28. https://scholar.google.com/
29. https://shodhganga.inflibnet.ac.in/
30. https://patents.google.com/
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32. https://www.cas.org/about-us
33. https://clarivate.com/products/scientific-and-academic-

	research/research-discovery-and-workflow-solutions/webofscience-platform/ 34. https://www.mendeley.com/guides	
	Course Outcomes:	
	On completion of this course, the students will be able to: • Students will understand the basic concept of science and scientific research. • Learn and follow the ethical guidelines while doing research avoid plagiarism in research publications. • Able to write a comprehensive literature review on a given research topic. • To be able to write a crisp research proposal or research project independently. • To be learn most advanced chemistry tools for the efficient research work. • Acquire knowledge about various hazardous chemical handling procedures and implement it while working in the laboratory.	

DSC-26

CH-412 : Chemistry Practical-I

(Physical Chemistry Practical)

(60 Hrs., 50 Marks, 2 Credits, 4 hours per week)

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.
7. To understand the basic principles of different techniques used in laboratory analysis.
8. To provide hands on training on various techniques of analysis.
9. To make appropriate measurements, analyze the data and report the results.

Students should perform minimum of Twelve (12) experiments from Physical Chemistry Practical's

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 tri chloro acetic acid, mono chloro acetic acid and acetic acid in the given by conductometric titration against sodium hydroxide solution.
3. To determine the concentration of Fe^{2+} ions by titrating with potassium dichromate solution conductometrically.

Potentiometry

4. To determine the stability constant of a complex ion $[Ag_2(S_2O_3)]^{-3}$ potentiometrically.
5. To determine the activity coefficient of an electrolyte (HCl) by potentiometry.
6. To determine the transport number of Ag^+ and NO^{3-}ion.

pH metry

7. Determination of Hammett constant of a given substituted benzoic acid by pH measurements.
8. Determine the effect of KCl on the pH of HCl solution.

Chemical Kinetics

9. To determine the rate constant for depolymerization of diacetone alcohol catalysed by sodium hydroxide using dilatometer.
10. Study the kinetics of reaction between potassium persulphate & potassium iodide and determine the rate constant.
11. Study the kinetics of reaction between potassium persulphate& potassium iodide and Study the influence of ionic strength on the rate constant.
12. To determine energy of activation of the hydrolysis of methyl acetate in presence of hydrochloric acid (Calculations and graphs expected from excel programming)

Polarimetry

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

Other Non-instrumental experiments

15. Determined the transport number of H^+ and Cl^- ions by moving boundary method.
16. 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

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

References:

1. Findley's Practical Physical Chemistry (9th edition), Edited by B. P. Levitt (Longman Group Ltd).
2. Systematic Experimental Physical Chemistry (2nd edition), By S. W. Rajbhoj and Dr. T. K. Chondekar (Anjali Publication, Aurangabad).
3. Advanced Practical Physical Chemistry (26th edition), J. B. Yadav (Goel Publishing House, Meerut).
4. Experimental Physical Chemistry, V. D. Athawale, P. Mathur (New Age International Ltd, New Delhi)
5. Advanced Practical in Physical Chemistry (13th edition or latest), Dr. Pande, Dr. Mrs. Datar, Dr. Mrs Bhadane, Manali Publication, Pune.
6. University Practical Chemistry, P.C. Kamboj,Vishal Publishing Co.Jalandhar, Panjab.
7. Practical Physical Chemistry, A. M. Jamesand F.F.Prichard, Longman Group Ltd.
8. Advanced Physical Chemistry Experiments Dr. J. N. Gurtu and Amit Gurtu, Pragati Prakashan Meerut.
9. Experiments in Physical Chemistry For Postgraduate Students, Dr. Kumar, Dr. Rathnam, Dr. Nandini and Dr. Pawar Prashant Publications
10. A Text book of Quantitative Analysis, A. I. Vogel , 4th and 5th edition.
11. Advanced Practical Inorganic Chemistry, Gurdeep Raj Goel Publishing House.
12. Post Graduate Practical Chemistry (Part – 1), H.N. Patel, S.P. Turakhia, S.S. Kelkar, S. R. Puniyani, Himalaya Publishing House.
13. Applied Analytical Chemistry: Vermani.
14. University Practical Chemistry, P. C. Kamboj.

15. Commercial Methods of Analysis: Shell and Biffen.

Course Outcomes (CO): After successful completion of the course students are expected to

Sr. No.	Course Outcomes (CO)	Cognitive level
1.	Students enable to understand the use of various principles, instruments and techniques for various analysis.	**4**
2.	This practical course is designed to make student aware about various methods and analytical tools.	**5**
3.	Students understand the principle behind ore analysis, gravimetric and volumetric analysis.	**4**
4.	Students can analyze contents present in sample.	**4**
5.	Students able to handle various instruments and perform the instrumental analysis techniques.	**3**
6.	Students can apply their knowledge for development of experiment involves analysis and estimations.	**4**

DSC-28

CH-414: Chemistry Practical-II

(Organic Chemistry Practical)

(60 Hrs.,50 Marks and 2 Credits (4 hours per week))

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 understand the basic principles of different techniques used in laboratory analysis.
5. To provide hands on training on various techniques of analysis.
6. Develop the ability to analyze given samples.
7. To make appropriate measurements, analyze the data and report the results.

Students should perform minimum of Twelve (12) experiments from Organic Chemistry practical's

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)
• Behavior: 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 behavior will not be tolerated.

Single Stage Preparation Monitored by TLC (Minimum 7)

1. Acetophenone to Benzalacetophenone.
2. Resorcinol to 7-hydroxy, 4-methyl coumarin.
3. Camphor to Borneol.
4. Benzophenone to Benzhydrol.
5. Acetoacetic ester to Pyrazalone.
6. Paramino Benzoic Acid to Parachloro Benzoic Acid.
7. 2-methoxy naphthalene to 1- formyl-2-methoxy naphthalene.
8. Glycine to Benzoyl glycine.
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 3 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/steam distillation technique

3. Column Chromatography technique should be performed for any one of the above preparations
4. Purification by Sublimation Method
5. TLC technique for identification of two different compounds present in mixtures
6. Solvent extraction using Soxhlet extractor/separatory funnel

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
5. A Text Book of Quantitative Analysis, A. I. Vogel , 4^{th} and 5^{th} edition.
6. Advanced Practical Inorganic Chemistry By Gurdeep Raj Goel Publishing House.
7. Post Graduate Practical Chemistry (Part-1), H.N. Patel, S.P. Turakhia, S.S. Kelkar, S. R. Puniyani, Himalaya Publishing House.
8. Applied Analytical Chemistry: Vermani.
9. University Practical Chemistry, P. C. Kamboj.
10. Commercial Methods of Analysis: Shell and Biffen.

Course Outcomes (CO): After successful completion of the course students are expected to		
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.	Chromatography is an important biophysical technique that enables students for the separation, identification, and purification of the components of a mixture for qualitative and quantitative analysis.	**3**

DSC-29

CH-415: Chemistry Practical-III

(Inorganic Chemistry Practical)

(60 Hrs.,50 Marks and 2 Credits (4 hours per week))

Course Objectives: The practical course is designed

8. To make students aware of how to perform organic compounds in laboratory.
9. The course includes synthesis of some derivatives and organic compounds, which will help them while working in research laboratory in future.
10. This course will help them in industry or while doing research in medicinal chemistry for Drug development.
11. To understand the basic principles of different techniques used in laboratory analysis.
12. To provide hands on training on various techniques of analysis.
13. Develop the ability to analyze given samples.
14. To make appropriate measurements, analyze the data and report the results.

Students should perform minimum of Six (6) experiments from Inorganic Chemistry Practical Section and Six (6) experiments from Analytical Chemistry Section

Section-I: Inorganic Chemistry Practical
minimum Six (6) experiments

Analysis of ore (minimum three)

1. Estimation of silica from pyrolusite ore gravimetrically.
2. Estimation of manganese from pyrolusite ore volumetrically.
3. Estimation of copper volumetrically from hematite ore
4. Estimation of iron gravimetrically from hematite ore.

Analysis of Alloy (minimum two)

5. Determination of tin gravimetrically from solder alloy.
6. Determination of iron volumetrically from stainless steel alloy.
7. Determination of chromium gravimetrically from stainless steel alloy.
8. Determination of nickel gravimetrically from cupro-nickel alloy.
9. Determination of copper volumetrically from cupro-nickel alloy.

Sample Analysis (minimum one)

10. Bleaching powder for its available chlorine content by iodometric method..
11. Nycil powder for its Zn content complexometrically.

Section-II: Analytical Chemistry Practical
minimum of Six (6) experiments

Thermochemistry (minimum one salt)

1. Lattice energy of binary salt by heat of dissolution, systems such as $CaCl_2$, NaCl and KCl.
2. Determination of heat of neutralization of strong acid and strong base.

Chromatography (minimum two)

3. Determination of the R_f value of Pb, Cu, Cd ions by using paper chromatographic technique.
4. Determination of the R_f value of Fe, Al, Cr ions by using paper chromatographic technique.
5. Determination of the R_f value of Ba, Sr, Ca ions by using paper chromatographic technique.

Instrumental method of Analysis (minimum two)

6. To determine the strength of given mixture of carbonate and bicarbonate by pH metric method

7. Estimation of PO_4^{-3} from waste water by calibration curve method by colorimetry/ Spectrophotometry

8. Estimation of Manganese from steel by colorimetry/spectrophotometry method.

9. Simultaneous determination of Cr^{6+} and Mn^{7+} ions by colorimetry/spectrophotometry method

Instrumental method of Analysis (minimum one)

11. Estimation of Boric acid using NH_4OH by conductometric method.

12. To determine Ca in the given solution by flame photometrically, by calibration curve method.

15. Determination of p-nitrophenol by colorimetry.

16. Determination of Asprin in drug tablet by pH metry titration with NaOH.

Course Outcomes (CO): After successful completion of the course students are expected to		
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 given sample	**4**
4.	Students are able to synthesize and evaluate the complex and also able to determination of complex purity	**5**
5.	Chromatography is an important biophysical technique that enables students for the separation, identification, and purification of the components of a mixture for qualitative and quantitative analysis.	**3**

Semester-II

DSC-30
CH-421 : Advanced Physical Chemistry-II
(60 L,100 Marks and 4 Credits)

Course Objectives:

1. To get oriented towards the basic theory underlying the chemical bond
2. To orient and acquaint the PG students towards the advanced aspects of thermodynamics.
3. To evoke the fundamental concepts of IR, electronic and Raman spectroscopy and understand the advance concept involved in it.
4. To understand the different types of adsorption isotherms and underlying principles.

UnitNo.	Name of the Units	Lectures
1	**Chemical Bonding** Variation principle approximation, LCAO-MO treatment of 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, HMO theory and its application to ethylene and butadiene. **Ref. 2,3,4,5**	**12**
2	**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, 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:1, 5, 6, 7, 8**	**12**
3	**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 the irsymmetry (water molecule and carbondioxide molecule) and related numerical. **Ref:1, 5, 6, 8, 9**	**12**
4	**Raman and Electronic Spectroscopy** (a) 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. (b) Electronic spectroscopy: Electronic vibrational spectra, intensity of vibrational electronic spectra, Franck-Condon principle, rotational fine structure, Fortrat diagram, dissociation energy, pre-dissociation. **Ref:1, 5, 6, 8, 9**	**12**

5	**Surface Chemistry** Adsorption, Adsorption of gases by solid, Types of adsorption isotherm, Freundlich isotherm, Langmuir adsorption isotherm (derivation expected), BET theory, derivation of BET equation and its application to determine surface area of adsorbent, derivation of Gibbs adsorption isotherm **Ref:1, 5, 6, 8, 10**	**12**

References:

1. Atkins, P.W.(1998) Physical Chemistry, ELBS.
2. Donald McQuerry, Quantum Chemistry, Viva Books
3. R.K. Prasad, Quantum Chemistry, New Age International
4. I. Levine, Quantum Chemistry, Pearson Education
5. D.A. McQuerry & J.D. Simon, Physical Chemistry Molecular Approach, VivaBooks
6. G. M. Barrow,.(2003) Physical Chemistry, International Student Edition.
7. Moore, W.J.(1998) Physical Chemistry, Orient Longman.
8. B.R. Puri, L.R. Sharma and M.S. Pathania (2007) Principles of Physical Chemistry (42ndEdition), Vishal Publishing Co., Jalandhar.
9. C. N. Banwell and McCash, E. M. (1996) Fundamentals of Molecular Spectroscopy, McGraw Hill International (UK).
10. B.S. Bahl, A. Bahl, G.D. Tuli (2005) Essentials of Physical Chemistry, Chand and CoLtd., NewDelhi.
11. Dr. L. S. Patil, Physical Chemistry I, Shree Book Co. Mumbai
12. 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	Differentiate between the nature of chemical bond concept from MOT and VBT	**2**
2	Students will be able to apply the Approximate quantum methods for simple conjugated systems	**4**
3	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**
4	Students will be able to explain the mechanism of spectroscopic methods and solve the numerical problems related with it.	**4**
5	Students will be able to differentiate between adsorption isotherms, and how it is used for surface area calculation	**3**

DSC-32
CH-423 : Advanced 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, NMR, C^{13}NMR and Mass spectroscopy.

Unit No.	Name of the Units	Lectures
1	**Rearrangements:** Mechanisms of the following reactions with examples **Rearrangements to electron deficient carbon:** Pinacol-pinacolone, Wagner-Meerwein, Tiffeneau–Demjanov, Dienone–Phenol, Arndt-Eistert synthesis; **Rearrangements to electron deficient nitrogen:** Beckmann, Hofmann, Curtius, Schmidt and Lossen rearrangements; **Rearrangements to electron deficient oxygen:** Baeyer-Villiger, Hydro peroxide rearrangement and Dakin rearrangements; Neber rearrangement, Benzil-Benzilic acid and Favorskii rearrangements	10
2	**Selective Name Reactions:** Aldol Condensation, Mannich reaction, Knoevenagel reaction, Stobbe Condensation, Dieckmann Condensation, Benzoin Condensation, Reimer-Tiemann reaction, Reformatsky reaction, Darzens reaction, Michael reaction, Henry reaction, Perkin reaction, Shapiro reaction, Bomford-Steven's reaction, Nef reaction, Baylis Hilman reaction, Cannizaro reaction, Barton reaction, Hofmann Loffler-Freytag reaction, Vilsmeir-Haack reaction	10
3	**Reagents in Organic Synthesis:** **Oxidizing Agents:** General mechanism, selectivity, and important applications 1. Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ). 2. Oxidation of alcohols to aldehydes and ketones: chromium reagents such as $K_2Cr_2O_7/H_2SO_4$, CrO_3-pyridine (Collin's reagent), PCC (Corey's reagent) and PDC, hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation) and Oppenauer oxidation. 3. Oxidation involving C-C bonds cleavage: Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using ozone, $KMnO_4$, CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$. 4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH_2 to CO by SeO_2, Oxidation of aryl methanes by CrO_2Cl_2 (Etard oxidation). 5. Oxidation of aldehydes and ketones: with H_2O_2 (Dakin reaction), with peracid (Baeyer-Villiger oxidation).	10

4	**Reducing Agents:** General mechanism, selectivity, and important applications: 1. Reduction of CO to CH_2 in aldehydes and ketones - Clemmensen reduction, Wolff-Kishner reduction and Huang-Minlon modification. Ra-Ni desulfurization of thioketal 2. Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, Na $(OAc)_3BH$), aluminium reagents ($LiAlH_4$, DIBALH, Red Al, L and K selectrides). NH_2NH_2 (diimide reduction) and other non-metal-based agents including organic reducing agents (Hantzsch dihydropyridine). 3. Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes	**10**
5	**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, Racemic modification and racemization, optical purity, pro-stereoisomerism (Homomorphic, Homotopic, Heterotopic, enantiotropic, diastrophic-atoms, groups and faces), stereospecific and stereoselective reactions Conformational analysis of cyclic (cyclohexane, mono-substituted cyclohexane).	**10**
6	**Spectroscopy:** IR (Characteristic IR absorption of functional groups: Alkanes, alkenes, alkynes, alcohol, ethers, alkyl-halides, carbonyl compounds (-CHO, C=O, -COOR, -COOH), amines, amides and Aromatic Compounds) H^1 NMR (PMR: Fundamentals of PMR, factors affecting chemical shift, integration coupling (1^{st} order analysis). C^{13} NMR (chemical shift, chemical shift features of aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbon, factors affecting chemical shifts), Mass-molecular ion peak, isotopic peaks, base peak, spectral fragmentation of Organic compounds. 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),**	**10**

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. Nasi Puri – 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):

After successful completion of the course students are expected to achieve

No.	CO	Cognitive level
1	Students can understand various reactions and rearrangements	4
2	Understand and write mechanism of reactions and their applications	5
3	Understand how to convert one molecule into another molecule by using oxidising and reducing agents	4
4	Plan the fundamental organic reactions of significance for organic synthesis and design synthesis of organic molecules.	4
5	Apply theoretical knowledge in practical's for various conversions	**5**
6	Understand the concept of stereochemistry and will able to write stereo chemical aspects inorganic chemistry	**4**
7	To know how to solve problems based on H1 and C13 NMR	**4**

DSE-6

CH-426-A: Advanced Inorganic Chemistry-II

(60L,100 Marks and 4Credits)

Course Objectives:

1. This course provides detailed information of ionic solids, examples with their structures and calculation of radius ratio w. r. t. C. N. 3, 4, 6.
2. This course offers to impart the basic knowledge about spectroscopy of inorganic compounds.
3. This course also offers to study the reaction mechanism in transition metal complexes.
4. This course helps to understand catalysis and structure reactivity of molecules.
5. This course provides methods of Preparation of Complexes and their Application

Unit No.	Name ofthe Unit	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 AX2 (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 B12)	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 edition.
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. 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.

Course Outcomes (CO):

After successful completion of the course students are expected to

No.	CO	Cognitive level
1	Students should a) Know the nature of solids b) Know the crystal structures of solids. c) Draw the simple cubic, BCC and FCC structures d) Identify the C.N. of an ion in ionic solid. e) Identify the type of void f) Know the effect of radius ratio in determining the crystal structure g) radius ratio rules for calculation of C. N. 3, 4, 6. h) able to solve simple problems based on Pauling's univalent radii and crystal radii to identify structure of inorganic solid.	**4**
2	Student should a) derive term symbols using vectors of spin and orbital angular momentum b) determine the number of microstates and meaningful term symbols, able to construction of microstate table for various electronic configuration. c) know Hund's rules for arranging the terms symbols on the basis of their energies. d) knowledge of the hole formalism for information about the configuration pairs e) know Laporte 'orbital' selection rule and spin selection rule f) able to convert term/state symbol to Mulliken state symbol for construction Orgel diagram. g) Interpret of electronic spectra for transition metal complexes using Orgel diagram.	**5**
3	Student should a) know types of reactions mechanisms in coordination compounds- dissociative, interchange, associative, b) know inert and labile complexes c) get detailed information of substitution reactions in	**4**

	coordination complexes and their mechanism d) know stereochemistry of reaction e) get knowledge about kinetics of reactions.	
4	Students should gain knowledge about a) Catalyst- types and properties, b) catalysis and catalytic steps in homogeneous catalysis c) Types of reaction involving organometallic compounds	**4**
5	Students should know a) method of Preparation of complexes b) Application of complexes in various fields - analytical chemistry, complexometric titration, metallurgy, industry, medical field. c) study of metal complexes in biological system- Haemoglobin, Chlorophyll, Vitamin B12)	**3**

DSE-6

CH-426-B : Industrial Safety and Good Laboratory Practices

(60L,100 Marks and 4Credits)

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 jewellery, proper responsible attitude, good housekeeping, use of proper PPE, no food in the laboratories.	**10**
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.	**10**
3	**Introduction to Industrial Safety** Types of fire extinguishers and their method of use, Material Safety DataSheets (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).	**10**
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.	**10**

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.	**10**
6	**Function of Pharmaceutical Industry Department** **Basic functions of Research and Development** Introduction and Summary, Role of Research andDevelopment in industry, Trends in R&D Spending andOutput of New Drugs, Modifications and Approved New Usesof Drugs, Innovation Models in Pharmaceutical R&D. **Basic functions of Production** Scope and objective, SOP, Responsibility of production department, process involved in chemical product, Drug development in the pharmaceutical industry, Hazardous industrial chemicals and Drug-related substances. **Basic functions of Q. C. in industry** Principle, Quality Relationship: Differences between QC and QA, Basic Principles of Good Quality Control Laboratory Practices,Equipment Material, Documentation, Sampling, Testing, On-going Stability Programme, Contract Analysis	**10**

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**

DSC-31

CH-422 : Chemistry Practical-IV

(Physical Chemistry Practical)

(60 Hrs., 50 Marks and 2 Credits, 4 hours per week)

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 Twelve (12) experiments from Physical Chemistry Practical's

INSTRUMENTAL

Conductometry

1. Determine the solubility of sparingly soluble salt ($BaSO_4$) at different temperatures conductometrically and determination of ΔG, ΔH and ΔS of the solution.
2. Study the second order velocity constant of hydrolysis of ethyl acetate by sodium hydroxide using conductance measurement.
3. Determination of critical micellar concentration (CMC) of sodium lauryl sulphate from the measurement of conductivities at different concentrations.

Potentiometry

4. To determine standard free energy change ΔG^0 and equilibrium constant for the reaction $Cu+2Ag^+ \square Cu^{2+}+2Ag$ potentiometrically.
5. 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.
6. To titrate ferrous ammonium sulphate solution with potassium dichromate solution potentiometrically using bimetallic electrode pair.

pHmetry

7. To determine the three dissociation constants of polybasic acid such as H_3PO_4 by pH measurements.
8. To determine acidic and basic dissociation constant of amino acid and the iso-electric point of the acid.

Colorimetry / Spectrophotometry

9. To determine the pKa and Ka of given indicator by colorimetry /spectrophotometry
10. Determine the amount of Cu(II) and Fe(III) in a mixture by titrating it against standard EDTA solution spectrophotometrically.
11. Determination of iron in water using a colorimeter.
12. Simultaneous determination of Co^{2+} and Ni^{2+} in the solution by spectrophotometry.

Refractometry

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

Other Non-instrumental experiments

14. Investigate the adsorption of acetic acid in aqueous solution by using activated charcoal and verify Freundlich's adsorption isotherm.
15. Determination of partial molar volume of ethanol in dilute aqueous solutions.
16. To obtain solubility curve for liquid say water-acetic acid-chloroform system

References:

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

Course Outcomes (CO): After successful completion of the course students are expected to

Sr. No.	Course Outcomes (CO)	Cognitive level
1.	Students enable to understand the use of various principles, instruments and techniques for various analysis.	**4**
2.	This practical course is designed to make student aware about various methods and analytical tools.	**5**
3.	Students understand the principle behind Complexometric, Quantitative and Spectroscopic estimation of various compounds.	**4**
4.	Students can analyze contents present in sample.	**4**
5.	Students able to handle various instruments and perform the instrumental analysis techniques.	**3**
6.	Students can apply their knowledge for development of experiment involves analysis and estimations.	**4**

DSC-33

CH-424 : Chemistry Practical-V

(Organic Chemistry Practical)

(60 Hrs.,50 Marks, 2 Credits, 4 hours per week)

Course Objectives: The practical course is designed

1. To make student aware of green chemistry and role of green chemistry in pollution reduction and pollution control.
2. The students learn how to avoid solvents and do solvent free reaction.
3. Also, the work-up procedure in many experiments is made more eco-friendly to environment.

Students should perform minimum of Twelve (12) experiments from Organic Chemistry

Use of Chemistry software's like, ISI Draw, Chem Draw, Chem Sketch (Mandatory)

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

Preparation of Derivatives: (Minimum 3)

1. Acetyl
2. Benzoyl
3. Semi carbazone,
4. Amide
5. Aryloxy acetic acid,
6. Ester
7. Oxime

Green Chemistry Preparations (Minimum 7)

1. Bromination of acetanilide using Ceric ammonium nitrate.
2. Preparation of Benzylic Acid using NaOH /KOH under Solvent-free Conditions.
3. Photo reduction of benzophenone to benzo pinacol 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 1H-NMR spectrum of above synthesized compounds. (Minimum 2 Compounds) (Mandatory)

Course Outcomes (CO): After successful completion of the course students are expected to		
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 use of chemistry software's like, ISI Draw, Chem Draw, Chem Sketch.	

4.	Students able to perform purification techniques in organic chemistry like recrystallization, distillation, steam distillation and extraction	**3**
5.	Students will understand the importance of green chemistry.	**2**
6.	Students will understand and analysis various UV, FT-IR and 1H-NMR spectrum spectra	
7.	Students able to apply their knowledge for binary mixture separation of inorganic compounds using quantitative analysis	**3**
8.	Students can analyze contents present in given sample	**4**

DSC-34

CH-425 : Chemistry Practical-VI

(Inorganic Chemistry Practical)

(60 Hrs., 50 Marks, 2 Credits, 4 hours per week)

Course Objectives: The practical course is designed

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.

Students should perform minimum of Six (6) experiments from Inorganic Chemistry Practical Section and Six (6) experiments from Analytical Chemistry Section

Section-I: Inorganic Chemistry Practical
minimum of Six (6) experiments

Analysis of binary mixture volumetrically and gravimetrically ((minimum two)

1. Nickel-Zinc

2. Copper – Magnesium

3. Copper- Zinc

4. Iron-Magnesium

Sample Analysis ((minimum one)

5. Analysis of Calcium from milk powder.

6. Analysis of Phosphate (PO_4^{3-}) from Fertilizer.

7. Determination of iron from given drug sample

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

8. Preparation of Potassium trioxalatoferrate (III), $K_3[Fe(C_2O_4)_3]$.

9. Tris(acetylacetonato)iron(III) acetylacetonate, $[Fe(acac)_3]$.

10. Potassium di aqua bis(oxalato) chromate (III)

11. Prussian Blue (Potassium Ferric Ferro cyanide)

12. Chloro penta aminocobalt(III) chloride

Section-II: Analytical Chemistry Practical
minimum of Six (6) experiments

Complexometric estimations (minimum one)

1.Estimation of Ca-Mg in the given mixture solution of both by titration with EDTA
2.Estimation of Zn-Mg in the given mixture solution of both by titration with EDTA

Quantitative estimations (minimum three)

3. Estimation of the percentage or number of hydroxyl groups in an organic compound by acetylation method.
1. Estimation of the percentage or number of amines by using acetylation method
2. Estimation of the percentage or number of amines by using bromate-bromide solution method
3. Estimation of phenols using bromate-bromide solution method
4. Determination of iodine value of an oil sample
5. Determination of saponification values of an oil sample.
6. Determination of Dissolved Oxygen (DO) in water sample.
7. Determination of Biological Oxygen Demand (BOD) in water sample.
8. Determination of Chemical Oxygen Demand (COD) in water sample.

Spectroscopic estimations (minimum one)

9. Amino acids
10. Carbohydrates
11. Proteins
12. Ascorbic acid
13. Aspirin from in drug sample/APC tablets
14. Cholesterol from blood sample

Non instrumental (minimum one)

1. Determination of available chlorine in bleaching powder by Bunsen method.
2. Determination of copper in fungicide.
3. Estimation of ascorbic acid by cerric ammonium sulphate method.
4. Estimation of lactose in milk by iodometry.

Course Outcomes (CO): After successful completion of the course students are expected to		
	Students understand the important of safety techniques and handling of chemicals	**2**
	Students are made aware of carrying out different types of reactions and their workup methods	**2**
	Students able to apply their knowledge for binary mixture separation of inorganic compounds using quantitative analysis	**3**
	Students can analyze contents present in given sample	**4**
	Students are able to synthesize and evaluate the complex and also able to determination of complex purity	**5**
	Chromatography is an important biophysical technique that enables students for the separation, identification, and purification of the components of a mixture for qualitative and quantitative analysis.	**3**

OJT or Int

CH-427 : On Job Training or Internship

(60 Hrs., 100 Marks, 4 Credits, 8 hours per week)

Students needs to complete one month on job training (OJT) or Internship (Int.) in any industry related to major subject.