

NATIONAL EDUCATION POLICY-2020

DSC/DSE/GE COURSES SYLLABUS FOR FOUR YEAR UNDERGRADUATE PROGRAMME (FYUP)/HONOUR'S/MASTER'S PROGRAMME IN CHEMISTRY

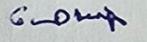
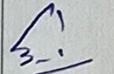
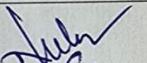
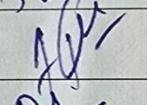
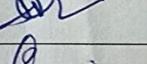
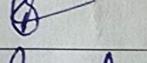
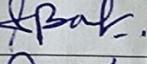
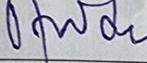
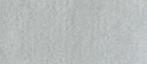
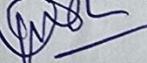


DEPARTMENT OF CHEMISTRY

**SRIDEV SUMAN UTTARAKHAND UNIVERSITY,
BADSHAHI THAUL, TEHRI, UTTARAKHAND**

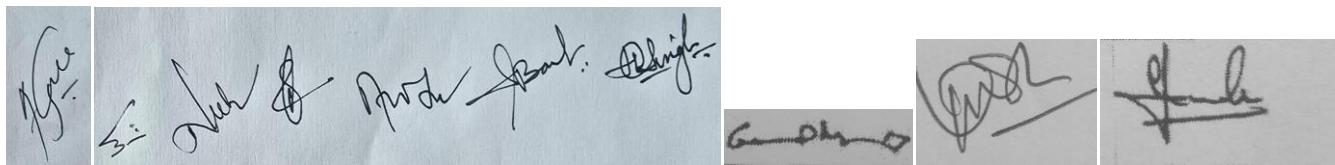
2025-26

DEPARMENT OF CHEMISTRUY
SDSU V BHADSHITHOUL TEHRI GARHWAL
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Internal Members				
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National Education Policy-2020
Common Minimum Syllabus for all Uttarakhand State Universities/ Colleges
SUBJECT: CHEMISTRY

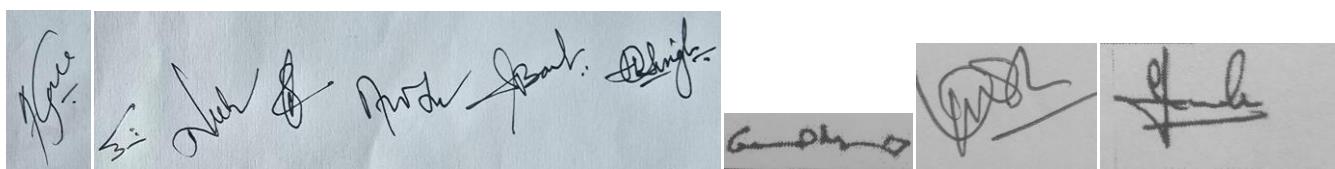
Multidisciplinary Courses of Study [Three core Disciplines]							Value Addition Course (VAC)	Total Credits	
Semester	Core (DSC)	Elective (DSE)	Generic Elective (GE)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Apprenticeship/ Project			
I	Discipline A1-(4)		Choose one from a pool of courses GE-1(4)	Choose one from a pool of AEC courses (2)	Choose one from a pool of courses (2)		Choose one from a pool of courses (2)	22 credits	
	Discipline B1-(4)								
	Discipline C1-(4)								
II	Discipline A2-(4)		Choose one from a pool of courses GE-2(4)	Choose one from a pool of AEC courses (2)	Choose one from a pool of courses (2)		Choose one from a pool of courses (2)	22 credits	
	Discipline B2-(4)								
	Discipline C2-(4)								
	Students on exit shall awarded Undergraduate Certificate (in the field of Multidisciplinary Study) after securing the requisite 44 credits in Semester I and II							Total=44 credits	
III	Discipline A3-(4)		Choose from pool of courses DSE A/B/C (4) OR Choose from pool of course GE-3(4)	Choose one from a pool of AEC courses (2)	Choose one SEC (2)		Choose one from a pool of courses (2)	22 credits	
	Discipline B3-(4)								
	Discipline C3-(4)								
IV	Discipline A4-(4)		Choose from pool of courses DSE A/B/C (4) OR Choose from pool of course GE-4(4)	Choose one from a pool of AEC courses (2)	Choose one SEC (2)		Choose one from a pool of courses (2)	22 credits	
	Discipline B4-(4)								
	Discipline C4-(4)								
	Students on exit shall awarded Undergraduate Diploma (in the field of Multidisciplinary Study) after securing the requisite 88 credits in Semester III and IV							Total=88 credits	
V /Third Year	Discipline A5-(4)		Choose from pool of courses DSE A/B/C (4) OR Choose from pool of course GE-5(4)		Choose one SEC (2)	Internship/ Apprenticeship/ Project/ Community outreach / Field Work(4)		22 credits	
	Discipline B5-(4)								
	Discipline C5-(4)								
VI/ Third Year	Discipline A6-(4)		Choose from pool of courses DSE A/B/C (4) OR Choose from pool of course GE-6(4)		Choose one SEC (2)	Internship/ Apprenticeship/ Project/ Community outreach / Field Work(4)		22 credits	
	Discipline B6-(4)								
	Discipline C6-(4)								
	Students on exit shall awarded Bachelor (in the field of Multidisciplinary Study) after securing the requisite 132 credits in Semester V and VI							Total=132 credits	
VII	DSC-(4)	Choose three DSE(3x4) Courses OR Choose two DSE(2x4) and one GE (4) Course OR Choose one DSE (4) and two GE(2x4) Course (Total = 12)					Dissertation on Major (4+2) OR Dissertation on Minor (4+2) OR Academic Project/ Entrepreneurship	22 Credits	
VIII	DSC-(4)	Choose three DSE(3x4) Courses					Dissertation on	22 Credits	



		OR Choose two DSE(2x4) and one GE (4) Course OR Choose one DSE (4) and two GE(2x4) Course (Total = 12)				Major (4+2) OR Dissertation on Minor (4+2) OR Academic Project/ Entrepreneurshi p	
Students on exit shall be awarded Bachelor of (in the field of Multidisciplinary Study) (Honours or Honours with Academic Projects/Entrepreneurship) after securing the requisite 176 credits on completion of Semester VIII							Total= 176
OR		If a student opts for a two-year PG Program, the have the option to obtain a PG diploma in the Core Subject upon earning 44 credits at the conclusion of the second semester of the PG program.					
IX	DSC-(4)	Choose three DSE(3x4) Courses OR Choose two DSE(2x4) and one GE (4) Course OR Choose one DSE (4) and two GE(2x4) Course (Total = 12)				Dissertation on Major (4+2) OR Dissertation on Minor (4+2) OR Academic Project/ Entrepreneurshi p	22 Credits
X	DSC-(4)	Choose three DSE(3x4) Courses OR Choose two DSE(2x4) and one GE (4) Course OR Choose one DSE (4) and two GE(2x4) Course (Total = 12)				Dissertation on Major (4+2) OR Dissertation on Minor (4+2) OR Academic Project/ Entrepreneurshi p	22 Credits
Students on exit shall be Master's in Core Subject after securing the requisite 220 credits on completion of Semester X							Total= 220

Contents

List of Papers (DSC,DSE,GE, SEC) with Semester Wise Titles for ‘Chemistry’
Programme Specific Outcomes (PSOs) (UndergraduateProgramme)
Programme Specific Outcomes (PSOs) (Honours Degree)
Programme Specific Outcomes (PSOs) (Master’s in Chemistry)
Semester-I
DSC 1-Course Title: Fundamentals of Chemistry-I.....
GE 1-Course Title:Basics of Chemistry- I.....
Semester-II.....
DSC 2-Course Title: Fundamental of Chemistry-II.....
GE 2-Course Title: Basics of Chemistry- II.....
Semester-III
DSC 3-Course Title: General Chemistry-I.....
DSE 3-Course Title: Environmental Chemistry
GE 3-Course Title: Basics of Chemistry-III
Semester-IV
DSC 4-Course Title: General Chemistry-II
DSE 4-Course Title: Chemistry of Biomolecules
GE 4-Course Title: Basics of Chemistry-IV
Semester-V
DSC 5-Course Title: Inorganic & Organic Chemistry
DSE 5-CourseTitle: Analytical Methods in Chemistry.....
GE 5-Course Title: Basics of Chemistry-V
Semester-VI
DSC 6-Course Title: Physical & Analytical Chemistry
DSE 6-Course Title: General Analytical Techniques
GE 6-Course Title: Basics of Chemistry- VI
Semester-VII
DSC 7-Course Title: Advanced Chemistry I
DSE 7A-Course Title: Advanced Inorganic Chemistry
DSE 7B-Course Title: Advanced Organic Chemistry
DSE 7C-Course Title: Advanced Physical Chemistry.....



GE 7A-Course Title: Biology for Chemists
 GE 7B-Course Title: Mathematics for Chemists
 Course Title: Dissertation.....

Semester-VIII.....

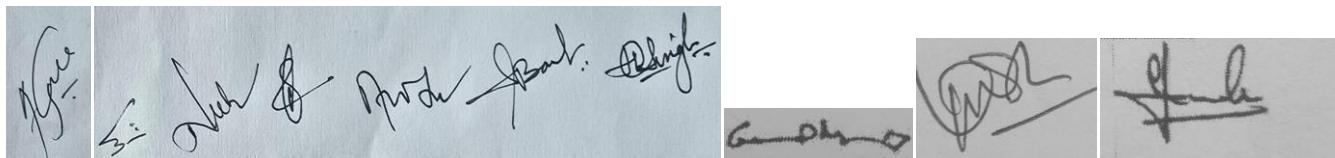
DSC 8-Course Title: Advanced Chemistry II
 DSE 8A-Course Title: Pericyclic Reactions and Photochemistry
 DSE 8B-Course Title: Spectroscopic Techniques.....
 DSE 8C-Course Title: Chemistry of Biological Systems
 GE 8A-Course Title: Solid State Chemistry and Supramolecular Chemistry
 GE 8B-Course Title: Analytical and Separation Techniques
 Course Title: Dissertation

Semester-IX

DSC 9-Course Title: Advanced Spectroscopic Techniques I.....
 DSE 9A-Course Title: Applied Photochemistry and Nuclear Chemistry
 DSE 9B-Course Title: Organic Synthesis
 DSE 9C-Course Title: Advanced Chromatography
 GE 9A-Course Title: Basic Physical Chemistry and Industrial Chemistry.....
 GE 9B-Course Title: Computer for Chemists
 GE 9C-Course Title: Essentials of Medicinal and Aromatic Plant Science
 Course Title: Dissertation

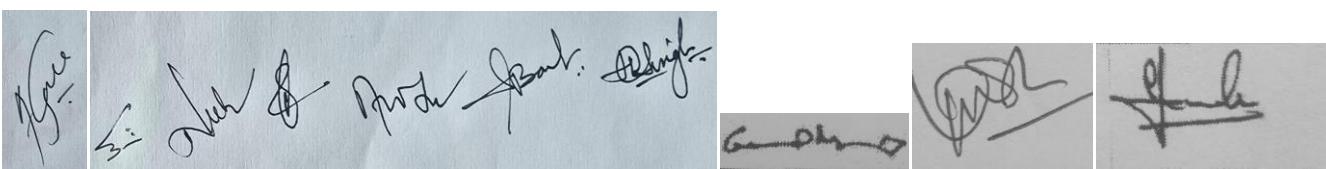
Semester-X.....

DSC 10-Course Title: Advanced Spectroscopic Techniques II
 DSE 10A-Course Title: Organometallic Chemistry.....
 DSE 10B-Course Title: Metal Ligand Bonding and Polymer Chemistry.....
 DSE 10C-Course Title: Photo Inorganic Chemistry
 DSE 10D-Course Title: Heterocyclic Chemistry
 DSE 10E-Course Title: Chemistry of Natural Products.....
 DSE 10F-Course Title: Medicinal Chemistry
 DSE 10G-Course Title: Advanced Chemical Dynamics and Statistical Thermodynamics
 DSE 10H-Course Title: Molecular Orbital Theory and Quantum Mechanics
 DSE 10I-Course Title: Radio and Electroanalytical Techniques
 GE 10A-Course Title: Corrosion, Energy and Polymers
 GE 10B-Course Title: Metallurgy and Inorganic Materials.....
 GE 10C-Course Title: Environmental Chemistry.....
 Course Title: Dissertation.....



List of Papers (DSC, DSE, GE) with Semester Wise Titles for 'Chemsirty'
7

Year	Semester	Course	Paper Title	Theory/Practical	Credits
Undergraduate Certificate in Chemistry					
FIRST YEAR	I	DSC 1	Fundamentals of Chemistry-I Chemical Analysis-I	Theory Practical	3 1
		GE 1	Basics of Chemistry- I	Theory	4
		DSC 2	Fundamentals of Chemistry-II Chemical Analysis-II	Theory Practical	3 1
	II	GE 2	Basics of Chemistry- II	Theory	4
		Undergraduate Diplomain Chemistry			
SECOND YEAR	III	DSC 3	GeneralChemistry-I Chemical Analysis-III	Theory Practical	3 1
		DSE 3	Environmental Chemistry	Theory	4
		GE 3	Basics of Chemistry- III	Theory	4
		DSC 4	General Chemistry-II Chemical Analysis-IV	Theory Practical	3 1
	IV	DSE 4	Chemistry of Biomolecules	Theory	4
		GE 4	Basics of Chemistry- IV	Theory	4
		Bachelor of Chemistry			
		DSC 5	Inorganic & Organic Chemistry Chemical Analysis-V	Theory Practical	3 1
THIRD YEAR	V	DSE 5	Analytical Methods in Chemistry	Theory	4
		GE 5	Basics of Chemistry- V	Theory	4
		DSC 6	Physical & Analytical Chemistry Chemical Analysis-VI	Theory Practical	3 1
		DSE 6	General Analytical Techniques	Theory	4
		GE 6	Basics of Chemistry- VI	Theory	4
	Bachelor of Chemistry with Honours				
	VII	DSC 7	Advanced Chemistry I Advanced Experiment Chemistry- I	Theory Practical	3 1
		DSE 7A	Advanced Inorganic Chemistry	Theory	4
		DSE 7B	Advanced Organic Chemistry	Theory	4
		DSE 7C	Advanced Physical Chemistry	Theory	4
		GE 7A	Biology for Chemists	Theory	4
		GE 7B	Mathematics for Chemists	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR AcademicProject/Entrepreneurship	Theory/ Practical	6
FOURTH YEAR	VIII	DSC 8	Advanced Chemistry II Advanced Experiment Chemistry-II	Theory Practical	3 1
		DSE 8A	Pericyclic Reactions and Photochemistry	Theory	4



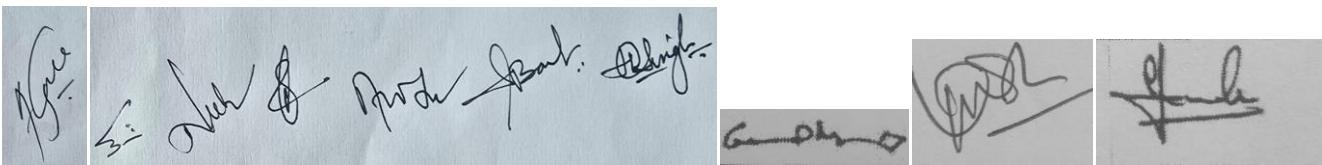
		DSE 8B	Spectroscopic Techniques	Theory	4
		DSE 8C	Chemistry of Biological Systems	Theory	4
		GE 8A	SolidState Chemistry and Supramolecular Chemistry	Theory	4
		GE 8B	Analytical and Separation Techniques	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR Academic Project/Entrepreneurship	Theory/Practical	6

Master's in Chemistry

FIFTH YEAR	IX	DSC 9	Advanced Spectroscopic Techniques I	Theory	3
			Advanced Experimental Chemistry-III	Practical	1
		DSE 9A	Applied Photochemistry and Nuclear Chemistry	Theory	4
		DSE 9B	Organic Synthesis	Theory	4
		DSE 9C	Advanced Chromatography	Theory	4
		GE 9A	Basic Physical Chemistry and Industrial Chemistry	Theory	4
		GE 9B	Computer for Chemists	Theory	4
		GE 9C	Essentials of Medicinal and Aromatic Plant Science	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR Academic Project/Entrepreneurship	Theory/Practical	6
	X	DSC 10	Advanced Spectroscopic Techniques II	Theory	3
			Advanced Experimental Chemistry-IV	Practical	1
		DSE 10A	Organometallic Chemistry	Theory	4
		DSE 10B	Metal Ligand Bonding and Polymer Chemistry	Theory	4
		DSE 10C	Photo Inorganic Chemistry	Theory	4
		DSE 10D	Heterocyclic Chemistry	Theory	4
		DSE 10E	Chemistry of Natural Products	Theory	4
		DSE 10F	Medicinal Chemistry	Theory	4
		DSE 10G	Advanced Chemical Dynamics and Statistical Thermodynamics	Theory	4
		DSE 10H	Molecular Orbital Theory and Quantum Mechanics	Theory	4
		DSE 10I	Radio and Electroanalytical Techniques	Theory	4
		GE 10A	Corrosion, Energy and Polymers	Theory	4
		GE 10B	Metallurgy and Inorganic Materials	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR Academic Project/Entrepreneurship	Theory/Practical	6

Abbreviations-

DSC-Discipline Specific Course; **DSE**- Discipline Specific Electives; **GE**-Generic Electives



Pattern of examination

A. Theory

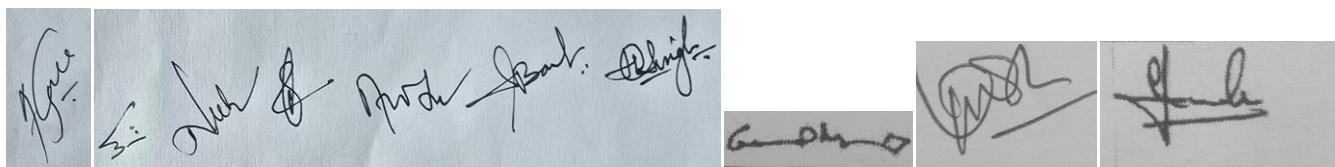
Each theory paper shall be of 03 hours and will consist of two sections, A and B. Section A: (Short answers type with reasoning); 40% of the total marks (30 marks, eight questions of six marks each, any five have to be attempted). Section B: (Long answers type); 60 % of the total marks, (45 marks, three questions out of five have to be attempted. Each question carries 15 marks).

B. Internal assessment

For each theory paper, an internal assignment (in the form of class test and or assignments including classroom attendance-05 marks) of 25 marks for each paper shall be conducted during each semester. The evaluated answer sheets/assignments have to be submitted to the Head of the Department/ Principal along with one copy of award list. The marks obtained have to be uploaded onto the University examination portal and the print out of the award list from portal have to be submitted to the Controller Examination.

C. Practical

The practical work of the students has to be evaluated periodically. The internal assessments (in the form of lab test, lab record, internal evaluation, assignment/home assignment and attendance) of total 25 marks for each semester shall be conducted during the semester. In each semester, practical examination of 75 marks has to be conducted by two examiners (External and internal) having duration of one day (6 Hours) for UG (3 year Degree) course and two days (time 6 hours each day) for PG course. The external examiner will examine the students only on the second day of examination. The total number of students to be examined per batch should not be more than sixty. One copy of award list of the practical examination along with attendance has to be submitted to the Head of the Department/ Principal. The marks obtained have to be uploaded onto the University examination portal and the print out of the award list from portal have to be submitted to the Controller Examination.

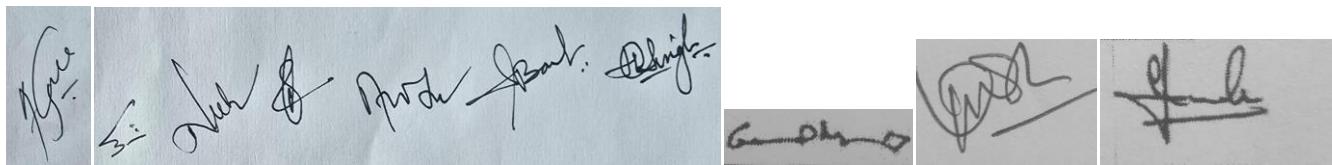


Programme Specific Outcomes (PSOs) (Undergraduate Programme)	
After this programme, the learners will be able to:	
PSO1	Basic knowledge of all the fundamental principles of chemistry like atomic structure, molecular polarity.
PSO2	Develop an understanding of bonding theories of different molecules, resonance concept, hyperconjugation, field effects, periodic properties of more than 111 elements, mechanism of organic reactions, stereochemistry.
PSO3	Acquire Knowledge about detailed study of states of matter including kinetic theories of gases, solid and liquid states, chemistry of aliphatic and aromatic compounds, chemical kinetics, its scope and first law of thermodynamics.
PSO4	Able to understand the qualitative and quantitative chemical analysis of the compounds in the laboratory.
PSO5	Acquire specialized knowledge about handling chemicals, apparatus, equipment and instruments.
PSO6	Acquire knowledge about second law of thermodynamics, chemical equilibrium, phase equilibrium, electrochemistry.
PSO7	Able to understand coordination chemistry, acid-base theories, chemistry of transition elements, halides, alcohols, phenols, aldehydes, ketones and carboxylic acids.
PSO8	Enhance the skill of the students regarding chemical and physical tests of inorganic as well as organic compounds along with some physical experiments
PSO9	Develop understanding about chemistry of nitrogen containing compounds, organometallic, lipids, fats, dyes, reagents in organic synthesis, carbohydrates, proteins, biomolecules, data analysis, nano-chemistry, green chemistry.
PSO10	Students will be able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments.

Yours
S. W. & Ruth Frank. Phillips

Programme Specific Outcomes (PSOs) (Honours Degree)
After this programme the learners will be able to:

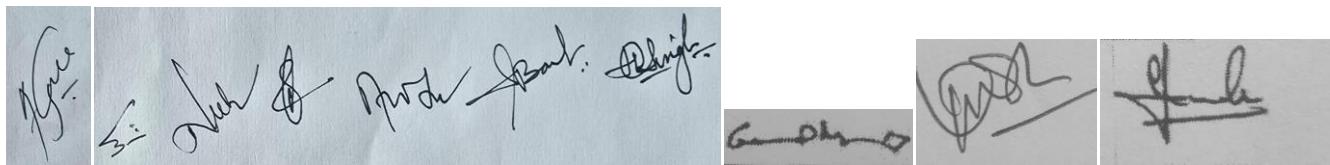
PSO1	Understand the stereochemistry and bonding in main group compounds. Acquire knowledge about substitution reactions and reaction mechanism of octahedral complexes. Understand the electronic spectra of transition metal complexes and cluster compound.
PSO2	Students will acquire practical knowledge about inorganic, organic and physical chemistry experiments.
PSO3	Understand all the concepts of symmetry and group theory. Will also be able to master X-ray and electron diffraction.
PSO4	Understand pericyclic reactions, their classification and mechanism. Also knowledge about basics of photochemistry along with photochemistry of organic compounds would be gained.
PSO5	Learn and appreciate the concepts from basic quantum to advanced quantum chemistry and their applications.
PSO6	Gain knowledge about the functions and significance of cell. Master the concepts of mathematical functions, differentiation, integrations and other fundamental mathematics that is involved in chemistry.
PSO7	Understand stereochemistry, reaction intermediate, reaction mechanism and its applications.
PSO8	Acquire knowledge and skills in inorganic, organic synthesis and experimentally verify different adsorption isotherm.
PSO9	Get knowledge of bio inorganic, bioorganic and biophysical chemistry.
PSO10	Understand metal ligand bonding, inorganic polymer chemistry and polymer characterization techniques.
PSO11	Masters the basics of solid-state chemistry. Understand the synthesis and applications of organic solids.
PSO12	Acquire knowledge in basic physical and industrial chemistry.
PSO13	Understand the chemical processes taking place in environment and chemistry of toxic chemical and pollutant.



Programme Specific Outcomes (PSOs) -Master's in Chemistry

After this programme, the learner will be able to:

PSO1	Acquire knowledge thermodynamics, polymer and surface chemistry. Acquire the practical knowledge in quantitative analysis of binary mixture and learn multistep preparation in organic chemistry.
PSO2	Master advanced nuclear chemistry along with learning the applications of photochemistry.
PSO3	Understand the use of reagents in organic synthesis. Apply disconnection approach and protecting groups in organic synthesis.
PSO4	Learn the principles involved in Chromatography along with their applications.
PSO5	Understand history of computers, software and their types. Understand extraction techniques, cultivation, processing and therapeutic potential of medicinal plants.
PSO6	Understand the principle and application of various spectroscopies. Through practical gain knowledge in inorganic, organic and physical chemistry experiment.
PSO7	Gain proficiency in advanced chemical dynamics and statistical thermodynamics.
PSO8	Acquire the knowledge of all classes of natural products. Understand the nomenclature and synthesis of heterocyclic compounds.
PSO9	Understand the organometallic compound of transition metals and mechanism of catalytic reactions.
PSO10	Gain basic knowledge in corrosion, energy and polymers. Understand metallurgical processes, analyze and synthesize a variety of inorganic materials, including cement, glass, ceramics, steel, and silicones.



Semester-I

Undergraduate Certificate in Chemistry

DISCIPLINE SPECIFIC COURSE (DSC 1)
Fundamentals of Chemistry-I
Chemical Analysis-I (Practical)

No. of Hours -60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Fundamental of Chemistry-I (Theory) Chemical Analysis-I (Practical)	4	3	0	1	Passed Class XII with Chemistry	Nil

UNDERGRADUATE CERTIFICATE IN CHEMISTRY

Programme: Undergraduate Certificate in Chemistry **Year: I** **Semester: I Paper: DSC 1**

Subject:Chemistry

Course:DSC (Theory) | CourseTitle: Fundamentals of Chemistry-I

Course Outcomes:

After studying this course, the students will be able to:

- Learn about atomic structure, periodic properties and shapes of molecules. Understanding these concepts enables students to predict the physical and chemical properties of molecules.
- Gain the knowledge of different bonding theories such as VSEPR and Valence Bond Theory, which are essential for predicting molecular structures and bonding parameters.
- Understand about the organic reaction mechanisms, including types of reactions, reactive intermediates and stereochemistry
- Understand about the intermolecular forces, law governing ideal gases, and methods for determining physical properties.
- Understand about the nature of material, space lattice, miller indices, law governing crystallography.
- Understand about colloids, types of colloids, and properties relating to it.

Fundamentals of Chemistry-I

Credits: 3	Discipline Specific Course
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Journal of Oral Rehabilitation 2003 30: 103–109

Discipline Specific Course

John S. Rockbank, M.D.
John S. Rockbank, M.D.
John S. Rockbank, M.D.

Max. Marks: As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	Hours
Unit I	Atomic Structure and Periodic Properties: Heisenberg uncertainty principle; its significance. Atomic orbitals, Quantum numbers, shapes of s, p and d orbitals. Aufbau energy diagram, Pauli's exclusion principle. Hund's rule of maximum multiplicity. Electronic configuration of elements (s block, p block and first series of d-block elements). Effective nuclear charge. The general idea of Modern periodic table, atomic and ionic radii, ionization potential, electron affinity, electronegativity-definition, trends of variation in periodic table and factors affecting periodic properties.	10
Unit II	Chemical Bonding-I: Valence Shell Electron Pair Repulsion Theory (VSEPR) and shapes of NH_3 , H_2O , H_3O^+ , SF_4 , ClF_3 , XeF_2 , XeOF_2 , XeOF_4 , XeO_3 , XeF_4). Valence Bond Theory; Hybridization and types of hybridization and shapes of different inorganic and organic molecules (CH_4 , C_2H_2 , C_2H_4 , CO_2 , NO_3^- , BCl_3 , SF_6 , BeCl_2 , PCl_5 , IF_7).	10
Unit III	Mechanism of Organic Reactions: Types of reagents- electrophiles and nucleophiles. Resonance, hyperconjugation, field effects- inductive, mesomeric, electromeric effect. Types of organic reactions: Substitution. Addition, rearrangement, elimination. Reactive intermediates- carbocations, carbanions, free radicals (with examples). Stereochemistry of Organic Compounds: Types of isomerism-optical isomerism- elements of symmetry, molecular chirality, enantiomers, stereogenic centers, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centre, diastereomers, threo and erythro diastereomers, meso compounds. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometrical isomerism: determination of configuration of geometrical isomers, E & Z system of nomenclature.	10
Unit IV	States of Matter-I: Solid State: Introduction to crystalline materials, Definition of space lattice, unit cell, Miller indices, Laws of crystallography – (i) law of constancy of interfacial angles (ii) law of rationality of indices (iii) law of symmetry. X-ray diffraction by crystals. Bragg's equation, Numerical problems. Gaseous State: Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waal's equation of states, Critical phenomena, relationship between critical constants and van der Waals constants. Qualitative discussion of the Maxwell's distribution of molecular velocities, Numerical problems.	15

Mr. John S. Parker, Bart. ~~Esq.~~

Georges

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	<p>Liquid State-Intermolecular forces, Physical properties of liquids: Surface tension and viscosity, methods of determination of surface tension: Drop counting method, method of determination of viscosity: Ostwald viscometer method, Numerical problems.</p> <p>Colloidal State: Definition of colloids, Solids in liquids (sols): properties – kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number.</p>	
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Recommended Readings

- Concise Inorganic Chemistry by J. D. Lee.
- Principles of Inorganic Chemistry by B. R. Puri, L.R. Sharma, and K.C. Kalia.
- Chemistry for Degree Students B. Sc. First Year by R. L. Madan.
- Selected topics in Inorganic Chemistry by R. D. Madan, U. M. Malik and G. D. Tuli.
- Comprehensive Inorganic Chemistry by S. Chandra.
- Advanced Inorganic Chemistry by S. Prakash, G. D. Tuli, S. K. Basu and R. D. Madan.
- Stereochemistry of Organic Compounds by E. L. Eliel and S.H. Wilen.
- Organic Chemistry by I.L. Finar.
- Reaction mechanism in Organic Chemistry by S.M. Mukerji.
- Undergraduate Organic Chemistry by Jagdamba Singh, and L.D.S. Yadav.
- Physical Chemistry by D.W. Ball.
- Essential of Physical Chemistry by A. Bahl, B. S. Bahl, and G. D. Tuli.
- Physical Chemistry by Puri, Sharma, Pathania

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online Content:

https://www.youtube.com/watch?v=q-P79gnqNR8&list=PLmUlqVgZsTVVRvO3R8gx12EMc5vmcq_c

<https://www.youtube.com/watch?v=gahQYHs0c8s>

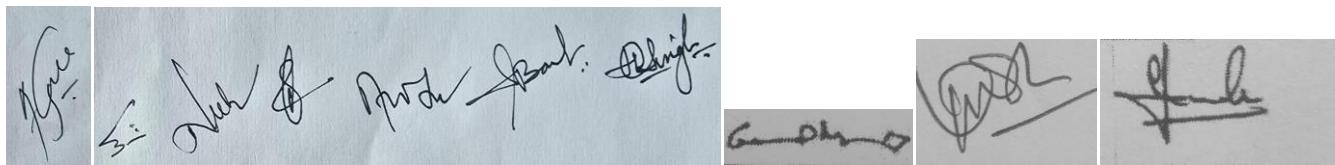
https://www.youtube.com/watch?v=w2He_Q0Mf0c

<https://www.youtube.com/watch?v=q1qMFcZVIPk>

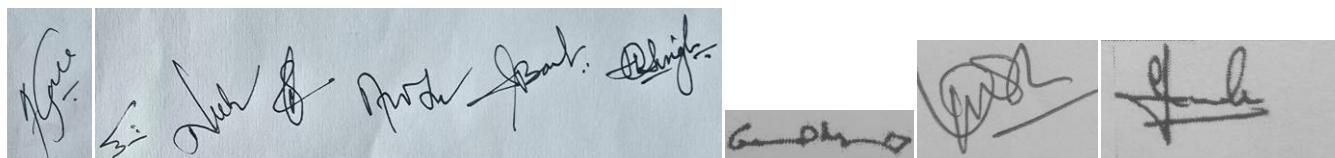
<https://www.youtube.com/watch?v=nWTgMr6idf0>

<https://www.youtube.com/watch?v=JNLJyhqXaTc&t=10s>

https://onlinecourses.swayam2.ac.in/cec20_lb01/preview



UNDERGRADUATE CERTIFICATE IN CHEMISTRY		
Programme: Undergraduate Certificate in Chemistry	Year: I	Semester: I Paper: DSC
Subject: Chemistry		
Course: DSC (Practical)	CourseTitle: Chemical Analysis-I	
Course Outcomes:		
After studying this course, the students will be able to:		
<ul style="list-style-type: none"> • Understand the laboratory methods and tests related to volumetric analysis. • Determine the relative surface tension of a given liquid. • Determine the absolute and relative configuration and determination of configuration of geometrical isomers. 		
Chemical Analysis-I		
Credits: 1	Discipline Specific Course	
Max.Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	No.of Hours
Unit I	Laboratory hazards and safety precautions	06
Unit II	Inorganic Exercise: Acid-base titrations; preparation of a solution in normal/molar terms, its standardization using a primary standard solution, determination of the strength of unknown solution. For example, preparation of NaOH solution (secondary standard say N/10), preparation of (COOH) ₂ solution (primary standard say N/10), standardization of NaOH solution titrating it against (COOH) ₂ solution using phenolphthalein (indicator) and then determination of the strength of given HCl solution.	08
Unit III	Organic exercise: Using Molecular Models: chiral and achiral molecules Determination of Relative and Absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometrical isomerism: Using Molecular Models: determination of configuration of geometrical isomers, E & Z system of nomenclature. Stability of carbocation based on reaction of primary, secondary, tertiary alcohol with Lucas reagent.	08
Unit IV	Physical exercise: Determination of relative surface tension of the given liquid using Stalagmometer.	08



Recommended Readings

- Stereochemistry of Organic Compounds by E.L.Eliel, and S.H. Wilen.
- Organic Chemistry by I. L. Finar.
- Vogel's Quantitative Chemical Analysis by J. Mendham.
- Quantitative Chemical Analysis by D. C. Harris.
- Exploring Chemical Analysis by D. C. Harris.
- Basic Concepts of Analytical Chemistry by S.M. Khopkar.
- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Note: Allocation of marks - External assessment: Total marks 75 (Inorganic exercise 20; Organic exercise 20; Physical exercise 20; Viva 15); Internal assessment: Total marks 25 (Record and viva 20 attendance 05).

Semester-I

Undergraduate Certificate in Chemistry

GENERIC ELECTIVE (GE 1) Basics of Chemistry-I

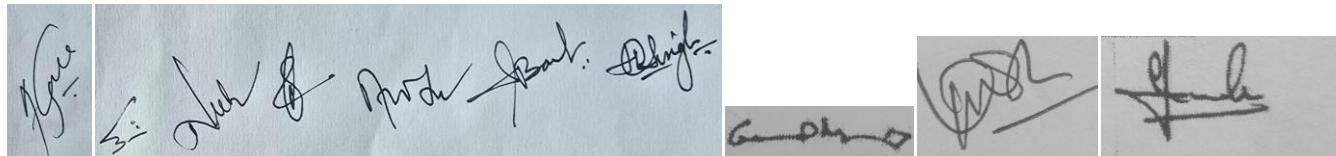
No.of Hours -60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

CourseTitle	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (ifany)
		Lecture	Tutorial	Practical/Practice		
GE: Basics of Chemistry-I	4	4	-	-	Passed Class XII	Nil

UNDERGRADUATE CERTIFICATE IN CHEMISTRY

Programme:Undergraduate Certificate in Chemistry	Year: I	Semester: I Paper:GE 1
Subject:Chemistry		
Course:GE	CourseTitle: Basics of Chemistry- I	

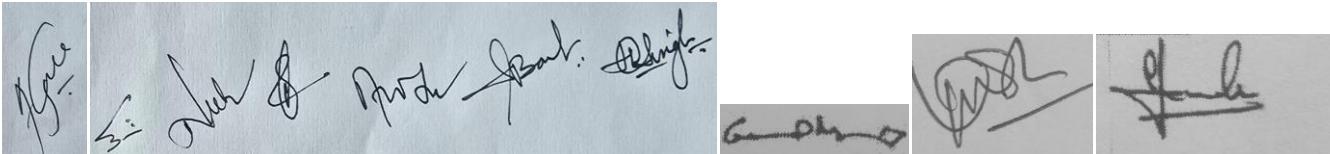


Course Outcomes:

After studying this course, the students will be able to:

- Understand the important features of matter.
- Understand the difference between elements, compounds and mixtures.
- Define different types of systems, thermodynamic processes, intensive and extensive properties and concept of heat and work.
- Understand the structure of atom by different type of models.
- Understand the basics of laboratory- Glass apparatus and types of burners.
- Able to distinguish between errors, precision and accuracy.
- Understand about the statistical tools of mean and standard deviation.

Credits:4		Generic Elective
Max. Marks: As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	<p>Basics of Matter Physical nature of matter, Characteristics of particles of matter, states of matter, physical and chemical changes, elements, compounds, mixtures, types of mixtures.</p> <p>Properties of Matter and their Measurement: Physical and chemical properties, the International System of Units (SI), Mass and Weight, Volume, Density, Temperature.</p>	10
Unit II	<p>Structure of Atom</p> <p>1. Dalton's Atomic Theory:</p> <p>2. Discovery of Sub-atomic Particles: Discovery of Electron, Protons and Neutrons, Charge to Mass Ratio of Electron, Charge on the Electron.</p> <p>3. Atomic Models: Thomson Model of Atom, Rutherford's Nuclear Model of Atom, Atomic Number and Mass Number, Isobars and Isotopes, Drawbacks of Rutherford Model</p> <p>4. Bohr's Model for Hydrogen Atom - Explanation of Line Spectrum of Hydrogen, limitations of Bohr's Model</p> <p>5. Atomic orbitals: Aufbau energy diagram in filling of electrons, Pauli's Exclusion Principle, Hund's rule of maximum multiplicity.</p>	20
Unit III	<p>Basic Laboratory</p> <p>Glass Apparatus: Beaker, test tube, boiling tube, conical flask, filtration flask, round bottom flask, flat bottom flask, funnel, separating funnel, watch glass. Measuring cylinder, Petridish, desiccator, measuring cylinder, glass rod, and glass tube.</p>	20



	Burner: Bunsen burner, Flames of burner, Air flow regulation Analytical approaches: Uncertainty in Measurement- Scientific Notation, Significant Figures, Dimensional Analysis, types of errors, precision & accuracy, absolute and relative uncertainty. Mean and standard deviation.	
Unit IV	Thermodynamics: Definition of thermodynamic terms, system, type of system, thermodynamic processes, intensive and extensive properties, concept of heat and work.	10

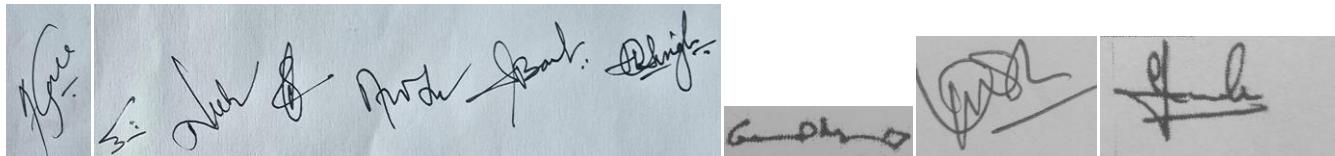
Suggested Readings:

- Physical Chemistry by Puri, Sharma, Pathania,
- Basic Inorganic Chemistry by Ajai Kumar.
- Concise Inorganic Chemistry by J. D. Lee.
- Basic Inorganic Chemistry by F. A. Cotton, G. Wilkinson and P. L. Gaus.
- Concepts and Models in Inorganic Chemistry by B. E. Douglas, D. H. McDaniel and J. J. Alexander.
- Inorganic Chemistry: Principles of Inorganic Chemistry by Huheey, Keiter, and Medhi.
- Understanding our Chemical World by Paul Monk.
- Physical Chemistry by G. M. Barrow.
- Physical Chemistry by G. W. Castellan.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations

Suggested equivalent online content:

<https://chem.washington.edu/lecture-demos/match-head-reaction>
<https://ncert.nic.in/textbook/pdf>
<https://www.youtube.com/watch?v=AYD7YJqQ0Q&t=23s>



Semester-II**Undergraduate Certificate in Chemistry**
DISCIPLINE SPECIFIC COURSE (DSC 2)
Fundamentals of Chemistry-II
Chemical Analysis-II
No.of Hours -60**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Prerequisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Fundamental of Chemistry-II (Theory) Chemical Analysis-II (Practical)	4	3	-	1	Passed B. Sc. Sem I with Chemistry (DSC 2)	Nil

UNDERGRADUATE CERTIFICATE IN CHEMISTRY

Programme: Undergraduate Certificate in Chemistry	Year: I	Semester:II
		Paper:DSC 2

Subject:Chemistry

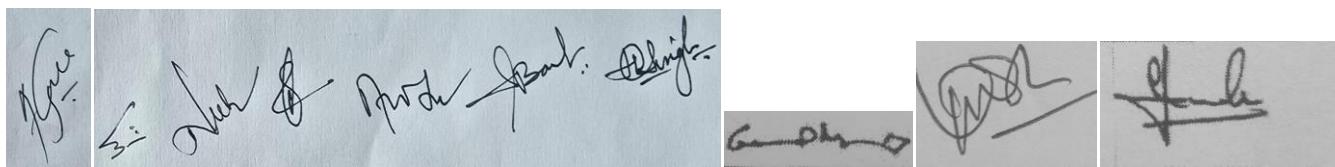
Course: DSC 2 (Theory)	CourseTitle:Fundamentals of Chemistry-II (Theory)
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Course Outcomes:

After studying this course, the students will be able to:

- Understand the bonding in inorganic molecules, salient features of s- and p- block elements.
- Describe the reactions shown by aliphatic and aromatic compounds.
- Different aspects of chemical kinetics, catalysis and first law of thermodynamics.

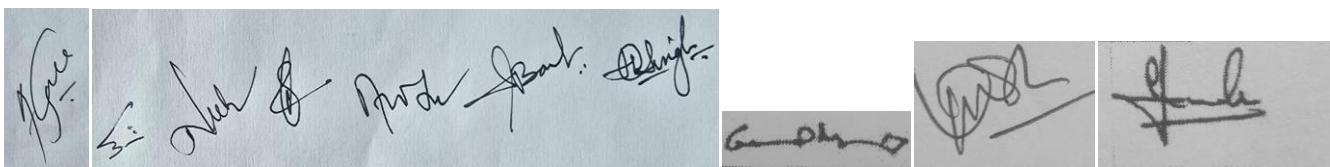
Credits: 3	Discipline Specific Course	
Max. Marks:As Per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	
Unit I	Chemical Bonding-II: Molecular Orbital Theory (MOT) as applied to diatomic homonuclear/heteronuclear inorganic molecules. MO diagrams and bond order of H_2 , He_2 , B_2 , C_2 , N_2 , O_2 , F_2 , Ne_2 , CO difference between VB and MO theories. Multicentre bonding in electron deficient molecules (B_2H_6); Polarizing power and polarizability; Fajan's rule. Salient Features of s- and p-Block Elements: General discussion with respect to all periodic (Occurrence, electronic configuration, atomic & ionic radii, density, ionization potential, metallic behaviour,	



	electropositive nature, electronegativity, electron affinity, hydration energy, flame colouration, photoelectric effect, polarization power, boiling and melting point). Diagonal relationship, catenation, inert pair effect, $p\pi-p\pi$, chemistry of hydrides, halides, oxides and oxyacids of p-block elements.	
Unit II	Aliphatic Compounds: general methods of preparation of alkanes, Mechanism of free radical halogenation of alkanes, Pyrolysis. Preparation & Chemical reactions of alkenes- mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's Rule, hydroboration-oxidation, Epoxidation, ozonolysis, hydration and oxidation with $KMnO_4$. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydration, metal-ammonia reduction. Aromatic Compounds: Aromaticity- the Hückel rule, Aromatic electrophilic substitution- general pattern of the mechanism, role of σ and π complexes. Mechanism of nitration, halogenation, sulphonation. Activating and deactivating substituents.	14
Unit III	Chemical Kinetics and Catalysis: Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction- concentration, temperature, Arrhenius equation, temperature coefficient, catalyst; hetero and homocatalysis, significance. Inhibitors, poisons, promoters. Concentration dependence of rates of simple reaction, Molecularity, Order of reaction- zero order, first order, second order, pseudo-order, half-life period, Numerical problems.	8
Unit IV	Thermodynamics I: Definition of thermodynamic terms, system, surroundings etc. Types of thermodynamic systems and thermodynamic processes. Intensive and extensive properties. Concept of heat and work, first law of thermodynamics, definition of internal energy and enthalpy. Heat capacity – heat capacities at constant volume and at constant pressure and their relationship, calculation of w , q , dU & dH for the expansion of ideal gases under isothermal and reversible conditions. Thermochemistry; standard state, standard enthalpy of formation. Hess's law of heat summation and its application, Numerical problems.	8

Recommended Readings:

- Principles of Inorganic Chemistry by B. R. Puri, L. R. Sharma and K. C. Kalia.
- Chemistry for Degree Students, B. Sc. First Year by R. L. Madan.
- Selected topics in Inorganic Chemistry by R. D. Madan, U. M. Malik and G. D. Tuli.
- Comprehensive Inorganic Chemistry by S. Chandra.



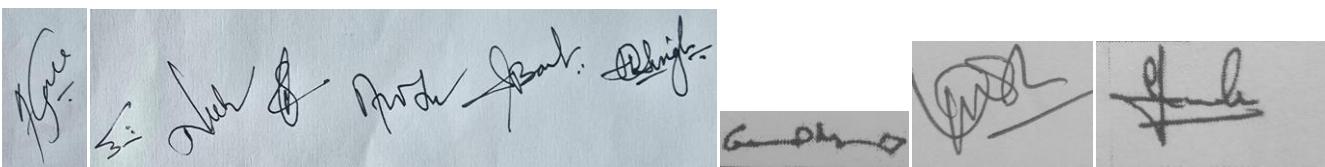
- Advanced Inorganic Chemistry by S. Prakash, G. D. Tuli, S. K. Basu and R. D. Madan.
- Organic Chemistry by I. L. Finar.
- Stereochemistry of Organic Compounds by E. L. Eliel and S. H. Wilen.
- Organic Chemistry by Boyd, Morrison and Bhattacharjee.
- Reaction mechanism in Organic Chemistry by S. M. Mukerji.
- Undergraduate Organic Chemistry by Jagdamba Singh and L. D. S. Yadav.
- Organic Chemistry by G. Marc. Loudon.
- Atkin's Physical Chemistry: International by P. W. Atkins.
- Physical Chemistry by D. W. Ball.
- Principles of Physical Chemistry by B. R. Puri, M. S. Pathania and L. R. Sharma.
- Essential of Physical Chemistry by A. Bahl, B. S. Bahland G. D. Tuli.
- Text Book for B. Sc. Chemistry I by A. Bariyar, R. P. Singh and A. Dwivedi.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online courses:

- https://www.youtube.com/watch?v=Gg4-go6tTiA&list=PLmxSS9XYst208kJs0npO_v_L-AGkHZJ1S
- https://www.youtube.com/watch?v=sz17_NnMPak&t=51s
- <https://www.youtube.com/channel/UCUxhnr9H2IYKsuRypG0MAfw/videos>
- https://onlinecourses.swayam2.ac.in/nce19_sc15/preview
- <https://www.openlearning.com/courses/introduction-to-physical-chemistry/?cl=1>
- <https://www.careers360.com/university/indian-institute-of-technology-bombay/chemistry-of-main-group-elements-certification-course>
- https://onlinecourses.swayam2.ac.in/cec20_lb01/preview
- <https://nptel.ac.in/courses/104/103/104103071/>

UNDERGRADUATE CERTIFICATE IN CHEMISTRY				
Programme: Undergraduate Certificate in Chemistry	Year: I	Semester: II Paper: DSC		
Subject: Chemistry				
Course: DSC(Practical)	Course Title: Chemical Analysis-II			
Course Outcomes:				
After studying this course, the students will be able to:				
<ul style="list-style-type: none"> • To analyse inorganic salt for the presence of acidic and basic radicals. • Systematically analyse and identify the organic compounds belonging to hydrocarbon category. • Measure the relative viscosity of a given liquid. 				



Chemical Analysis- II		Discipline Specific Course
Credit: 1	Max.Marks:As per University rules	Min.PassingMarks:As per University rules
Unit	Topic	No.of Hours
Unit I	Laboratory hazards and safety precautions	06
Unit II	Inorganic exercise: Salt mixture analysis: Identification of acidic radicals (3-4 radicals, excluding interfering radicals) including basic radical's upto II Group in the given salt.	08
Unit III	Organic exercise: Systematic analysis and identification of any two of the following organic compounds (minimum one from each group) i. Simple Hydrocarbons: Naphthalene, Anthracene, Biphenyl ii. Hydrocarbons with special elements: <i>m</i> -Dinitrobenzene, <i>p</i> -Dichlorobenzene	08
Unit IV	Physical exercise: Determination of relative viscosity of the given liquid using Ostwald viscometer.	08

Note: Allocation of marks - External assessment: Total marks 75 (Inorganic exercise 20; Organic exercise 20; Physical exercise 20; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05).

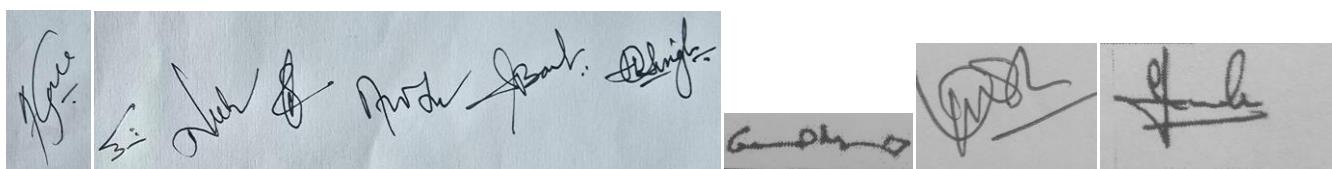
Recommended Readings

- Vogel's Quantitative Chemical Analysis by J. Mendham.
- Instrumental Methods of Analysis by H. H. Willard.
- Analytical Chemistry by G. D. Christian.
- Exploring Chemical Analysis by D. C. Harris.
- Basic Concepts of Analytical Chemistry by S. M. Khopkar.
- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman.
- Laboratory Handbook of Chromatographic & Allied Methods by O. Mikes and R. A. Chalmes.
- Analytical Chemistry: Methods of separation by R. V. Ditts.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Suggested equivalent online Content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>



Semester-II**Undergraduate Certificate in Chemistry****GENERIC ELECTIVE (GE 2)
Basics of Chemistry-II****No.of Hours-60****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Basics of Chemistry-II	4	4	-	-	Passed Class XII	Nil

UNDERGRADUATE CERTIFICATE IN CHEMISTRY

Programme: Undergraduate Certificate in Chemistry	Year: I	Semester: II
		Paper: GE 2

Subject: Chemistry

Course: GE 2	Course Title: Basics of Chemistry-II
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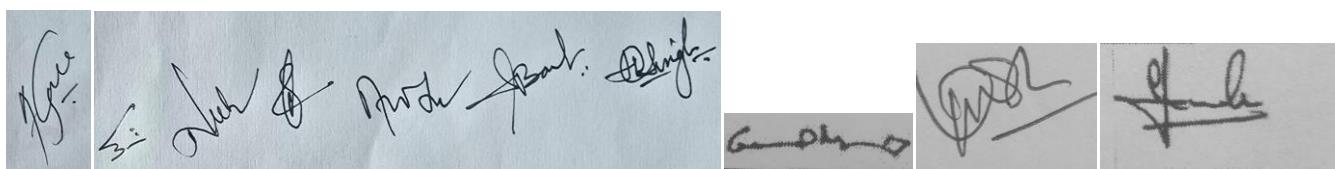
Course Outcomes:

After studying this course, the students will be able skilled to:

- Understand the concept of mole, molarity and molality
- Define periodic law and setup a relationship among the elements through atomic size, ionization energy, electron affinity, electronegativity.
- Understand the reasons for the tetravalence of carbon and shape of organic molecules write structures of organic molecules and classify the organic compounds.
- Understand the definition of pollution and various acts governing pollution control.
- Understand the environment concepts for healthy life.

Max.Marks: As per University rules	Generic Elective
	Min. Passing Marks: As per University rules

Unit	Topic	No. of Hours
Unit I	Mole Concept and Molar Masses: Percentage composition and molecular formula, Mass percent, Mole Fraction, Molarity, Molality, PPM Use of Measuring Equipments in sample preparation in Lab: Apparatus as Pipette, Burette, Measuring cylinder, Volumetric flasks, Chemical balance, least count of apparatus.	15

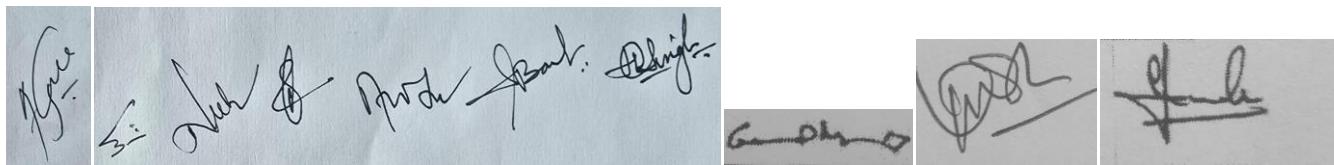


Unit II	Periodic Properties: History of Periodic Classification: Dobereiner's triads, Newlands Octaves, Mendeleev's periodic table. Periodic table and periodic law, periodic classification of the elements, Periodic relationship among the elements, periodic properties-atomic size, ionization energy, electron affinity, electronegativity	10
Unit III	Some Basic Principles of Organic chemistry 1. General Introduction: Vital force theory, the origin of name 'organic chemistry', synthesis of urea in lab. 2. Tetravalence of Carbon: Shapes of Organic Compounds, 3. Structural Representations of Organic Compounds: Complete, Condensed and Bond-line, Structural Formulas. 4. Classification of Organic Compounds —Acyclic, open chain compounds, Cyclic, closed chain or ring compounds; Alicyclic compounds, Aromatic compounds, Functional Group, Homologous Series.	10
Unit IV	Environmental pollution: Definition of Pollutants, Major types of Pollutants, Major Sources and Effects. Functions of Pollution Control Boards; Penalties and Procedure; Duties and Responsibilities of Citizens for Environmental Protection; Environment (Protection) Act 1986; Hazardous Waste (Management and Handling) Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Public Awareness and Public Interest Litigations; Its Role in Control of Environmental Pollution in India.	15

Recommended Readings

- Introductory Chemistry by J. Nivaldo and Ho Yu Au-Yeung Tro.
- Basic Chemistry by K. C. Timberlake and W. Timberlake.
- Green Chemistry by V. K. Ahluwalia.
- Environmental Chemistry: A global perspective by Gary W. Vanloon and Stephen J. Duffy
- Environmental Chemistry by A. K. Day.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



Semester-III

Undergraduate Diploma in Chemistry

DISCIPLINE SPECIFIC COURSE (DSC 3)

General Chemistry- I

Chemical Analysis- III

No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: General Chemistry-I	4	3	-	1	Passed Certificate in B.Sc. with Chemistry (DSC)	Nil

UNDERGRADUATE DIPLOMA IN CHEMISTRY

Programme: Undergraduate Diploma in Chemistry

Year:II

Semester:III

Paper:DSC 3

Subject: Chemistry

Course: DSC 3 CourseTitle: General Chemistry- I

Course Outcomes:

After studying this course, the students will be able to:

- Detailed understanding of the d-block elements and their characteristics.
- Gather the information regarding Werner's theory and VBT of transition metal complexes.
- Provides detailed knowledge of properties of halides, alcohols and phenols highlighting their chemical reactions and their mechanism.
- Learn the basic concepts of spontaneity, chemical and phase equilibrium after that students will be able to solve the numerical problems based on these concepts.

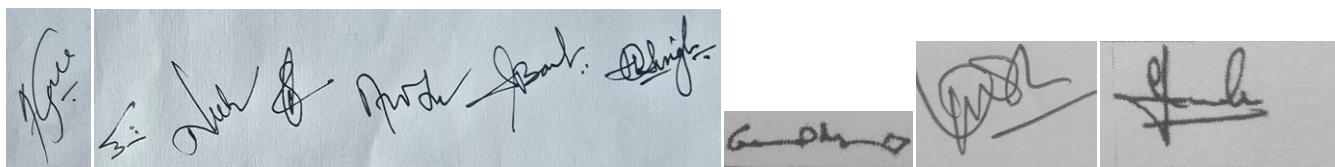
Credits:4

Discipline Specific Course

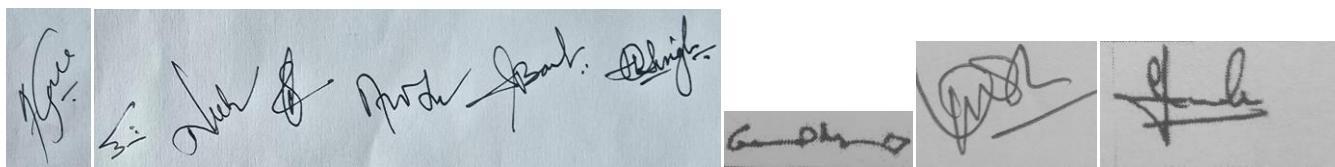
Max. Marks: As per University rules

Min. Passing Marks: As per University rules

Unit	Topic	No. of Hours
Unit I	Chemistry of Transition Elements (First, second and third Transition Series): Characteristic properties of the elements; electronic configuration, atomic & ionic radii, oxidation states,	15



	<p>ionization energy, complex compound formation, colour, and magnetic properties. Coordination number and geometry. Comparative treatment of 3d, 4d and 5d elements</p> <p>Coordination Chemistry-I: Definition, terminology (ligand, coordination number, coordination sphere, complex ion etc.), Nomenclature of coordination compounds (IUPAC system), Werner's theory for coordination compounds; its experimental verification, stability of complexes and factors contributing to the stability, Chelates and isomerism in coordination compounds</p> <p>Valence Bond Theory (VBT) for coordination compounds, geometry of complexes (tetrahedral, octahedral, square planar), magnetic properties of complex compounds.</p>	
Unit II	<p>Alkyl and aryl halides: Preparation and comparison of their chemical properties. Mechanism of nucleophilic substitution reactions, S_N2 and S_N1 reactions with energy profile diagrams.</p> <p>Alcohols and Phenols:</p> <p>Alcohols: Preparation and chemical properties of mono hydric alcohols. General introduction of diols and triols.</p> <p>Phenols: Preparation and chemical properties of phenols, acidic character. Comparative acidic strengths of alcohols and phenols, Reactions of phenols. Mechanism of Fries rearrangement, Claisen condensation, Gatterman synthesis and Reimer-Tiemann reaction.</p>	12
Unit III	<p>Thermodynamics II: Second law of thermodynamics, different statements of the law. Carnot cycle and its efficiency, Carnot theorem. Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T, entropy change in physical and chemical processes, entropy change for reversible, irreversible and equilibrium condition. Entropy as criteria of spontaneity and equilibrium. Entropy changes in ideal gases. Gibbs free energy and Helmholtz work functions. Criteria for thermodynamic equilibrium and spontaneity, advantage Gibbs free energy and Helmholtz work functions over entropy change for spontaneity, Numerical problems.</p>	10
Unit IV	<p>Chemical Equilibrium: The law of mass action, free energy and equilibrium constant, factors influencing equilibrium constant, relationship between K_p and K_c. Le-Chatelier's principle, Numerical problems.</p> <p>Phase Equilibrium: Statement and meaning of the terms: phase, component and degree of freedom, Gibb's phase rule, phase</p>	8

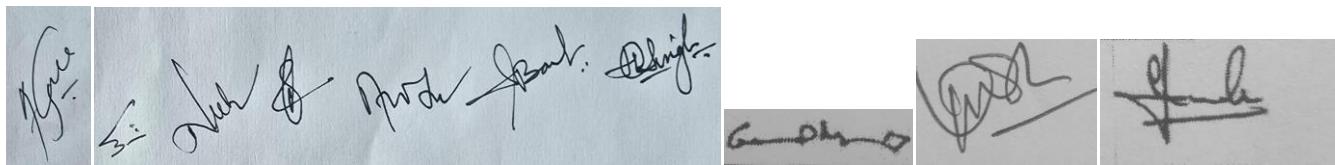


	equilibria of one component systems- water, carbon dioxide. Numerical problems	
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Recommended Readings

- Concise Inorganic Chemistry by J. D. Lee.
- Principles of Inorganic Chemistry by B. R. Puri, L. R. Sharma and K. C. Kalia.
- Chemistry for Degree Students, B. Sc. Second Year by R. L. Madan.
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- Undergraduate Organic Chemistry by Jagdamba Singh and L. D. S. Yadav.
- Organic Chemistry by G. Marc. Loudon.
- Atkin's Physical Chemistry: International by P. W. Atkins.
- Physical Chemistry by D. W. Ball.
- Principles of Physical Chemistry by B. R. Puri, M. S. Pathania and L. R. Sharma.
- Essential of Physical Chemistry by A. Bahl, B. S. Bahl and G. D. Tuli.
- Text Book for B. Sc. Chemistry I by A. Bariyar, R. P. Singh and A. Dwivedi.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



UNDERGRADUATE DIPLOMA IN CHEMISTRY

Programme: Undergraduate Diploma in Chemistry	Year: II	Semester: III
		Paper: DSC

Subject: Chemistry

Course: DSC (Practical)	Course Title: Chemical Analysis-III
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Course Outcomes:

After studying this course, the students will be able to:

- To test the inorganic salts for the presence of acidic and basic radicals from IIA and IIB groups.
- Understand the systematic identification of the organic compounds belonging to alcohols and phenols.
- Determine the critical solution temperature of partially miscible liquids.

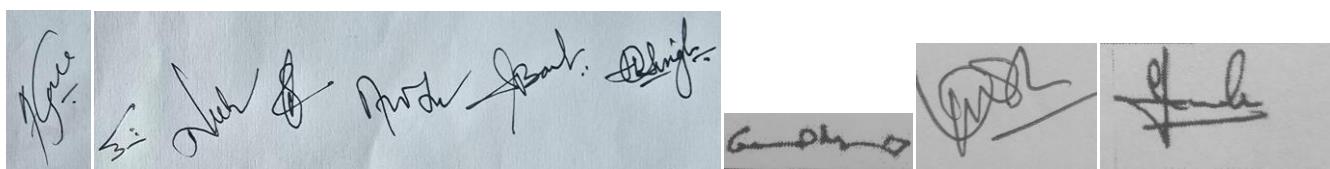
Chemical Analysis-III

Credits: 1	Discipline Specific Course	
Max. Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	No. of Hours
Unit I	Laboratory hazards and safety precautions	04
Unit II	Inorganic exercise: Completer Inorganic mixture analysis including both acidic and basic radicals with special emphasis of common ion effect and solubility product.	08
Unit III	Organic exercise: Systematic analysis and identification of organic compounds: Alcohols and Phenols/ Stability of carbocation based on reaction of primary, secondary, tertiary alcohol with Lucas reagent	10
Unit IV	Physical exercise: Determination of critical solution temperature (CST)/Experiment based on thermodynamic and Chemical equilibrium.	08

Note: Allocation of marks - External assessment: Total marks 75 (Inorganic exercise 20; Organic exercise 20; Physical exercise 20; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05).

Recommended Reading

- Vogel's Quantitative Chemical Analysis by J. Mendham.
- Instrumental Methods of Analysis by H. H. Willard.
- Analytical Chemistry by G. D. Christian.
- Exploring Chemical Analysis by D. C. Harris.
- Basic Concepts of Analytical Chemistry by S. M. Khopkar.
- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman.
- Laboratory Handbook of Chromatographic & Allied Methods by O. Mikes and R. A. Chalmes.



- Analytical Chemistry: Methods of separation by R. V. Ditts.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Suggested equivalent online Content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>

Semester-III

Undergraduate Diploma in Chemistry

DISCIPLINE SPECIFIC ELECTIVE (DSE 3) Chemistry of Environment

No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Chemistry of Environment	4	4	-	-	Passed Class XII with Chemistry	Nil

UNDERGRADUATE DIPLOMA IN CHEMISTRY

Programme: Undergraduate Diploma in Chemistry	Year: II	Semester: III Paper: DSE 3
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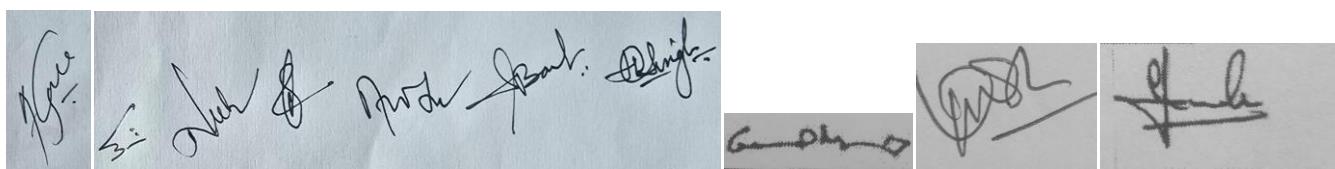
Subject: Chemistry

Course: DSE	Course Title: Chemistry of Environment
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Course Outcomes:

- State Atmosphere, Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere.
- Understand natural resources and management, Coal, Petroleum, natural gas, nuclear fission and fusion, solar energy and wind energy.
- Define environment pollution, diseases caused by environmental factor, type of pollution.
- Understand gulf wars in environment, earth summits, environmental policies and laws (India).

Credits: 4	Discipline Specific Elective
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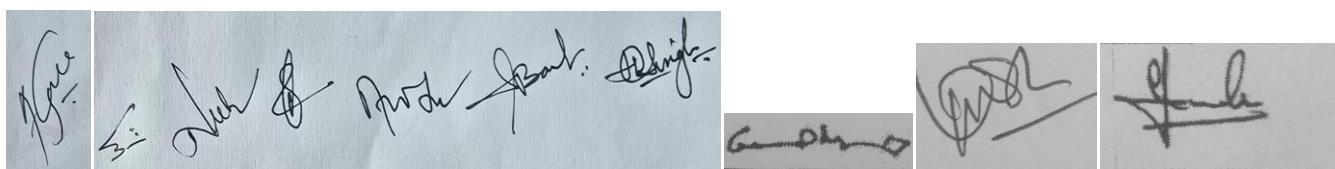


Max. Marks:As per University rules		Min.Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	Environment Concept of environmental chemistry, Our planet Earth, Environment, Composition or structure of the atmosphere (Troposphere, Stratosphere, Mesosphere, Ionosphere or thermosphere, Exosphere. Vertical temperature and vertical structure of the atmosphere. Heat budget of earth atmospheric system.	15
Unit II	Natural Resources and Management Mineral Resources: Metals and Non-metals, wood, Energy Resources (Coal, Petroleum and Natural Gas, Nuclear Fission and Nuclear Fusion, Solar Energy, Hydrogen, Gasohol), World Energy Resources-Consumption and Conservation, Environmental Management.	15
Unit III	Environment pollution Pollution, Pollutant, Diseases caused by environmental factors, Biodegradable pollutants, non-biodegradable pollutants, Types of pollution, Thermodynamics, petroleum and pollution.	15
Unit IV	The state of the Global Environment State of Global Environment, The Gulf Wars and Environment, The Earth Summits, Human Development and Environmental Clean-up Budget, Myths and Ground Realities (Indian Context), Environmental Policies and Laws (India).	15

Recommended Readings

- Textbook of Biochemistry with Clinical Correlation by T. M. Devlin.
- Biochemistry by J. M. Berg, J. L. Tymoczko and L. Stryer.
- Fundamentals of Biochemistry by U. Satyanarayana and U. Chakrapani.
- Principles of Biochemistry by A. L. Lehninger, D. L. Nelson and M. M. Cox.
- Harper's Illustrated Biochemistry by R. K. Murray, D. K. Granner and P. A. Mayes and V. W. Rodwell.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class room tests, home assignments, group discussions or oral presentations



Semester-III

Undergraduate Diploma in Chemistry

GENERIC ELECTIVE (GE 3)

Basics of Chemistry-III

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE:Basics of Chemistry-III	4	4	-	-	Passed Class XII	Nil

UNDERGRADUATE DIPLOMA IN CHEMISTRY

Programme: Undergraduate Diploma in Chemistry	Year: II	Semester: III Paper: GE 3
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Subject:Chemistry

Course:GE | **CourseTitle: Basics of Chemistry-III**

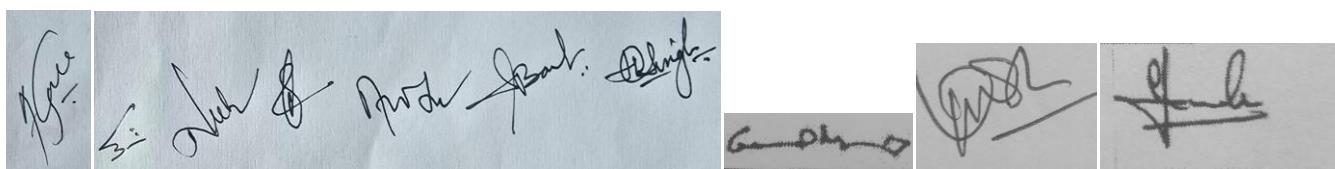
Course Outcomes:

After studying this course, the students will be able to:

- Explain various laws of chemical combination; appreciate the significance of atomic mass, average atomic mass, molecular mass and molecular formula.
- Describe that terms mole and molar mass, mass percent of component element constituting a compound, perform stoichiometric calculation.
- Name the compound according to the IUPAC system of nomenclature and also derive their structure from the given names; write the chemical reactions.
- Understand the laws governing ideal gas, kinetic molecular theory of gases
- Able to distinguish between solid, liquid, and gas in terms of kinetic theory.
- Define various physical constants.

Credits:4	Generic Elective
Max.Marks: As per University rules	Min. Passing Marks: As per University rules

Unit	Topic	No.of Hours
Unit I	Basic Concepts of Chemistry <ol style="list-style-type: none"> <li>Laws of Chemical Combinations: Law of Conservation, Law of Mass, Law of Definite Proportions, Law of Multiple Proportions, Gay Lussac's Law of Gaseous Volumes, Avogadro's Law, and Dalton's Atomic Theory. <li>Atomic and Molecular Masses- Atomic and molecular Mass, Average Atomic 	

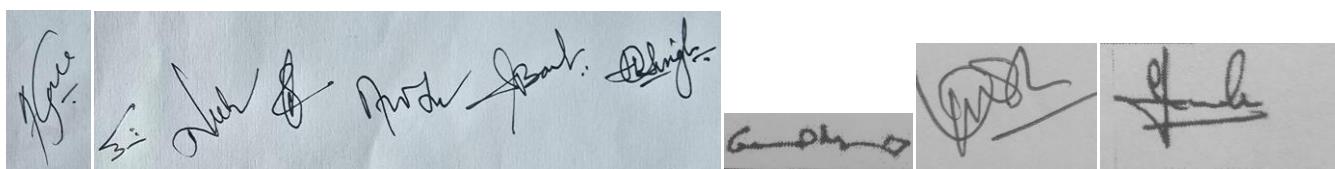


	Mass, Formula Mass 3. Stoichiometry and Stoichiometric Calculations: Limiting Reagent, Reactions in Solutions, simple numericals on stoichiometry.	15
Unit II	Chemical Bonding and Molecular Structure Kössel-Lewis Approach: Octet rule taking the example of elements with $Z=18$, Lewis symbols of elements up to $Z=20$. Electronic Configurations of Elements and the Periodic Table upto $Z=20$ Bonding: Ionic or Electrovalent Bond: Meaning, formation of NaCl , CaO , BaCl_2 , types of ions with examples. Covalent Bond: Meaning, formation of HCl , CH_4 , CO_2 , NH_3 , types of covalent bond with examples. Nomenclature of Organic Compounds: The IUPAC System of Nomenclature, IUPAC Nomenclature of Straight chain hydrocarbons, Branched chain, Unbranched Saturated hydrocarbons, Substituted Benzene Compounds.	20
Unit III	1. Chemical Equation and Reaction Chemical equations, types of chemical equations, Thermo chemical equation: endothermic and exothermic reaction	10
Unit IV	Gaseous State 1. The Gaseous State: experiment on the gaseous state: Boyle, Charles and Avogadro's laws, Ideal Gas Equation 2. Kinetic Molecular Theory of Gases: Postulates and Explanation Difference between solid, liquid, and gas in terms of Kinetic theory. Physical Constant Melting point, melting point theory, mixture melting point, packing of melting point tube, Determination of melting point; decomposition, discoloration, softening, shrinking and sublimation. Boiling point, determination of boiling point, use of boiling chips, calibration of thermometer.	15

Recommended Readings

- Physical chemistry by Puri, Sharma, Pathania.
- Basic Inorganic Chemistry by Ajai Kumar.
- Concise Inorganic Chemistry by J. D. Lee.
- Concepts and Models in Inorganic Chemistry by B. E. Douglas, D. H. McDaniel and J. J. Alexander.
- Principles of Inorganic Chemistry by B. R. Puri, L. R. Sharma and K. C. Kalia.
- Chemistry for Degree Students, B. Sc. First Year by R. L. Madan.
- Selected topics in Inorganic Chemistry by R. D. Madan, U. M. Malik and G. D. Tuli.
- Comprehensive Inorganic Chemistry by S. Chandra.
- Advanced Inorganic Chemistry by S. Prakash, G. D. Tuli, S. K. Basu and R. D. Madan.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score



obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-classroom, on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online Content:

https://onlinecourses.nptel.ac.in/noc22_cy36/preview

https://onlinecourses.swayam2.ac.in/cec20_lb01/preview

<https://www.youtube.com/watch?v=ZeV3V0DjupQ&list=PLmxSS9XYst20arjxnrIpnl0P99AnswmSs>

<https://www.youtube.com/watch?v=zGk6VeTfpE&list=PLmxSS9Xyst21tCVCVKQ9nZdW3OO->

<https://www.youtube.com/watch?v=zUwbVaBaxTY&list=PLmxSS9XYst22fU510ryKC>

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<https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>

https://www.youtube.com/watch?v=_AYD7YJqQ0Q&t=23s

<https://www.youtube.com/watch?v=0LaL11wskEg>

Semester-IV

Undergraduate Diploma in Chemistry

DISCIPLINE SPECIFIC COURSE (DSC 4)

General Chemistry- II

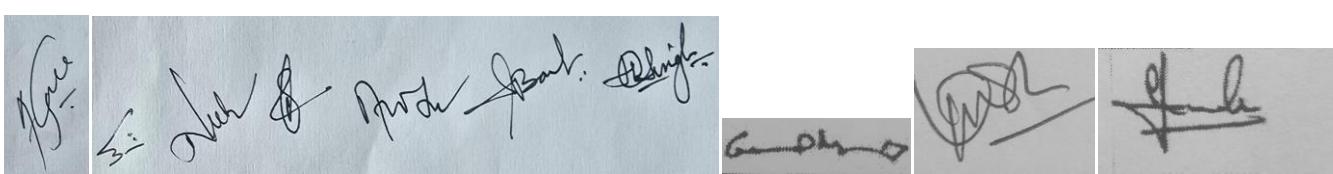
No of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC 4: General Chemistry-II (Theory) Chemical Analysis-IV (Practical)	4	3	-	1	Passed B.Sc. III Sem with Chemistry (DSC 4)	Nil

UNDERGRADUATE DIPLOMA IN CHEMISTRY

Programme:Undergraduate Diploma in Chemistry	Year:II	Semester:IV
		Paper: DSC 4
Subject: Chemistry		
Course: DSC (Theory)	CourseTitle: General Chemistry- II	

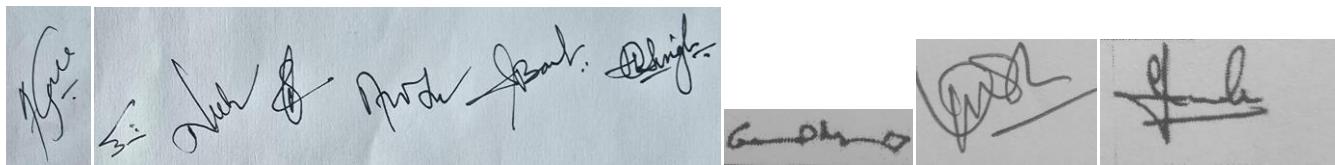


Course Outcomes:

After studying this course, the students will be able to:

- Define the acids and bases on the basis of various concepts/ theories.
- Identify the position of Inner transition elements in the periodic table and able to explain their properties on the basis of their position.
- Knowledge of synthesis of aldehydes, ketones, carboxylic acids and functional groups inter conversion.
- Describe the concepts of electrochemistry in detail and its applications. Also, they will be able to solve the numerical problems based on these concepts.

Credits:4		Discipline Specific Course
Max. Marks:As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No.of Hours
Unit I	Acids and Bases: Arrhenius concept, Bronsted-Lowry concept, Lux-Flood and Lewis concept of acids and bases; Hard and Soft Acid-Base Theory:Classification of acids and bases as hard and soft. Pearson's hard and soft acid base concept, acid base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness.	5
Unit II	Chemistry of Inner Transition Elements: Chemistry of Lanthanides: Electronic configuration, oxidation states, atomic & ionic radii, lanthanide contraction and its consequences, complex formation, colour; Methods of separation of lanthanides- fractional crystallization, fractional precipitation, change in oxidation state, solvent extraction and ion exchange methods. Chemistry of Actinides: General features of actinides-electronic configuration, atomic & ionic radii, ionization potential, oxidation states and complex formation.	10
Unit III	Aldehydes and Ketones: General methods of preparation and their chemical properties.Rossemund reaction,Stephen's reduction, Etard reaction, Gattermann Koch reaction, Mechanism of nucleophilic additions to carbonyl group with particular emphasis on aldol, Perkin and Knoevenagel condensation,Oxidation of aldehydes,Cannizzaro reaction, Clemmensen reduction. Carboxylic Acids: General methods of preparation Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction. Reduction of carboxylic acids,	15

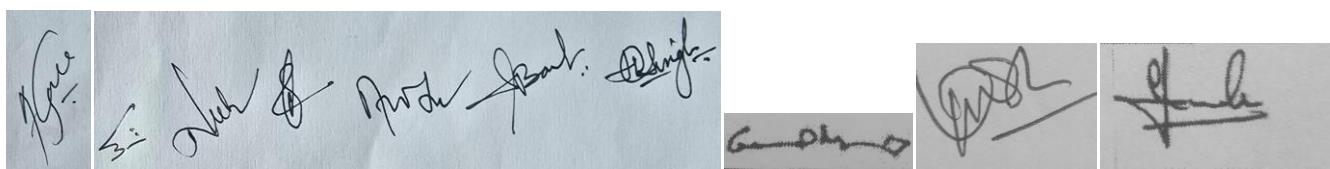


	mechanism of decarboxylation. Dicarboxylic acids-methods of preparation and effect of heat and dehydrating agents	
Unit IV	<p>Electrochemistry I: Electrical transport-conduction in metals and electrolytic solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution. Arrhenius theory of electrolytic dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations, Numerical Problems.</p> <p>Electrochemistry II: Oxidation state, types of redox reactions, Meaning of electrode (Half-cell), Electrode reactions, standard hydrogen electrode-reference electrode, determination of standard electrode potential, determination of p^H and pK_a from hydrogen standard electrode, sign conventions, electrochemical series and its significance. Galvanic cells, conventional representation of electrochemical cells. EMF of a cell and its measurements. Derivation of Nernst equation for electrode potential of half-cell and for EMF of cell. Numerical Problems.</p>	15

Recommended Readings

- Concise Inorganic Chemistry by J. D. Lee.
- Principles of Inorganic Chemistry by B. R. Puri, L. R. Sharma and K. C. Kalia.
- Chemistry for Degree Students, B. Sc. Second Year by R. L. Madan.
- Selected topics in Inorganic Chemistry by R. D. Madan, U. M. Malik and G. D. Tuli.
- Comprehensive Inorganic Chemistry by S. Chandra.
- Advanced Inorganic Chemistry by S. Prakash, G. D. Tuli, S. K. Basu and R. D. Madan.
- Organic Chemistry by I. L. Finar.
- Stereochemistry of Organic Compounds by E. L. Eliel and S. H. Wilen.
- Organic Chemistry by Boyd, Morrison and Bhattacharjee.
- Reaction mechanism in Organic Chemistry by S. M. Mukerji.
- Undergraduate Organic Chemistry by Jagdamba Singh and L. D. S. Yadav.
- Organic Chemistry by G. Marc. Loudon.
- Atkin's Physical Chemistry: International by P. W. Atkins.
- Physical Chemistry by D. W. Ball.
- Principles of Physical Chemistry by B. R. Puri, M. S. Pathania and L. R. Sharma.
- Essential of Physical Chemistry by A. Bahl, B. S. Bahl and G. D. Tuli.
- Text Book for B. Sc. Chemistry I by A. Bariyar, R. P. Singh and A. Dwivedi.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



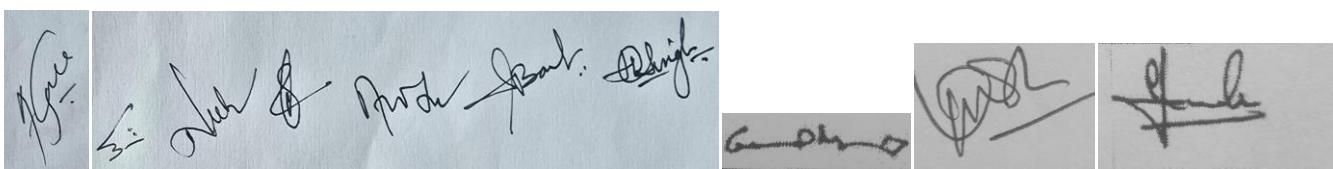
Suggested equivalent online content:

<https://www.youtube.com/watch?v=UJgzQ5XP8wQ&list=PLmxSS9XYst20FfphDeS03pqkcuJk0vuvv>
<https://www.youtube.com/watch?v=2G791CT5Os8&list=PLmxSS9XYst23WTFnTwuRg-Ww0k6foth7e>
<https://www.youtube.com/watch?v=SNXFYz31iFI&list=PLmUlqVgZsTVUfjMBLDQvNLUbF9CIrEsef>
https://www.youtube.com/watch?v=1t0GDMSzZ9A&list=PLmxSS9XYst21dec_6u2yWWj295Y8pHGrA

UNDERGRADUATE DIPLOMA IN CHEMISTRY						
Programme: Undergraduate Diploma in Chemistry		Year:II	Semester: IV Paper: DSC			
Subject:Chemistry						
Course:DSC (Practical)	CourseTitle: Chemical Analysis-IV					
Course Outcomes:						
After studying this course, the students will be able to:						
<ul style="list-style-type: none"> Analyze inorganic salts for the presence of acidic radicals including interfering radicals along with basic radicals from III and IV groups Qualitatively differentiate between aldehydes, ketones and carboxylic acids 						
Determine the solubility of salts						
Chemical Analysis-IV						
Credits:1		Discipline Specific Course				
Max.Marks:As per University rules		Min. Passing Marks:As per University rules				
Unit	Topic	No.of Hours				
Unit I	Laboratory hazards and safety precautions	04				
Unit II	Inorganic exercise: Volumetric exercise (double titration) based on redox reaction involving internal as well as external indicators. Gravimetric analysis of metal ions: $\text{Ba}^{2+}/\text{Ni}^{2+}/\text{Zn}^{2+}$	08				
Unit III	Organic exercise: Systematic analysis and identification of aldehydes, ketones and carboxylic acids. Differentiation between aldehyde and ketones.	10				
Unit IV	Physical exercise: Determination of solubility of salts./ Experiment based on Electrochemistry	08				

Note: Allocation of marks - External assessment: Total marks 75 (Inorganic exercise 20; Organic exercise 20; Physical exercise 20; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05).

Recommended Readings



- Vogel's Quantitative Chemical Analysis by J. Mendham.
- Instrumental Methods of Analysis by H. H. Willard.
- Analytical Chemistry by G. D. Christian.
- Exploring Chemical Analysis by D. C. Harris.
- Basic Concepts of Analytical Chemistry by S. M. Khopkar.
- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman.
- Laboratory Handbook of Chromatographic & Allied Methods by O. Mikes and R. A. Chalmes.
- Analytical Chemistry: Methods of separation by R. V. Ditts.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Suggested equivalent online content:

<https://www.labster.com/chemistry-virtual-labs/>

<https://www.vlab.co.in/broad-area-chemical-sciences>

<http://chemcollective.org/vlabs>

Semester-IV

Undergraduate Diploma in Chemistry

DISCIPLINE SPECIFIC ELECTIVE (DSE 4) Chemistry of Biomolecules

No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Chemistry of Biomolecules	4	4	-	-	Passed Class XII with Chemistry	Nil

UNDERGRADUATE DIPLOMA IN CHEMISTRY

Programme: Undergraduate Diploma in Chemistry	Year: II	Semester: IV
		Paper: DSE 4

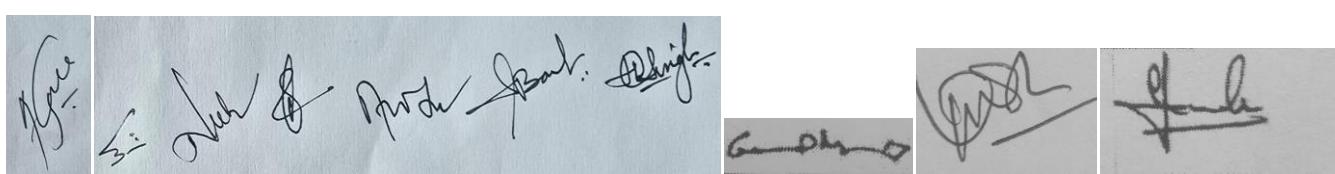
Subject:Chemistry

Course:DSE 4 **CourseTitle:** Chemistry of Biomolecules

Course Outcomes:

- Understand the importance of bio molecules in our biological system.
- Gain knowledge about their natural sources and diseases caused by the vitamin and mineral deficiencies.

General Organic Chemistry

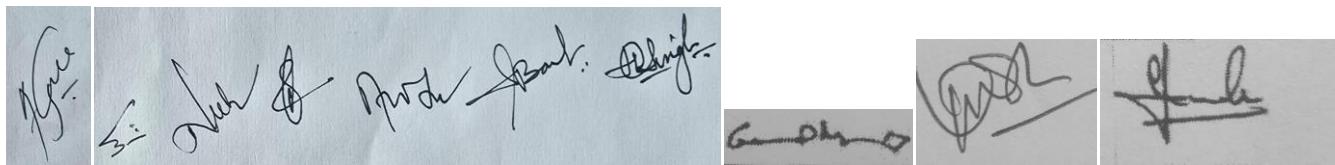


Credits:4		Discipline Specific Elective
Max. Marks:As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	Amino acids: Classification, Pk value, Zwitter ion, isoelectric point, Configuration of amino acids.	15
Unit II	Vitamins and Minerals: Types of vitamins and their sources and functions; Minerals and their sources and functions, Vitamin and mineral deficiencies	15
Unit III	Carbohydrates: Classification, and general properties, glucose and fructose (open chain and cyclic structure), determination of configuration of monosaccharides, absolute configuration of glucose and fructose, mutarotation.	15
Unit IV	Lipids: Classification, Biological importance of triglycerides and phosphor glycerides and cholesterol; Liposomes and their biological functions and underlying applications.	15

Recommended Readings

- Textbook of Biochemistry with Clinical Correlation by T. M. Devlin.
- Biochemistry by J. M. Berg, J. L. Tymoczko and L. Stryer.
- Fundamentals of Biochemistry by U. Satyanarayana, U. Chakrapaniand.
- Principles of Biochemistry by A. L. Lehninger, D. L. Nelson, M. M. Cox.
- Harper's Illustrated Biochemistry by R. K. Murray, D. K. Granner, P. A. Mayes, V. W. Rodwell.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in class or on-line tests, home assignment, group discussions or oral presentations.



Semester-IV

Undergraduate Diploma in Chemistry

GENERIC ELECTIVE (GE 4)

Basics of Chemistry-IV

No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

CourseTitle	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE 4: Basics of Chemistry-IV	4	4	-	-	Passed Class XII	Nil

UNDERGRADUATE DIPLOMA IN CHEMISTRY

Programme:Undergraduate Diploma in Chemistry

Year:II

Semester:IV

Subject:Chemistry

Course:GE CourseTitle: Basics of Chemistry-IV

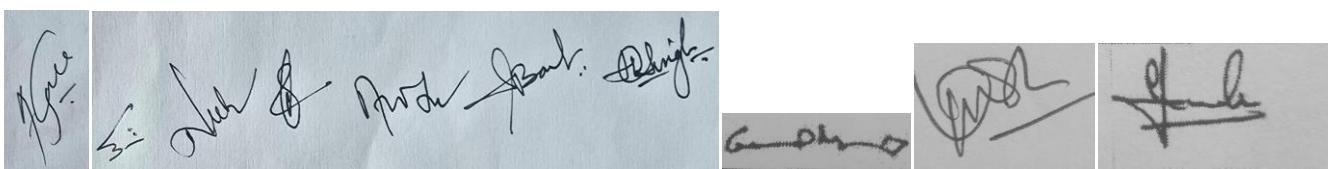
Course Outcomes:

After studying this course, the students will be able to:

- Understand the basic concepts of electronegativity and polarization of covalent bond and its significance
- Explain the types of solutions and their uses in daily life.
- Understand different phenomena based on chemistry in the chemical world.
- Define crystallography and types of distillation.
- Understand the concept of isomerism and stereochemistry in chemical compounds.

Yours
W. H. Brewster
Mass. Audubon Society
Concord

Credits:4 Max.Marks:As per University rules		Generic Elective 4 Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	Electronegativity and polarization of covalent bond; Inductive, mesomeric, electromeric effect, Resonance, dipole dipole bonding, vanderwaal bonding, Hydrogen bonding and its significance Isomerism in Co-ordination Compound Concept of isomerism, Types of isomerism: Structural Isomerism and its type, Stereoisomerism	
Unit II	Liquid States: Differences between solids, liquids and gases. Liquid State- Intermolecular forces, Physical properties of liquids including their methods of determination: surface tension, viscosity, Numerical problems. Solution Chemistry Solutions, characteristics of solutions, solute and solvent, saturated, unsaturated and super saturated solutions, effect of temperature on solution, neutral, acidic and alkaline solutions, Solubility, suspensions, colloidal solutions.	15
Unit III	Crystallization: definition evaporative and cooling crystallization, Types of crystals. Distillation: Simple distillation, distillation theory, fractional distillation, difference between simple and fractional distillation. Reduced pressure distillation.	15
Unit IV	Applied Chemistry: Chemistry around us as drugs, dyes, polymers, medicines, hormones, Food, beverages, colour, fragrances, Chemicals, fertilizers, paint, cosmetics, alloys. Understanding Our Chemical World a. Explanation of the following observations/ phenomenon with the help of the concepts learned 1. Why does the mercury in a barometer go up when the air pressure increases? (Gaseous Laws) 2. Why does a hot-air balloon float? (Relation between pressure and temperature) 3. Why is it unwise to incinerate an empty can of air freshener? (Relation between pressure and temperature) 4. Why does petrol evaporate faster than water at the same temperature? (Intermolecular interactions) 5. Why chlorine gas lethal is yet sodium chloride is vital for life? (Chemical bonding, ion) 6. What is the reason for the fizzing of cold drinks? (Solubility and pressure) 7. What is the state of matter in a hot star like the sun? (States of matter) 8. Alcohol (ethanol) is miscible with water but petrol is immiscible. Why? Intermolecular interactions)	20



<p>9. The elements of group 18 in the modern periodic table are called as noble gases. Why? (Periodic Table)</p> <p>10. If we take 10 g of hydrogen and make it react with 50g of oxygen to form water, part of the hydrogen remains unreacted whereas the whole oxygen is consumed. Why? (Stoichiometry).</p> <p>b. Explanation of the following observation/ phenomena with the help of chemical reactions involved:</p> <ol style="list-style-type: none"> 1. The photochromatic glasses become dark in the sun and light in the dark. 2. Fizzing of Eno (A common antacid) on adding water. 3. Use of baking powder to make the bread fluffy. 4. Burning of matchstick with a pungent smell. <p>Bleaching action of bleaching powder.</p>	
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Recommended Readings

- Physical chemistry by Puri, Sharma, Pathania.
- Basic Inorganic Chemistry by Ajai Kumar.
- Concise Inorganic Chemistry by J. D. Lee
- Basic Inorganic Chemistry by Cotton, Wilkinson and Gaus.
- Concepts and Models in Inorganic Chemistry by Douglas, McDaniel and Alexander.
- Inorganic Chemistry: Principles of Inorganic chemistry by Huheey, Keiter, Keiter, and Medhi.
- Understanding our Chemical World by Paul Monk.
- Physical Chemistry by G. M. Barrow.
- Physical Chemistry by G W. Castellan.

Suggested Continuous Evaluation Methods:

Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in class or on-line tests, home assignment, group discussions or oral presentations.

Suggested equivalent online content:

<https://chem.washington.edu/lecture-demos/match-head-reaction>

<https://ncert.nic.in/textbook/pdf>

https://onlinecourses.nptel.ac.in/noc22_cy36/preview

https://onlinecourses.swayam2.ac.in/cec20_lb01/preview

<https://www.youtube.com/watch?v=ZeV3V0DjupQ&list=PLmxSS9XYst20arjxnrIpnL0P99Answm>

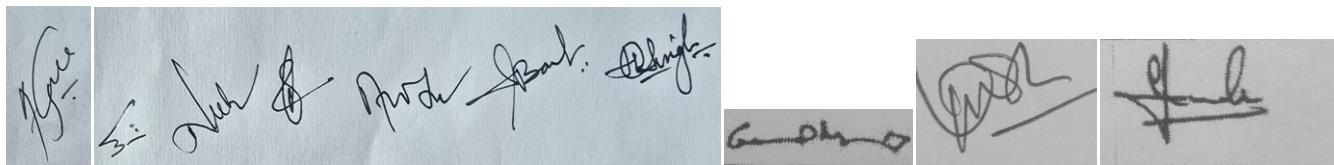
<https://www.youtube.com/watch?v=zGk6VeTfpE&list=PLmxSS9XYst21tCVcVKQ9nZdW3O20i>

<https://www.youtube.com/watch?v=zUwbVaBaxTY&list=PLmxSS9XYst22fU5l0ryKCEZNxuVki6-v>

<https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>

<https://www.youtube.com/watch?v=AYD7YJqQ0Q&t=23s>

<https://www.youtube.com/watch?v=0LaLl1wskEg>



Semester-V**Bachelor of Chemistry**
DISCIPLINE SPECIFIC COURSE (DSC 5)
Inorganic & Organic Chemistry
Chemical Analysis- V
No.of Hours-60**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Inorganic & organic Chemistry	4	3	-	1	Passed B.Sc. IV Sem with Chemistry (DSC)	Nil

Bachelor of Chemistry

Programme: Bachelor of Chemistry	Year:III	Semester: V
Paper: DSC 5		

Subject:Chemistry

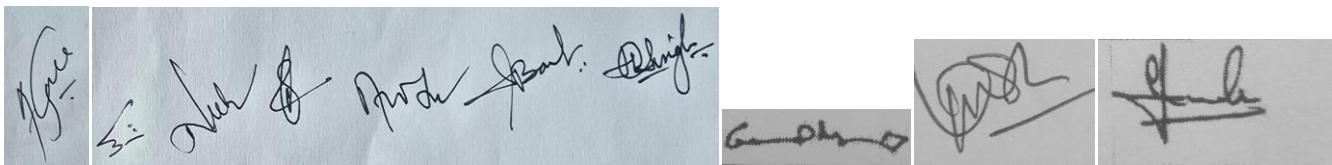
Course:DSC 5 (Theory)	CourseTitle: Inorganic & Organic Chemistry
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Course Outcomes:

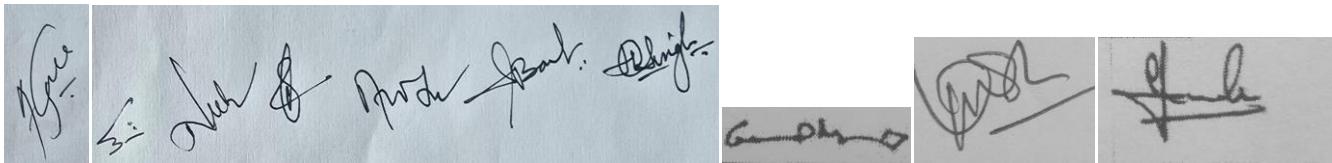
After studying this course, the students will be able to:

- Describe bonding, EAN and 18-electron rule of metal carbonyls and metal nitrosyls.
- Learn about organometallic compounds, some industrially important inorganic materials and their applications in various industries.
- Understand the various regants utilized in organic synthesis.
- Describe crystal field theory, electronic spectra, magnetic properties and stability of coordination compounds.
- Describes selection rules and, Orgel diagrams for explaining possible electronic transitions and colour of complexes.
- Have a broader idea about the nitrogen containing organic compounds.
- Understand about the carbohydrates and proteins.

Credits: 3	Discipline Specific Course
Max.Marks: As per University rules	Min. Passing Marks: As per University rules



Unit	Topic	No. of Hours
Unit I	<p>Organometallic chemistry: Metal carbonyls and metal nitrosyls. Nature of bonding, structure and preparation. EAN and 18-electron rule. Definition, nomenclature, classification, general methods of preparation of organometallic compounds and a brief account of metal-ethylenic complexes. Applications of organometallic compounds.</p> <p>Reagents in Organic Synthesis: Reagent compounds, types of reagents, NBS, n-butyl lithium, chromium trioxide, LiAlH_4, OsO_4, sodium borohydride (NaBH_4).</p>	10
Unit II	<p>Electronic Spectra of Transition Metal Complexes: Types of electronic transitions, selection rules for d-d transitions, calculations of spectroscopic ground states (Russell Saunders/L-S coupling), Orgel energy level diagram for d^1, d^4 and d^6, d^9 tetrahedral and octahedral complexes, discussion of the electronic spectrum of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ complex ion.</p>	10
Unit III	<p>Magnetic Properties of Transition Metal Complexes: Origin of magnetic behavior, concept of magnetic susceptibility, diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism and antiferromagnetism, magnetic moments, quenching of orbital magnetic moment by crystal field, magnetic susceptibility- definition relationship with temperature, Curie law and Curie Weiss law.</p>	10
Unit IV	<p>Nitrogen Containing Organic Compounds:</p> <p>Nitro compounds: Chemical reactions of nitroalkanes. Mechanism of nucleophilic substitution in nitroarenes and their reduction in acidic, neutral and alkaline medium.</p> <p>Amines: Physical properties, Structural features affecting basicity of amines. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), Gabriel-phthalimide reaction. Reaction of amines, electrophilic aromatic substitution in aryl amines. Synthetic transformations of aryl diazonium salts, azo coupling.</p> <p>Carbohydrates and Proteins:</p> <p>Carbohydrates: Classification, Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chainlengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers. Cyclic structure of D(+)-glucose. Mechanism of mutarotation.</p> <p>Proteins: Classification. Structure, Properties and stereochemistry of amino acids. Acid-base behavior, Zwitter ions, isoelectric point and electrophoresis, General introduction of peptides.</p>	15



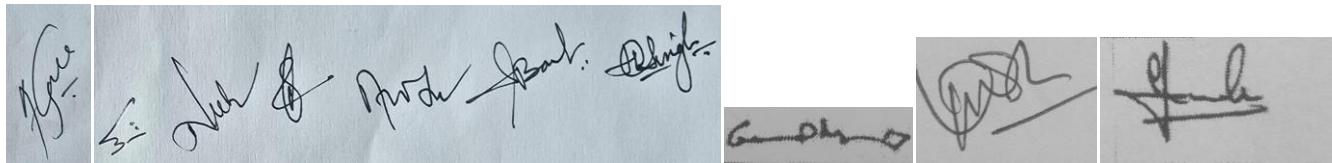
Recommended Readings

- Concise Inorganic Chemistry by J. D. Lee.
- Principles of Inorganic Chemistry by B. R. Puri, L. R. Sharma and K. C. Kalia.
- Chemistry for Degree Students, B. Sc. Second Year by R. L. Madan.
- Selected topics in Inorganic Chemistry by R. D. Madan, U. M. Malik and G. D. Tuli.
- Comprehensive Inorganic Chemistry by S. Chandra.
- Advanced Inorganic Chemistry by S. Prakash, G. D. Tuli, S. K. Basu and R. D. Madan.
- Organic Chemistry by I. L. Finar.
- Stereochemistry of Organic Compounds by E. L. Eliel and S. H. Wilen.
- Organic Chemistry by Boyd, Morrison and Bhattacharjee.
- Reaction mechanism in Organic Chemistry by S. M. Mukerji.
- Undergraduate Organic Chemistry by Jagdamba Singh and L. D. S. Yadav.
- Organic Chemistry by G. Marc. Loudon.
- Atkin's Physical Chemistry: International by P. W. Atkins.
- Physical Chemistry by D. W. Ball.
- Principles of Physical Chemistry by B. R. Puri, M. S. Pathania and L. R. Sharma.
- Essential of Physical Chemistry by A. Bahl, B. S. Bahl and G. D. Tuli.
- Text Book for B. Sc. Chemistry I by A. Bariyar, R. P. Singh and A. Dwivedi.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in class or on-line tests, home assignment, group discussions or oral presentations.

Suggested equivalent online content:

<https://www.youtube.com/watch?v=0BQ38GEYF7s&list=PLmxSS9XYst22OYcJbKWq66APcEq5pVsL1>
<https://www.youtube.com/watch?v=9oQcm281TT0&list=PLmxSS9XYst20MhuKSMREzLhG4ZBIdNys9>
https://www.youtube.com/watch?v=WGd4gOncw9s&list=PLmxSS9XYst22CtJwFrXW_VA9kCp7OP0kn
<https://www.youtube.com/watch?v=R4rPlpWT1cA&list=PLmxSS9XYst21uxf3tsohnDUmTRFrvfVv8>
<https://www.youtube.com/watch?v=3TWLAJuVN0c&list=PLmxSS9XYst23hk5m9-MsHTpbADe1Mx-p8>
<https://www.youtube.com/watch?v=0k4ryWpwhmo&list=PLmxSS9XYst22xP0d02UtcIlgt0GlofvVm>
<https://www.youtube.com/watch?v=0ZBMRjyHWfY&list=PLmxSS9XYst205pTMkWPmDa31v0s6DFoXM>
https://www.youtube.com/watch?v=najS_fXL38U&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=6
<https://www.youtube.com/watch?v=3VoKRgPj7OI&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=8>
<https://www.youtube.com/watch?v=57hQHf1E3PE&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=7>

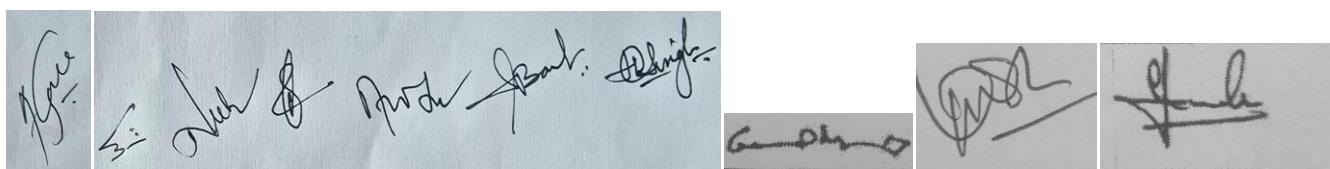


UNDERGRADUATE DEGREE IN CHEMISTRY				
Programme: Undergraduate Degree in Chemistry	Year: III	Semester: V Paper: DSC		
Subject: Chemistry				
Course: DSC (Practical)	CourseTitle: Chemical Analysis-V			
Course Outcomes:				
After studying this course, the students will be able to:				
<ul style="list-style-type: none"> Knowledge and skills to understand the inorganic synthesis. Analyze the inorganic salts containing acidic radicals and basic radicals form V and VI groups. Separate the binary organic mixture and identify the organic compounds present in it. 				
Chemical Analysis-V				
Credits: 1	Discipline Specific Course			
Max.Marks: As per University rules	Min.Passing Marks: As per University rules			
Unit	Topic	No.of Hours		
Unit I	Laboratory hazards and safety precautions	04		
Unit II	i. Inorganic synthesis: Cuprous chloride, potash alum, chrome alum, ferrous oxalate, ferrous ammonium sulphate, tetraamminecopper (II) sulphate and hexaamminenickel(II) chloride. Crystallization of compounds.	08		
	ii. Inorganic salt analysis: All acidic radicals and basic radicals containing interfering radicals.	06		
Unit III	i. Organic qualitative analysis: Separation and identification of organic mixture by water	08		
	ii. Organic synthesis: Through nitration, halogenation, acetylation, sulphonation and simple oxidation	04		

Note: Allocation of marks - External assessment: Total marks 75 (Inorganic exercise 30; Organic exercise 30; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05).

Recommended Readings

- Vogel's Quantitative Chemical Analysis by J. Mendham.
- Instrumental Methods of Analysis by H. H. Willard.
- Analytical Chemistry by G. D. Christian.
- Exploring Chemical Analysis by D. C. Harris.
- Basic Concepts of Analytical Chemistry by S. M. Khopkar.



- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman.
- Laboratory Handbook of Chromatographic & Allied Methods by O. Mikes and R. A. Chalmes.
- Analytical Chemistry: Methods of separation by R. V. Ditts.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Suggested equivalent online content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>

Semester-V

Bachelor of Chemistry

DISCIPLINE SPECIFIC ELECTIVE (DSE 5)
Analytical Methods in Chemistry

No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 5: Analytical methods in Chemistry	4	4	-	-	Passed B.Sc. IV Sem with Chemistry	Nil

Bachelor of Chemistry

Programme: Bachelor of Chemistry	Year: III	Semester: V
		Paper: DSE 5

Subject:Chemistry

Course Code: DSE 5 **Course Title: Analytical methods in Chemistry**

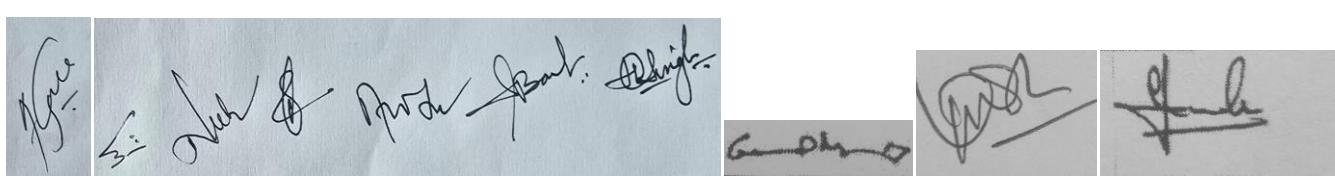
Course Outcomes:

After studying this course, the students will be able to:

- Understand about the different techniques utilized in solvent extraction.
- To know about the basics of chromatographic technique and optical methods of analysis.
- Understand about the thermal and electroanalytical methods of analysis.
- Define the quantitative and qualitative aspects of analysis.

Credits:4

Discipline Specific Elective

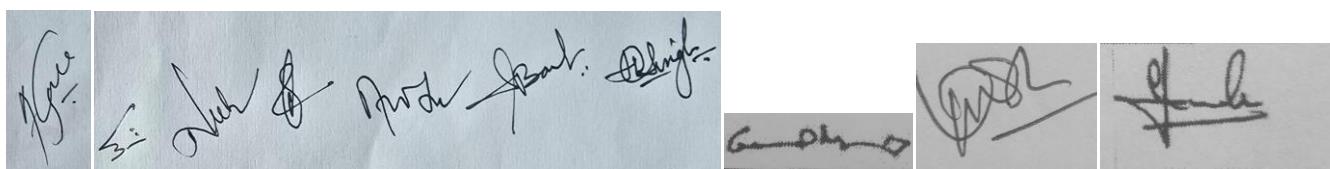


Max.Marks: As per University rules		Min.Passing Marks:As per University rules
Unit	Topic	No. of Hours
Unit I	Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation, Technique of extraction: batch, continuous and counter current extractions, Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution.	15
Unit II	Chromatography: Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition & ion-exchange, Development of chromatograms: frontal, elution and displacement methods.	12
Unit III	Optical methods of analysis: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Transmittance. Absorbance and Beer-Lambert law Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.	15
Unit IV	Thermal methods of analysis: Theory of thermogravimetry (TG) and basic principle of instrumentation of thermal analyser. Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values. Qualitative and quantitative aspects of analysis: Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression. Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.	18

Recommended Readings

- Physical chemistry by Puri, Sharma, Pathania.
- Advanced Physical Chemistry by D.N.Bajpai.
- Modern Physical Chemistry by Kundu and Jain.
- Nuclear Chemistry by Arnikar.
- Fundamentals of Photochemistry by K.K.Rohtagi and Mukherji.
- Essentials of Molecular Photochemistry by A.Gilbert and J.Baggott.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in class or on-line tests, home assignment, group discussions or oral presentations.



Semester-V

Bachelor of Chemistry

GENERIC ELECTIVE (GE 5)

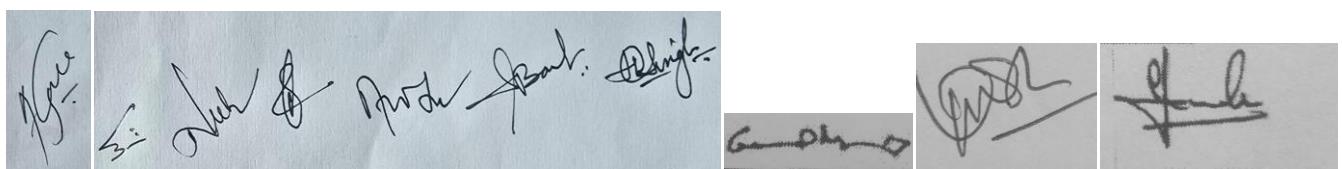
Basics of Chemistry-V

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Basics of Chemistry-V	4	4	-	-	Passed Class XII	Nil

Bachelor of chemistry		
Programme: Bachelor of Chemistry	Year:III	Semester:V
Subject: Chemistry		
Course:GE 5	CourseTitle: Basics of Chemistry-V	
Course Outcomes:		
After studying this course, the students will be able to:		
<ul style="list-style-type: none"> • Understand the chemistry of sustainable green reactions. • To understand the chemistry of natural products • A basic introduction to chromatography and its types • Have a broad picture of UV- Visible and IR spectroscopy. 		
Credits:4	Generic Elective	
Max.Marks:As per University rules	Min. Passing Marks:As per University rules	
Unit	Topic	No.of Hours
Unit I	Green Chemistry: Basic principles of green chemistry. Designing green reagents: green catalyst phase transfer catalysis for green synthesis choice of starting materials, organic synthesis in solid phase reagents, and versatile ionicliquids as Scherrer method.	13
Unit II	Natural Products: Introduction, Primary and Secondary metabolites, use of natural products in traditional medicine, potential of natural products, natural products in drug discovery and development.	15



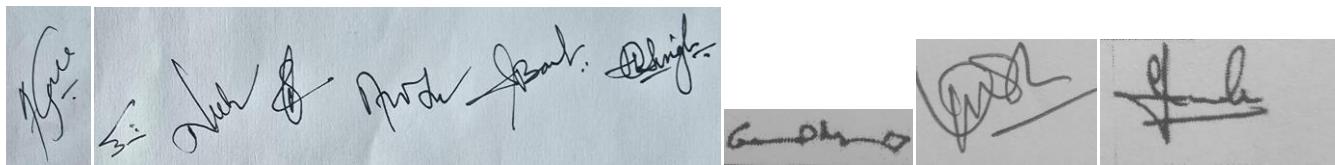
	Chemistry of natural products: Introduction, occurrence, classification, extraction, isolation, separation, purification	
Unit III	Chromatography: An introduction to Chromatography, Principle, instrumentation and applications of gas and liquid chromatography, Partition Chromatography, Adsorption Chromatography, ion, size-exclusion Chromatography. Extraction-distribution law. Principle and application of TLC, paper, and column chromatography	12
Unit IV	<p>Ultra Violet-Visible Spectroscopy: Introduction, principle, various electronic transitions (185 to 800 nm), Lambert-Beer's Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds. Instrumentation and applications. Problem based on UV.</p> <p>Infra-red Spectroscopy: Introduction, principle, instrumentation and sample handling. Selection rules, normal modes of vibration, Characteristic vibrational frequencies of various functional groups. Problem based on IR.</p>	18

Recommended Readings:

- Introductory Chemistry by J. Nivaldo and Ho Yu Au-Yeung Tro.
- Basic Chemistry by K. C. Timberlake
- Microscale and Macroscale Techniques in the Organic Laboratory by D. L. Pavia, G. M. Lampman, G. S. Kriz and R. G. Engel.
- Exploring Chemical Analysis by D. C. Harris.
- Quantitative Chemical Analysis by D. C. Harris
- Fundamental Concepts of Applied Chemistry by Jayshree Ghosh.
- Principles of Instrumental Analysis by Skoog.
- Organic Chemistry by I. L. Finar.
- Green Chemistry by V. K. Ahluwalia.
- Environmental Chemistry by W. van Loon and J. Duffy Stephen.
- Environmental Chemistry by A.K. Day.

Suggested Continuous Evaluation Methods:

Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



Semester-VI
Bachelor of Chemistry

DISCIPLINESPECIFIC COURSE (DSC 6)
Physical & Analytical Chemistry

No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Physical & Analytical Chemistry (Theory) Chemical Analysis-VI (Practical)	4	3	-	1	Passed B.Sc. Sem V with Chemistry (DSC)	Nil

Bachelor of Chemistry

Programme: Bachelor of Chemistry

Year:III

Semester: VI

Paper:DSC 6

Subject: Chemistry

Course: DSC 6 (Theory)

CourseTitle: Physical & Analytical Chemistry

Course Outcomes:

After studying this course, the students will be able to:

- Understand Surface Phenomenon, Freundlich's and Langmuir's adsorption model.
- Help to the students to gain the knowledge of Elementary Quantum Mechanics and Photochemistry.
- Assess the types of errors and the importance of accuracy and precision.
- Understand various analytical techniques and their importance.
- Understand spectroscopic techniques will assist the students in solving problems based on the same.

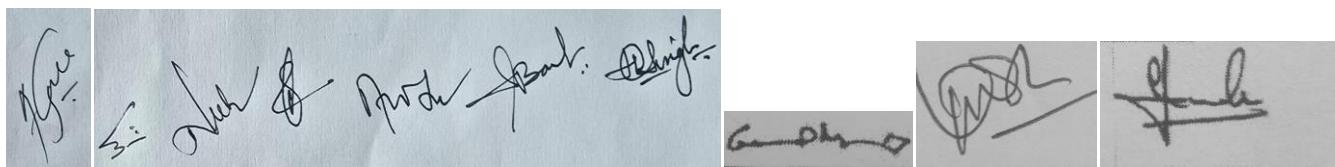
Credits:3

Discipline Specific Course

Max.Marks:As per University rules

Min. Passing Marks: As per University rules

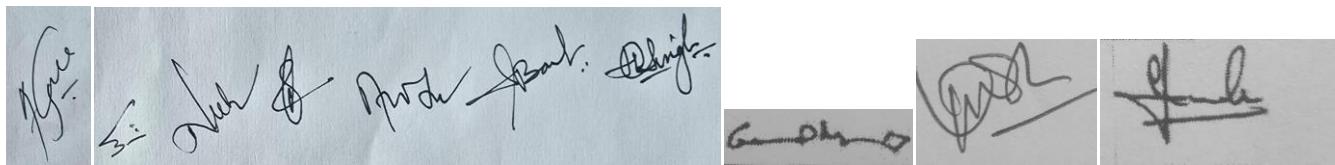
Unit	Topic	
Unit I	Surface Chemistry: Definition of surface phenomenon-Adsorption. Chemical and physical adsorption, Factors affecting adsorption. Isotherm and Isobar. Free energy of adsorption. Quantitative treatment of adsorption, Freundlich's and Langmuir's adsorption model and their applications. Limitation of Langmuir adsorption model.	10



Unit II	Elementary Quantum Mechanics: Black-body radiation, Plank's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects. Compton effect, de Broglie hypothesis, Heisenberg's uncertainty principle, operator concept, Hamiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, Numerical Problems.	10
Unit III	Photochemistry: Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry, Grothuss-Draper law, Lambert's law, Lambert-Beer's law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, Numerical Problems.	10
Unit IV	<p>Analytical Techniques: Basic concepts of electro-gravimetric and coulometric analysis. Thermo gravimetric analysis. Voltammetry; principle of polarography</p> <p>Chromatography: Introduction, types, paper and column chromatography</p> <p>Spectroscopy: Electromagnetic radiation, Ultraviolet (UV) spectroscopy-absorption laws (Beer-Lambert law), molar absorptivity, types of electronic transitions, effect of conjugation, concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones.</p> <p>Infra-Red (IR) spectroscopy: molecular vibrations, Hooke's Law, selection rules, measurement of IR spectrum, finger print region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds. Problems based on UV and IR.</p> <p>Data Analysis: Errors, Definition, types of errors, precision, accuracy, absolute, Significant Figures; significant figures in Arithmetics-addition, subtraction, multiplication and division, Mean and Standard deviation, Standard deviation and probability.</p>	15

Recommended Readings

- Chemistry for Degree Students by R. L. Madan.
- Atkin's Physical Chemistry: International by P. W. Atkins.
- Principles of Physical Chemistry by Puri, Pathania and Sharma.
- Essential of Physical Chemistry by A. Bahl, B. S. Bahl and G.D. Tuli.
- Physical Chemistry by P. Atkins and J. de Paula.
- Physical Chemistry by W. J. Moore.
- Fundamentals of Photochemistry by K.K. Rohtagi and Mukherji.
- Essentials of Molecular Photochemistry by A. Gilbert and J. Baggott.
- Introduction to Quantum Chemistry by A. K. Chandra.



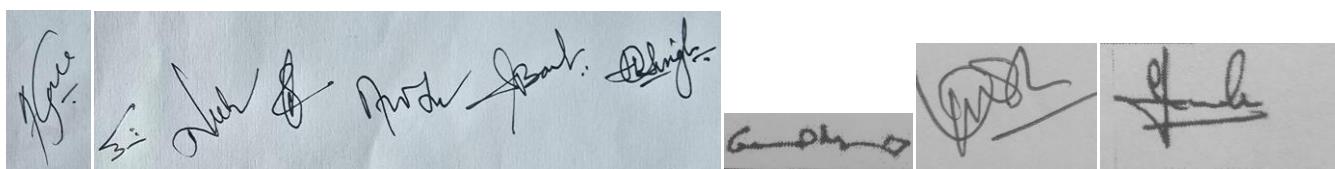
Suggested Continuous Evaluation Methods:

Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested online content:

<https://www.youtube.com/watch?v=CMYg3ElZwDY>
https://www.youtube.com/watch?v=01dY_ILWdMA&t=4s
https://onlinecourses.nptel.ac.in/noc20_cy27/preview
https://onlinecourses.nptel.ac.in/noc21_cy20/preview
<https://www.classcentral.com/course/swayam-chemistry-i-introduction-to-quantum-chemistry-and-molecular-spectroscopy-3981>
<https://www.classcentral.com/course/swayam-quantum-chemistry-of-atoms-and-molecules-19982>
<https://www.classcentral.com/course/swayam-concepts-of-thermodynamics-13015>
https://onlinecourses.nptel.ac.in/noc20_me20/preview
<https://www.careers360.com/university/indian-institute-of-technology-kharagpur/concepts-of-thermodynamics-certification-course>
https://onlinecourses.nptel.ac.in/noc22_cy14/preview
https://onlinecourses.nptel.ac.in/noc20_cy22/preview
https://onlinecourses.nptel.ac.in/noc21_cy45/preview
https://onlinecourses.nptel.ac.in/noc21_ch48/preview

UNDERGRADUATE DEGREE IN CHEMISTRY				
Programme: Undergraduate Degree in Chemistry	Year: III	Semester: VI Paper: DSC		
Subject:Chemistry				
Course: DSC (Practical)	CourseTitle: Chemical Analysis-VI			
Course Outcomes:				
After studying this course, the students will be able to:				
<ul style="list-style-type: none"> • Understanding the laboratory hazards and safety precautions. • To determine the solubility of organic compound by titration method. • To know about the heat of neutralization. • Able to separate organic compounds using paper chromatography. 				
Chemical Analysis-VI				
Credits: 1	Discipline Specific Course			
Max.Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No.of Hours		
Unit I	Laboratory hazards and safety precautions	04		



Unit II	Physical exercise: i. Determination of solubility of organic compound (viz.oxalic acid) in water by titration method. Determination of Heat of neutralization.	12
Unit III	Chromatographic technique: Demonstrative Chromatography- paper chromatography (separation of organic compounds-Amino acids/ dyes)	14

Note: Allocation of marks - External assessment: Total marks 75 (Physical exercise 30; Chromatographic technique: 30; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05).

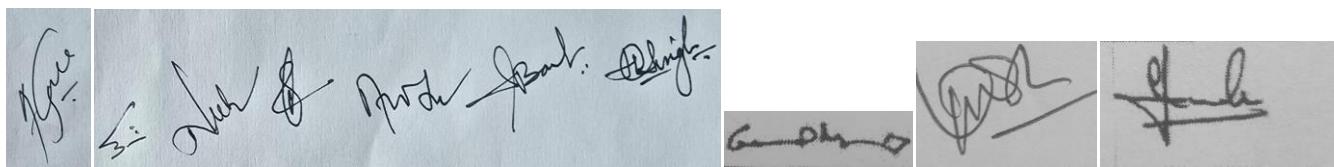
Recommended Readings

- Vogel's Quantitative Chemical Analysis by J. Mendham.
- Instrumental Methods of Analysis by H. H. Willard.
- Analytical Chemistry by G. D. Christian.
- Exploring Chemical Analysis by D. C. Harris.
- Basic Concepts of Analytical Chemistry by S. M. Khopkar.
- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman.
- Laboratory Handbook of Chromatographic & Allied Methods by O. Mikes and R. A. Chalmes.
- Analytical Chemistry: Methods of separation by R. V. Ditts.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Suggested equivalent online content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>



Semester-VI

Bachelor of Chemistry

DISCIPLINE SPECIFIC ELECTIVES (DSE 6)

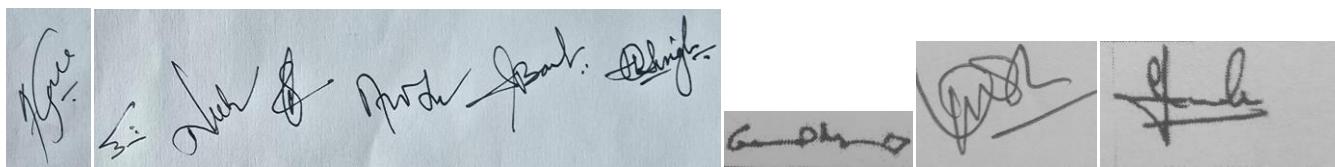
General Analytical Techniques

No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 6: General Analytical Chemistry	4	4	-	-	Passed B.Sc. Sem V With Chemistry	Nil

Bachelor of Chemistry		Year:III	Semester:VI
Programme: Bachelor of Chemistry		Paper: DSE 6	
Subject: Chemistry			
Course: DSE 6	CourseTitle: General Analytical Techniques		
Course Outcomes:			
After studying this course, the students will be able to:			
<ul style="list-style-type: none"> Understand the basic principles of UV-Visible, Mass, IR, Molecular spectroscopic techniques. Understanding the applications of these spectroscopic techniques instructure elucidation. 			
Credits:4	Discipline Specific Elective 6		
Max.Marks:As per Univ.rules	Min.Passing Marks: As per Univ. rules		
Unit	Topic		No.of Hours
UnitI	UV-Visible Spectroscopy: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules. Types of electronic transitions, λ_{max} , chromophores and auxochromes, Bathochromic and Hypsochromic shifts. Problems based on UV.		15
UnitII	Introduction to Mass Spectrometry: Principle of massspectrometry, the mass spectrum, massspectrometry diagram, Molecular ion, metastable ion, base peak, fragmentation process. Applicationsof mass spectrometry. Problems based on MassSpectrometry.		15
UnitIII	Infra-Red (IR) absorption spectroscopy: molecular vibrations, selection rules, intensity and position of IR bands, measurementof IR spectrum, finger printregion, characteristic absorptions of various functional groups andinterpretation of IR spectraofsimpleorganic compounds. Problems based on		15



	Infra-Red (IR).	
UnitIV	Molecular Spectroscopy: Introduction: Electromagnetic radiation, regions of the spectrum, statement of the Born-Oppenheimer approximation, degrees of freedom Rotational Spectrum: Diatomic molecules. Energy levels of a rigid rotor (semi-classical principles), selection rules, determination of bond length, isotope effect.	15

Recommended Readings

- Fundamentals of Molecular Spectroscopy by C. N. Banwell and E. M. Mccash.
- Introduction to Spectroscopy by D. L. Pavia.
- Biochemistry by T. A. Brown
- Organic Chemistry by I. L Finar.
- Instrumental methods of analysis by H. H. Willard L. L. Jr. Merritt, J. A. Dean and F. A. Jr. Settle.
- Analytical Chemistry by G. D. Christian.
- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and S. Crouch.
- Elementary Spectroscopy by Y.R.Sharma.

Suggested Continuous Evaluation Methods:

Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Semester-VI

Bachelor of Chemistry

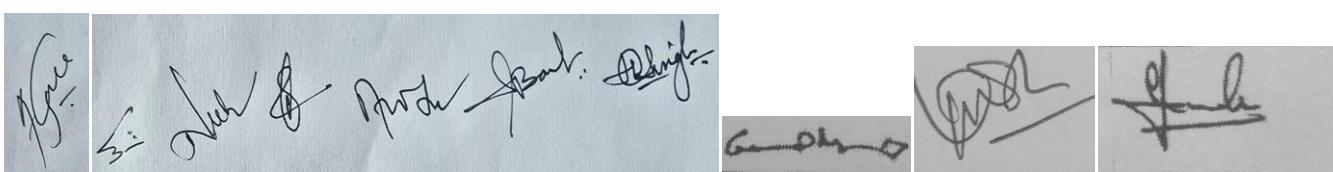
GENERIC ELECTIVES (GE 6)

Basics of Chemistry-VI

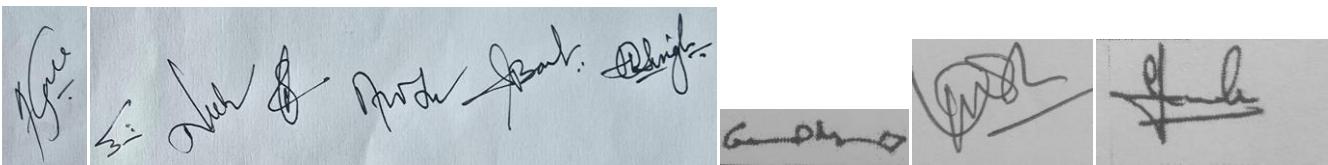
No.of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Basics of Chemistry-VI	4	4	-	-	Passed Class XII	Nil
Bachelor of Chemistry						



Programme: Bachelor of Chemistry		Year:III	Semester: VI					
Paper: GE 6		Subject:Chemistry						
Course:GE 6	CourseTitle: Basics of Chemistry-VI							
Course Outcomes:								
After studying this course, the students will be able to:								
<ul style="list-style-type: none"> • Understand the theory behind nano chemistry and Green Chemistry. • Regarding the carbohydrates, proteins, and nucleic acids. • Understand the chemistry behind the synthetic dyes, making of soap and detergents. • Understand the importance of chemical approach to polymers with respect to synthesis and various polymerization reactions. • Understanding the classification of oils and fats 								
Credits:4	Generic Elective							
Max.Marks:As per University rules	Min.Passing Marks: As per University rules							
Unit	Topic	No of Hours						
UnitI	Nanochemistry: History, definition, and scope of nanomaterials, chemical methods for synthesis of nanomaterials methods of characterization, determination of particle size and surface structure. Green Chemistry: Basic principles of green chemistry. Designing green reagents: green catalyst phase transfer catalysis for green synthesis choice of starting materials, organic synthesis in solid phase reagents	15						
UnitII	Chemistry of carbohydrate: classification of carbohydrate, reducing and non reducing sugars, General properties of glucose and fructose their open chain structure, epimers and mutarotation, monomers etc. Protein and nucleic acids: Introduction, Structure and nomenclature of proteins, classification, uses. Nucleic acid: introduction, constituents of nucleic acid, Ribonucleosides and ribonucleotides (nomenclature). DNA	15						
UnitIII	Synthetic dyes: Colour and constitution classification of dyes. Formation, occurrence, uses Medicinal Chemistry: Primary knowledge of structure activity relationship, SAR, quantitative structure activity relationship (QSAR), Chemistry of antineoplastic agents and cardiovascular drugs.	15						
UnitIV	Fats, Oils and Detergents: Natural fats, edible and industrial oils of vegetable origin, common fatty acids, Saponification value, iodine value, Soaps, synthetic detergents, alkyl and aryl sulphonates Polymers: Polymers and their characteristics, classification of polymer, natural synthetic, crosslinked and network, plastic elastomers, fiber, homopolymers, copolymers, bonding in polymers, primary and secondary bond force of polymer. Polymerization addition or chain-growth polymerization. Free radical vinyl	15						

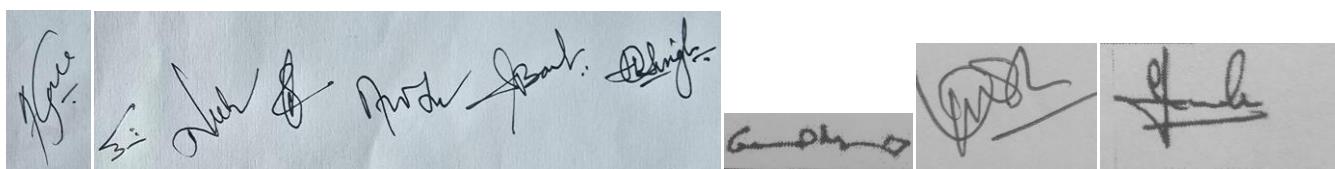


	polymerization, ionic vinyl polymerization, natural and synthetic rubbers.	
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Recommended Readings:

- Nanochemistry by G.B.Sergeev, K.J. Klabunde.
- Nanotechnology: Importance and Application by M.H.Fulekar.
- Nanotechnologies, Hazards, and Resource efficiency by M.Stinfeldt.
- Nanotechnology: Health and Environmental risk by JoAnneShatkin.
- Handbook of Nano fabrication by GaryWiederrcht.Elsevier,2010.
- Nano structured conductive polymers by AliEftekhari.
- Adsorption and diffusion in nano porous material by Rolando M.A.RaqueMalherbe.
- Environmental Chemistry by A.K.Day.
- Supramolecular Chemistry by J. W.Steed and J. L. Atwood.
- Crystal Engineering: The Design of Organic Solids by G.R.Desiraju.
- Supramolecular Chemistry by J.M.Lehn.
- Toxicology: The Basic Science of Poisons by Casarett and Doull's.
- An Introduction to Toxicology by P.C. Burcham.
- Analytical Chemistry by G.D.Christian.
- Analytical Chemistry: Principles by J.H.Kennedy.
- Fundamentals of Molecular Spectroscopy by C.N.Banwell and E.M.McCash.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



Semester-VII
Bachelor of Chemistry with Honours

DISCIPLINE SPECIFIC COURSE (DSC 7)
Advanced Chemistry I (Theory)
Advanced Experimental Chemistry -I (Practical)

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Advanced Chemistry I (Theory) Advanced Experimental Chemistry -I (Practical)	4	3	-	1	Chemistry in Bachelor of Science	Nil

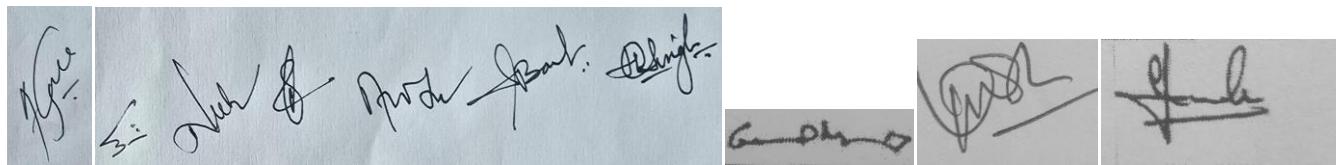
BACHELOR OF CHEMISTRY WITH HONOURS

Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: VII
		Paper: DSC 7

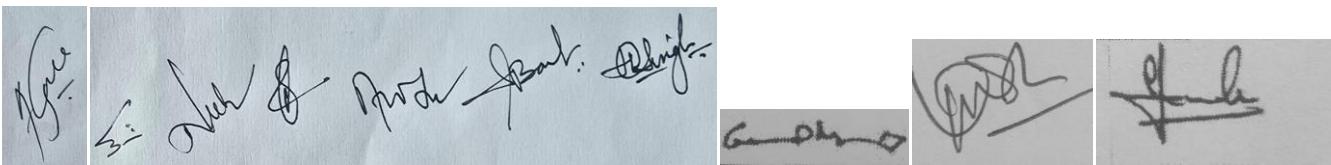
Subject: Chemistry	
Course: DSC 7	Course Title: Advanced Chemistry I

Course Outcomes:
Upon successful completion of this course, the students will be able to:
<ul style="list-style-type: none"> Have a deep knowledge of the electronic spectra of transition metal complexes Learn electronic angular momentum in diatomic molecules Understand the various reaction intermediates of chemical reactions. Have a broad understanding about the Thermodynamics and its relative phenomena. Describe the elements of symmetry, point groups, orthogonality theorem and character table.

Credits: 3	Discipline Specific Course
Max. Marks: As per University rules	Min. Passing Marks: As per University rules
Unit	Topic
Unit I	<p>Electronic Spectra of Transition Metal Complexes:</p> <p>a) Introduction, types of transition, factors affecting band width and intensity, spectroscopic ground state terms (Russell Saunders coupling/ L-S coupling/Spin orbit coupling), determination of spectroscopic terms, atomic terms. Microstates- calculation and representation, Mullikan terms (molecular</p>



	<p>term), splitting of atomic terms in octahedral and tetrahedral field. Correlation diagram (general idea), Orgel diagram, (d^1 - d^{10} octahedral and tetrahedral complexes), selection rules (spin and Laporte) and their relaxation. Discussion of the electronic spectrum of d^1 - d^9 octahedral and tetrahedral complexes. Inter-electronic repulsion parameters-Racah parameters (A, B, C), Nephelauxetic effect. Ground state terms symbol of transition metal complexes. Tanabe Sugano diagram (d^1 - d^9 octahedral complexes). Application of Tanabe-Sugano diagram- Calculation of B, Δ_0, β. Spin-crossover in coordination compounds. Charge transfer spectra- Introduction, types, factors affecting. Spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, magnetic properties- magnetic moment, orbital contribution to magnetic moment.</p> <p>b) Electronic angular momentum in diatomic molecules (classification of states)- calculation of states</p>	
Unit II	<p>Reaction Intermediates in Chemical reactions: Carbocations: Classical and non-classical, neighbouring group participation, molecular rearrangements (Wagner-Meerwein rearrangement, Benzilic acid rearrangement, Schmidt reaction), stability and reactivity of bridge-head carbocations. Carbanions: Generation, structure and stability, and their general reactions (Claisen, Wittig and Mannich reaction).</p> <p>Free Radicals: Generation, structure, stability, types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, autoxidation.</p> <p>Carbenes: Formation and structure, reactions involving carbenes (Reimer Tiemann reaction).</p> <p>Nitrenes: Generation, structure and reactions of nitrenes. Benzyne and cine substitution reaction</p>	11
Unit III	<p>Advanced Thermodynamics-I: Laws of thermodynamics: Fundamental concepts, state and path dependent functions, determination of work done, enthalpy change, and internal energy change in reversible and irreversible expansion and compression, zero, first, second law of thermodynamics and their applications, entropy and its calculations, Nernst heat theorem and third law of thermodynamics, residual entropy</p>	7
Unit IV	<p>Advanced Thermodynamics-II: Free energy and its calculation, properties of Helmholtz free energy and Gibb's free energy, , Clausius-Claypeyron equation, chemical potential and entropies. Partial molar properties; partial molar free energy, partial molar volume and chemical potential and their significance, Gibbs-Duhem equation, Concept of fugacity and its determination, chemical potential and fugacity, thermodynamic functions of mixing.</p>	6
Unit V	<p>Symmetry and Group Theory: Symmetry elements and symmetry operations, definitions of group and subgroup and their characteristics, relation between orders of and subgroup and their characteristics, relation between orders of a finite group and its subgroup. Conjugacy relation and classes of symmetry operations, point symmetry (or group) and its classification, Schonflies symbols, representation of group by matrices</p>	6



	(representation for the C_n , C_{nv} , C_{nh} etc. groups to be worked out explicitly), products of symmetry operations. Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use in spectroscopy.	
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Recommended Readings:

- F. A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, John Wiley & Sons, New York, 2003.
- J. D. Lee, Concise Inorganic Chemistry, Fifth Edition, Wiley India, 2012.
- Atkins, Overton, Rourke, Weller and Armstrong, Inorganic Chemistry, Oxford University Press.
- J. E. Huheey, E. A Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, Fourth Edition, Pearson Education, 2003.
- W. W. Porterfield, Inorganic Chemistry: A Unified Approach, Elsevier.
- G. Wulfsberg, Inorganic Chemistry, Viva Books.
- G. L. Miessler and D. A. Tarr, Inorganic Chemistry, Pearson Education.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online content:

<https://nptel.ac.in/courses/104/106/104106089/>

http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000658/M014009/ET/1456899566C HE P3 M5 etext.pdf

http://ddugu.ac.in/epathshala_content1.aspx

<https://www.uou.ac.in/sites/default/files/slms/BSCCH-301.pdf>

<https://nptel.ac.in/courses/104/106/104106064/>

<https://www.youtube.com/watch?v=bsfMa1nwNEw&list=PLmxSS9XYst21Z1kmeqDbVZM6lp-RWSWIo>

<https://www.youtube.com/watch?v=keoaaCXmUJo&list=PLmxSS9XYst22ylDk1NOSmCLA-i9X7xTzh>

<https://www.youtube.com/watch?v=JbPvMNIcdf8&list=PLmxSS9XYst22VQmOe6CFkXqAjPtCCDg6O>

https://www.youtube.com/watch?v=zUwbVaBaxTY&list=PLmxSS9XYst227ymEa_ovzDf7xs8snXlRp

<https://www.youtube.com/watch?v=9oQcm281TT0&list=PLmxSS9XYst22B6gnqyEAx7R1A4Lqu3nmf>

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>

<https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cy19/>

https://onlinecourses.nptel.ac.in/noc22_cy02/preview

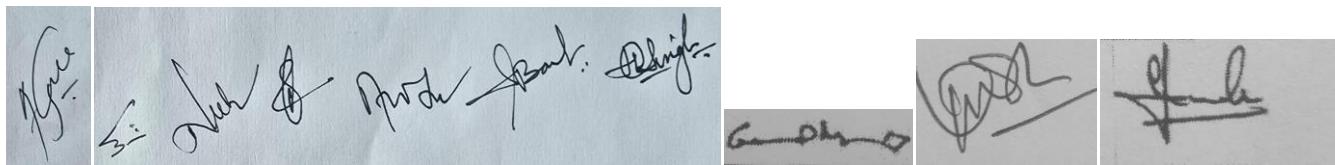
<https://nptel.ac.in/courses/104/105/104105033/>

<https://egyankosh.ac.in/bitstream/123456789/15794/1/Unit-7.pdf>

<https://www.hhrc.ac.in/ePortal/Chemistry/IImscchem-18pche3-unit1-sv.pdf>

<http://www.du.edu.eg/upFilesCenter/sci/1596861612.pdf>

BACHELOR OF CHEMISTRY WITH HONOURS



Programme: Bachelor of Chemistry with Honours		Year: IV	Semester: VII		
Subject: Chemistry		Paper: DSC			
Course: DSC (Practical)					
Course Title: Advanced Experimental Chemistry -I					
Course Outcomes:					
Upon successful completion of this course, the students will be able to:					
<ul style="list-style-type: none"> Understand the laboratory methods and tests related to inorganic mixture analysis including the salts of normal and rare-earth elements and insoluble salts. Also, they can understand the quantitative estimation of organic molecules, viscosity constant and activation energy. Qualitatively estimate cations and anions in samples. Quantitative estimation of percentage of hydroxyl groups, amines/ phenolic contents in organic compounds. Determine of iodine and saponification values of an oil sample. Determine of DO, COD and BOD of water samples. • 					
Credits:1		Discipline Specific Course			
Max. Marks: As per University rules		Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours			
Unit I	Laboratory hazards and safety precautions	6			
Unit II	Inorganic Chemistry <ul style="list-style-type: none"> (i) Inorganic Salt Analysis: Qualitative analysis of mixtures of salts containing six radicals including Rare-earth element salts (two rare element ions), interfering radicals, other anions, which have not been done in under graduate practical and insolubles and simple salts (ii) Determination of DO, COD and BOD of water sample. (iii) Determination of organic carbon in soil (iv) Estimation of Na/K/Ca in water/aerated drinks/soil using flame photometer (v) Estimation of alkali content in antacid tablets. 	8			
Unit III	Organic Chemistry <ul style="list-style-type: none"> i. Determination of the percentage of number of hydroxyl groups in an organic compound by acetylation method ii. Estimation of amines/ phenols using bromate-bromide solution/ or acetylation method. iii. Determination of Iodine and Saponification values of an oil sample. 	8			
Unit IV	Physical Chemistry <ul style="list-style-type: none"> (i) Determination of the velocity constant of acid catalyzed hydrolysis of an ester. (ii) Determination of activation energy of a reaction. (iii) Determination of Frequency factor of a reaction by kinetic 	8			

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	<p>studies.</p> <p>(iv) Validity of Arrhenius equation.</p> <p>(v) Determination of the effect of change in temperature on rate constant of a reaction.</p> <p>(vi) Determination of the effect of change in concentration of the reactants on rate constant of a reaction.</p> <p>(vii) Determination of the effect of change in concentration of the catalyst on rate constant of a reaction.</p> <p>(viii) Determination of the effect of change in temperature on rate constant of a reaction.</p> <p>(ix) Determination of the effect of change in concentration of the reactants on rate constant of a reaction.</p> <p>(x) Determination of the effect of change in concentration of the catalyst on rate constant of a reaction.</p> <p>(xi) Determination of the effect of change in ionic strength on the rate constant of a reaction.</p> <p>(xii) Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide.</p>	
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Note: Allocation of marks - External assessment: Total marks 75 (Inorganic exercise 20; Organic exercise 20; Physical exercise 20; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05).

Recommended Readings:

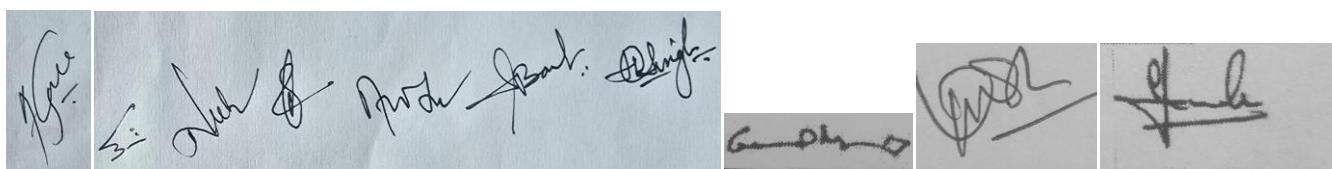
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis,
- Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Suggested equivalent online content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>

Semester-VII



Bachelor of Chemistry with Honours

DISCIPLINE SPECIFIC ELECTIVE (DSE 7 A)

ADVANCED INORGANIC CHEMISTRY

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Advanced Inorganic Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-

BACHELOR OF CHEMISTRY WITH HONOURS

Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: VII Paper: DSE 7 A
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Subject: Chemistry

Course: DSE 7A **Course Title: Advanced inorganic chemistry**

Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Understand the stereochemistry and bonding in main group compounds and simple reactions of covalently bonded molecules
- Learn about the substitution reactions in square planar complexes.
- Understanding reaction mechanism of octahedral complexes
- To determine the electronic angular momentum in diatomic molecules- calculation of States.

Credits:4	Discipline Specific Elective 7A	
Max. Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	No. of Hours
Unit I	Stereochemistry and Bonding in Main Group Compounds: Hybridization, Isovalent hybridization, Drago Rule, Bent rule, its applications and energetics of hybridization, some simple reactions of covalently bonded molecules (Atomic inversion, Berry pseudorotation, nucleophilic substitution reactions, free radical mechanism).	15
Unit II	Reaction Mechanism of Octahedral Complexes I: Energy profile of a reaction, reactivity of metal complexes, kinetic application of valence bond	10

Yours
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Mass. Audubon Soc.
Boston, Mass.

	and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, anation reactions, reactions without metal ligand bond cleavage.	
Unit II	Reaction Mechanism of Octahedral Complexes II: Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions. Complimentary and non-complimentary electron transfer reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.	10
Unit IV	Substitution Reactions of Square Planar Complexes: Substitution reactions in square planar complexes: Types, mechanism, potential energy diagrams, transition states and intermediates. Factors affecting the substitution reaction. <i>Trans</i> effect and its applications in synthesis of complexes, theories of <i>trans</i> effect.	10
Unit V	PROBLEM SOLVING BASED ON THE ABOVE THEORY	15

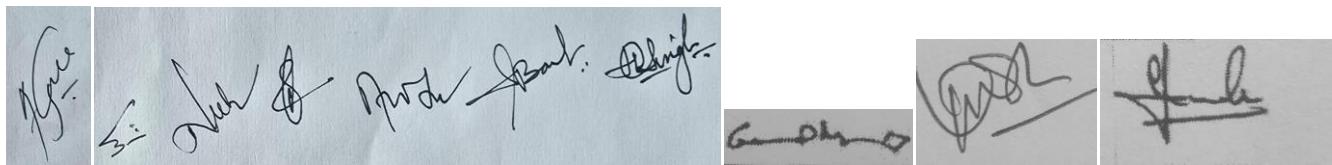
Recommended Readings:

- F.A. Cotton, Chemical Application of Group Theory, Wiley.
- D. C. Harris, Bertolucci, Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy, Dover Publications, New York.
- P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House, Mumbai.
- Gurdeep Raj, Ajay Bhagi and Vinod Jain, Group Theory and Symmetry in Chemistry, Krishna Prakashan Media (P) Ltd., Meerut.

Suggested Continuous Evaluation Methods: Since the class is conceived as learner-centric and built around tasks that require learners to actively use various language skills, formative assessment can and should be used extensively. Oral presentations, peer interviews, and group tasks can be used for this purpose. The end-semester written examination will test all the areas targeted in the course.

Suggested equivalent online courses:

<https://nptel.ac.in/courses/113/106/113106069/>
https://onlinecourses.nptel.ac.in/noc20_mm22/preview
<https://nptel.ac.in/courses/112/106/112106223/>
<https://nptel.ac.in/courses/104/104/104104080/>
<https://nptel.ac.in/courses/104/101/104101094/>
https://onlinecourses.nptel.ac.in/noc22_cy28/preview



Semester-VII**Bachelor of Chemistry with Honours****DISCIPLINE SPECIFIC ELECTIVE (DSE 7B)
ADVANCED ORGANIC CHEMISTRY****No. of Hours- 60****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)		
		Lecture	Tutorial	Practical/Practice				
DSE: Advanced Organic chemistry	4	4	-	-	Chemistry in Bachelor of Science	-		
BACHELOR OF CHEMISTRY WITH HONOURS								
Programme: Bachelor of Chemistry with Honours				Year: IV	Semester: VII Paper: DSE 7B			
Subject: Chemistry								
Course: DSE 7B	Course Title: Advanced Organic chemistry							

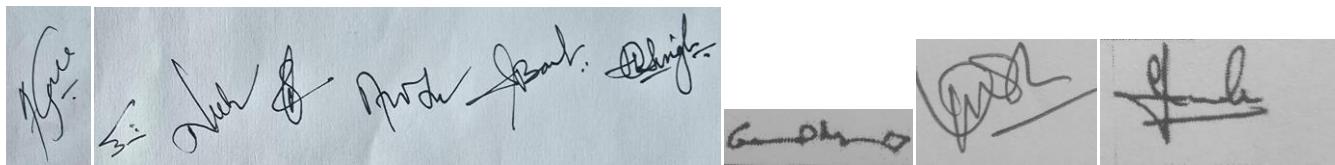
Course outcome:

- This course will provide a deep knowledge of reaction mechanism. After completion of this course, the students will be able to understand the mechanism and stereochemistry of electrophilic, & nucleophilic substitution reactions and elimination reaction.
- Study of the name reactions and the mechanism and stereochemistry of all the mentioned name reactions will enhance student's skill to understand the various important methods of synthesizing compound which are industrially important.
- This will not only help them to clear the competitive exams but also increase the job opportunities related to these industries.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
Unit I	Reaction mechanism-I: Aliphatic Electrophilic Substitution: Biomolecular mechanisms- S_E2 and S_E1 . The S_E1 mechanism, electrophilic substitution accompanied by double bonds shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.	9



	Aliphatic Nucleophilic Substitution: The S_N^2 , S_N^1 , mixed S_N^1 and S_N^2 , S_N^i and SET mechanisms. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity. Neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system. Neighbouring group assistance in substitution reactions. Substitution reactions involving non-classical carbocations.	
Unit II	Reaction mechanism-II: Elimination reactions: The E2, E1 and E1cB mechanisms and their spectrum. Orientation of the double bond. Reactivity-effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination	06
Unit III	Reaction mechanism-II: Aromatic Nucleophilic Substitution: The $S_N Ar$, S_N^1 , benzyne and S_N^1 mechanism. Reactivity-effect of substrate structure leaving group and attacking nucleophile. The Von-Richter, Sommelet-Hauser and Smiles rearrangements. Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ispo attack, orientation in other ring systems. Diazonium coupling.	15
Unit IV	Name Reactions and their applications: Vilsmeier reaction, Gattermann-Koch reaction, Sandmeyer reaction, Hunsdiecker reaction, Michael reaction. Sharpless asymmetric epoxidation, Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, Wittig reaction, Heck reaction, Still reaction, Sonogashira, Negishi coupling, Grubbs Catalyst.	15
Unit V	SYNTHESIS AND IDENTIFICATION OF RELATED PROBLEMS	15

Recommended Readings:

- Jerry March, Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley.
- RT Morrison and RN Boyd Organic Chemistry, , Prentice Hall.
- CK Ingold, Structure and Mechanism in Organic Chemistry, Cornell University Press.
- SM Mukherji and SP Singh, Reaction Mechanism in Organic Chemistry, Macmillan.
- D Nassipuri, Stereochemistry of Organic Compounds, New Age International
- PS Kalsi, Stereochemistry of Organic Compounds, New Age International.
- FA Carey and RJ Sundberg, Advanced Organic Chemistry, Plenum.
- Modern Organic Reactions, HO House, Benjamin.
- Jonathan Clayden, Nick Greeves, and Stuart Warren, Organic Chemistry, Oxford Chemistry press.

Suggested online links:

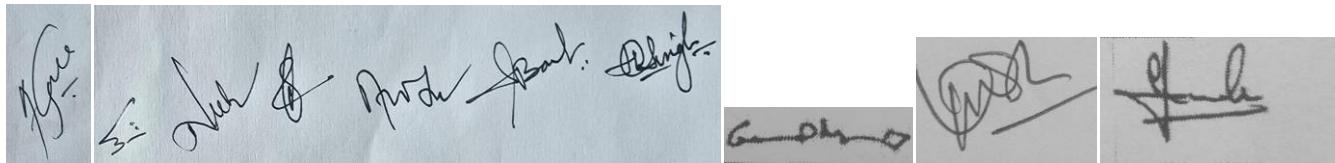
<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>

<https://nptel.ac.in/content/storage2/courses/104103022/download/module5.pdf>

<https://nptel.ac.in/content/storage2/courses/104103022/download/module9.pdf>

<https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%208.pdf>

<https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%207.pdf>



Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Semester-VII

Bachelor of Chemistry with Honours

DISCIPLINE SPECIFIC ELECTIVE (DSE 7C) ADVANCED PHYSICAL CHEMISTRY

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

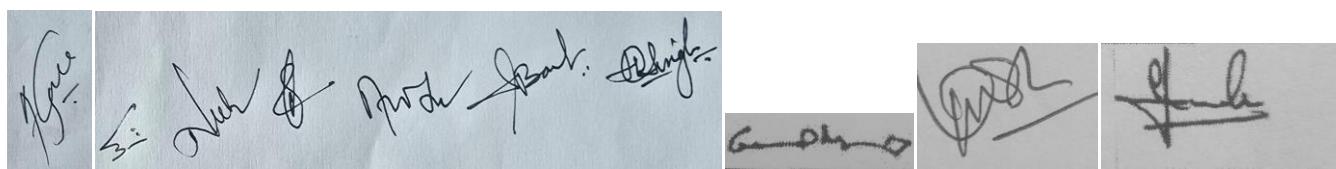
Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)		
		Lecture	Tutorial	Practical/Practice				
DSE: Advanced Physical Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-		
BACHELOR OF CHEMISTRY WITH HONOURS								
Programme: Bachelor of Chemistry with Honours				Year: IV	Semester: VII Paper: DSE 7C			
Subject: Chemistry								
Course: DSE 7C	Course Title: Advanced Physical Chemistry							

Course Outcomes:

- This paper provides detailed knowledge of surface, polymer, electro and quantum chemistry.
- Upon successful completion of this course, the students should be able to describe Gibb's adsorption isotherm, Freundlich and Langmuir adsorption isotherm, BET method, applications of polymers, Debye-Hückel theory, Debye-Hückel-Onsagar theory and concept of quantum chemistry.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60



Unit	Contents	Number of Lectures
Unit I	Surface Chemistry: Gibb's adsorption isotherm, Freundlich and Langmuir adsorption isotherms, determination of free energy of adsorption, BET theory for multilayer adsorption with derivation, determination of surface area using BET method, catalytic activity on solid surfaces, macromolecules,	7
Unit II	Polymer Chemistry: Polymers and their general applications, classification of polymers, chain configuration of polymers, liquid crystals and their applications. Molecular mass, number and mass average molecular mass, molecular mass determination using osmometry, viscometry, diffusion and light scattering methods.	8
Unit III	Advanced Electrochemistry: Determination of activity coefficient, Debye-Huckel theory of strong electrolytes with derivation, ionic atmosphere and thickness of ionic atmosphere, Debye-Huckel-Onsagar theory, theory of conduction, Onsagar equation including mathematical deduction.	10
Unit IV	Advanced Quantum Chemistry: de-Broglie concept and de-Broglie equation, physical interpretation and properties of wave functions, Linear, Laplacian, Linear-momentum and Hamiltonian operators, postulates of quantum mechanics, eigen values, eigen functions, derivation of the Schrodinger's wave equation, concept of cartesian and spherical coordinates. Schrodinger's wave equation general and detailed discussion on the applications of Schrodinger's wave equation to some model systems <i>viz.</i> particles in a 1D-, 3D- box, harmonic oscillator, rigid rotator and hydrogen atom.	20
Unit V	PROBLEM SOLVING BASED ON ABOVE UNITS	15

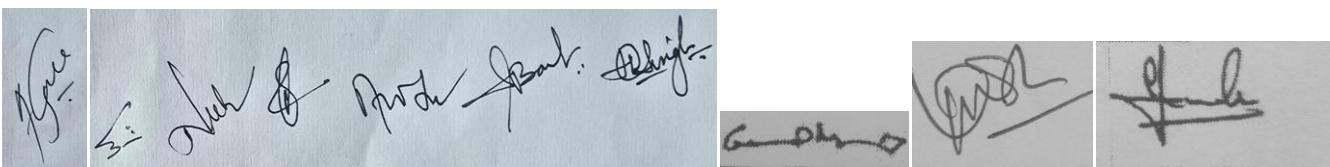
Recommended Readings:

- R. Puri, L. R. Sharma and M. S. Pathnia, Physical Chemistry, Milestone Publisher & Distributors, New Delhi.
- K. L. Kapoor, Physical Chemistry. Macmillan Publishers India Limited.
- K. J. Laidler, Kinetics, Pearson Education India.

Suggested online links:

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>
https://books.google.co.in/books/about/Basics_of_Polymer_Chemistry.html?id=ciRHDwAAQBAJ&redir_esc=y
https://www.google.co.in/books/edition/Applied_Colloid_and_Surface_Chemistry/FGyIJ1Z5Tr4C?hl=en&gbpv=1&dq=SURFACE+CHEMISTRY&printsec=frontcover

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line



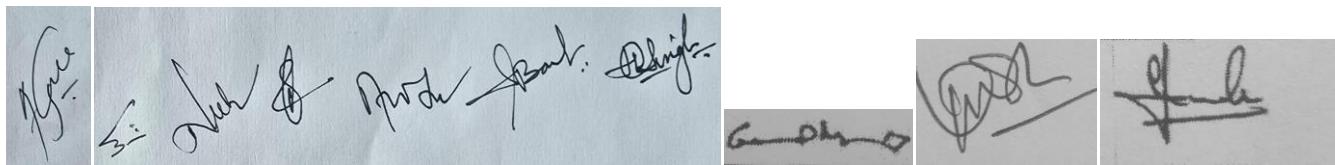
tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10 marks

Course prerequisites: To study this course, a student must have had passed theory papers of VII semester.

Suggested equivalent online courses:

- https://onlinecourses.nptel.ac.in/noc21_cy45/preview
- https://onlinecourses.nptel.ac.in/noc21_ch48/preview
- https://onlinecourses.nptel.ac.in/noc20_cy27/preview
- https://onlinecourses.nptel.ac.in/noc21_cy20/preview
- <https://www.classcentral.com/course/swayam-chemistry-i-introduction-to-quantum-chemistry-and-molecular-spectroscopy-3981>
- <https://www.classcentral.com/course/swayam-quantum-chemistry-of-atoms-and-molecules-19982>
- <https://nptel.ac.in/courses/104/108/104108057/>
- <https://nptel.ac.in/courses/115/101/115101107/>
- <https://nptel.ac.in/courses/104/101/104101124/>
- <https://nptel.ac.in/courses/104/105/104105128/>



Semester-VII

Bachelor of Chemistry with Honours

GENERIC ELECTIVE (GE 7A)- Biology for Chemists

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Biology for Chemists	4	4	-	-	Chemistry in Bachelor of Science	-

BACHELOR OF CHEMISTRY WITH HONOURS

Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: VII Paper: GE 7A
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Subject: Chemistry

Course: GE 7A Course Title: Biology for Chemists

Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Understand the functions and significance of cell organelles. This course will make them appreciate the structural and functional aspects of cell and organelles.
- Have the basic understanding of the metabolic processes in biological system which will help them to have better grip on biochemistry.

Credits:4		Generic Electives 2
Max. Marks: As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	<p>Cell as Unit of Life: The cell theory; prokaryotic and eukaryotic and eukaryotic cells; cell size and shape; Eukaryotic cell components.</p> <p>Cell Membrane and Cell Wall: The functions of membranes; Models of membrane structure; faces of the membrane, selective permeability of permeability of the membranes; cell wall</p>	15
Unit II	Cell Organelles-I: Mitochondria: Structure, marker enzymes, composition; function. Chloroplast: Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA. ER, Golgi body and Lysosomes: Structures and roles of ER, golgibody and lysosomes.	15
Unit III	Cell Organelles-II: Nucleus: Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief). Nucleoside and Nucleotides and DNA structure.	15

3. New & Rock Art. Albigny

Unit IV	Metabolism: Introduction, basal metabolic rate (BMR), Carbohydrate protein and lipid metabolism, cell respiration, anaerobic respiration, aerobic respiration, formation of acetyl CoA, citric acid cycle, electron transport system, adenosine triphosphate, mechanism. ATP generation.	15
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Recommended Readings:

- P. H. Raven, Biology, Tata MacGraw Hill.
- P. Sheeler, Cell and Molecular Biology, John Wiley.
- N. A. Campbell, Biology Pearson.
- L. Styer, Biochemistry, Freeman & Co.
- Outlines of biochemistry. Fourth edition (Conn, Eric E.; Stumpf, P. K.). Wiley India Pvt. Limited

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online courses:

<https://nptel.ac.in/courses/102/103/102103012/>

<https://nptel.ac.in/content/storage2/courses/102106025/Mod%201/Lec-1.pdf>

https://books.google.co.in/books/about/Biology_for_Chemists.html?id=N4nToAEACAAJ&redir_esc=y

Semester-VII
Bachelor of Chemistry with Honours

GENERIC ELECTIVE (GE 7B)
Mathematics for Chemists

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

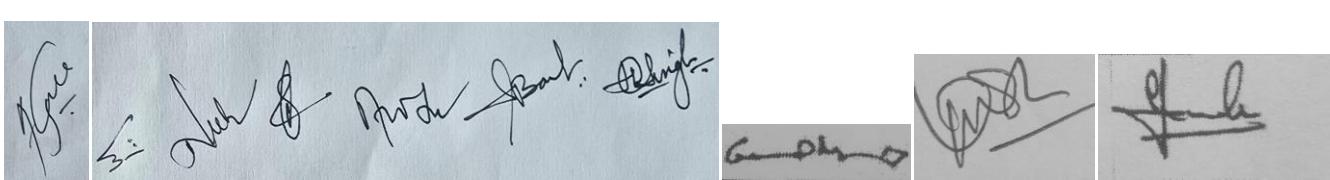
Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE 7B: Mathematics for Chemists	4	4	-	-	Chemistry in Bachelor of Science	-

BACHELOR OF CHEMISTRY WITH HONOURS

Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: VIII
Paper: GE 7B		

Subject: Chemistry

Course: GE 7B	Course Title: Mathematics for Chemists
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Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Understand the concept of mathematical functions, graphs, differentiations, integration and mathematical relations. It will help them to have better grip on mathematics involved in chemistry.

Credits:4	Generic Electives 2	
Max. Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	No. of Hours
Unit I	Mathematical Functions: Polynomial expression, exponential function, trigonometrically functions. Inverse trigonometrically function. Logarithms and antilogarithms	10
Unit II	Curve Sketching/Graph: Inclination of a line and the slope of a line, General equation of straight line, slope-intercept form, and slope-point form. Two-point form, Intercept form, Parallel and perpendicular lines	10
Unit III	Differentiation: Differentiation formulas, Concept of maximum and minimum, Rules of finding maxima and minima, Partial differentiation, Euler reciprocal relation, exact and inexact differentials, Chain rule for partial differential. Integration: Methods of integrations, substitution, partial function, by parts, successive, reduction, integration formulas including concept of limit	20
Unit IV	Fundamentals of Mathematical Relations: Permutations and Combination, Probability, vectors mathematical relations, Vectors, Matrices, Determinants, Complex number, Series, Stirling approximation, Roots of quadratic equation. Methods of solving equation. Coordinate systems in three dimensions (Cartesian, spherical and polar).	20

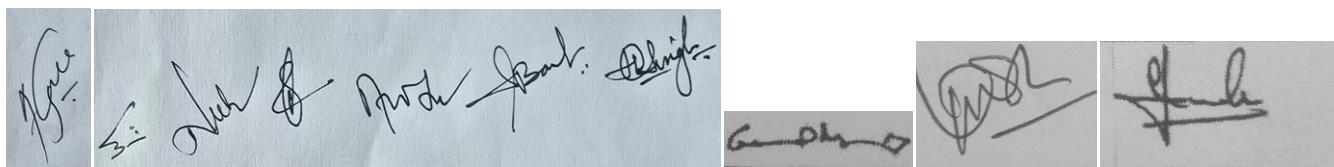
Recommended Readings:

- D.A. McQuarrie, Mathematics for physical Chemistry University Science Books.
- R. Mortimer, Mathematics for Physical Chemistry, 3rd Ed. Elsevier.
- E. Steiner, The Chemical Maths Books, Oxford University Press.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online courses:

https://www.jcu.edu.au/_data/assets/pdf_file/0004/115897/Maths-for-Chemistry.pdf
<https://www.birmingham.ac.uk/Documents/college-eps/college/stem/Student-Summer-Education-Internships/Maths-for-Chemists-Booklet.pdf>



Semester-VIII

Bachelor of Chemistry with Honours

DISCIPLINE SPECIFIC COURSE (DSC 8)

Advanced Chemistry II (Theory)

Advanced Experimental Chemistry -II (Practical)

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC 8: Advanced Chemistry II	4	3	-	1	Chemistry in Bachelor of Science	-
Advanced Experimental Chemistry -II (Practical)						

BACHELOR OF CHEMISTRY WITH HONOURS

Programme: Bachelor of Chemistry with Honours **Year: IV** **Semester: VIII**
Paper: DSC 8

Subject: Chemistry

Course: DSC 8 **Course Title: Advanced Chemistry II**

Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Understand stereoselectivity, stereospecificity, regioselectivity, chemo selectivity, enantiomeric and diastereomeric excess.
- understand about the metal ligand bonding and cluster compounds
- a brief introduction about the stereochemistry of organic molecules
- to know about the higher order reactions, collision theory and arrhenius equation
- understand the thermodynamics of non ideal solutions

Credits:3		Discipline Specific Course 8
Max. Marks: As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	Metal-Ligand Bonding: Sigma bonding in octahedral complexes: Classification of metal valence orbitals into sigma symmetry, formation of ligand group orbitals (LGOs) of sigma symmetry, Formation of molecular orbitals of sigma symmetry, construction of molecular orbital energy level	

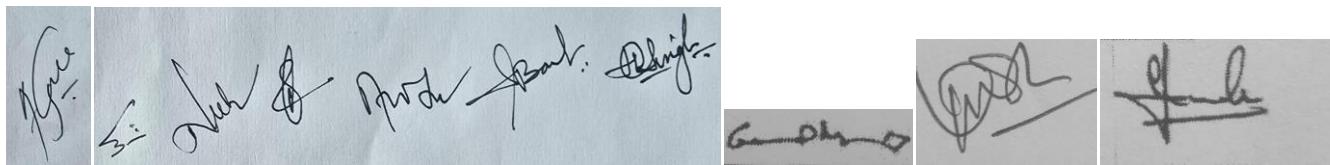
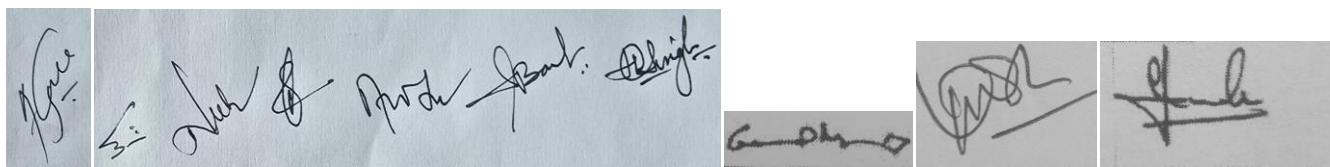


	diagram involving only sigma bond contribution from ligands, pi bonding in octahedral complexes: Classification of metal valence orbital into pi symmetry, Formation of LGOs of pi symmetry. Formation of pi MOs and construction of molecular orbital energy level diagram involving sigma and pi contribution from pi donor ligands, Sigma and pi bonding in tetrahedral complexes and square planar complexes	10
Unit II	Cluster Compounds: Introduction, classification, higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and metal halide clusters. Clusters with metal-metal multiple bonds. Electron counting in clusters (Wade's rule), Isolobal analogy.	5
Unit III	Stereochemistry Axial and planar chirality and helicity (P & M); stereochemistry and configurations of allenes, spiranes, alkylidene, cycloalkanes, adamantanes, catenanes, biphenyls (atropisomerism), bridged biphenyls, ansa compounds and cyclophanes. Topicity and prosteroisomerism: Topicity of ligands and faces and their nomenclature, stereogenicity, cyclosteroisomerism; configurations, conformations and stability of cyclohexanes, (mono and di Substituted), cyclohexenes, cyclohexanones, halocyclohexanones, decalines, decalols, decalones. Asymmetric induction; Cram's, Prelog's and Horeaus rules. Dynamic stereochemistry (cyclic and acyclic). Stereochemistry of compounds containing N, S and P. Stereospecificity, regioselectivity and chemoselectivity. Enantiomeric and diastereomeric excess.	15
Unit IV	Chemical Dynamics: Third and general order reactions, Experimental methods for kinetic studies, viz; conductometric, potentiometric and spectrophotometric methods, effect of temperature on rate of reaction, Arrhenius equation. Chemical molecular dynamics: Collision theory of reaction rates, steric factor, activated complex theory, comparison of collision and activated complex theories, ionic reactions, kinetic salt effects, steady state concept, kinetic and thermodynamic control of reactions. Kinetics of gaseous reactions on solid surface, unimolecular and bimolecular surface reactions, kinetics of condensation and addition polymerization reactions, mechanism of H_2-Br_2 , H_2-Cl_2 reactions, decomposition of the following compounds: acetaldehyde, ozone and H_2O_2 .	10
Unit V	Thermodynamics of Non-ideal Solutions: Non-ideal systems; Excess functions for non-ideal solutions, activity, activity coefficient, Debye-Hückel theory for activity coefficient of electrolytic solutions, determination of activity coefficients, ionic strength.	5

Recommended Readings:



- Jerry March, Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley.
- R. T. Morrison and R. N. Boyd, Organic Chemistry, Prentice Hall.
- K. Ingold, Structure and Mechanism in Organic Chemistry, Cornell University Press.
- S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan.
- Nasipuri, Stereochemistry of Organic Compounds, New Age International
- P. S. Kalsi, Stereochemistry of Organic Compounds, New Age International.
- S. M. Mukherjee, Pericyclic Reactions, Macmillan, India.
- F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Plenum
- Benjamin, Modern Organic Reactions, HO House
- Ernest L. Eliel and Samuel H. Wilen, Stereochemistry of Organic Compounds, Wiley India
- Ernest L. Eliel, Stereochemistry of Carbon Compounds. Tata McGraw Hill.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online content:

<https://nptel.ac.in/courses/104/106/104106127/>
<https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cy25/>
https://onlinecourses.swayam2.ac.in/ugc19_ch01/preview
<https://nptel.ac.in/courses/104/101/104101005/>
<https://nptel.ac.in/courses/104/106/104106077/>
<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>
<https://nptel.ac.in/content/storage2/courses/104103022/download/module5.pdf>
<https://nptel.ac.in/content/storage2/courses/104103022/download/module9.pdf>
<https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%208.pdf>

BACHELOR OF CHEMISTRY WITH HONOURS

Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: VIII
Paper: DSC 8		

Subject: Chemistry

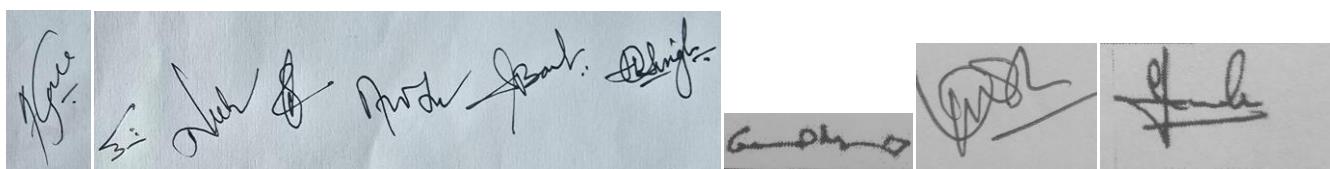
Course: DSC 8	Course Title: Advanced Experimental Chemistry -II
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Course Outcomes:

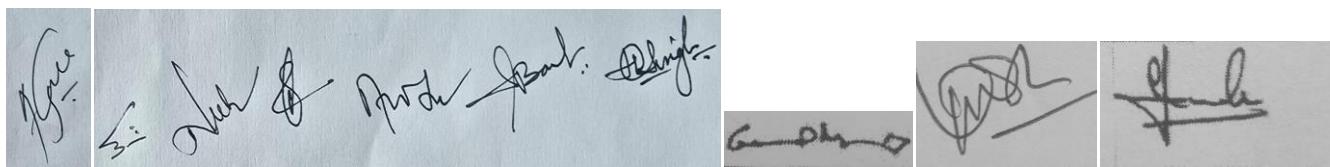
The students will able to

- Synthesize various inorganic compounds
- Synthesize organic compounds via two steps. This will include photochemical and enzymatic synthesis of various organic compounds.
- Experiments to physically verify different adsorption isotherms.

Credits:1	Discipline Specific Elective
Max. Marks: As per University rules	Min. Passing Marks: As per University rules



Unit	Topic	No. of Hours
Unit I	Laboratory hazards and safety precautions	06
Unit II	<p>(A) Inorganic Compound Synthesis: Preparation of selected inorganic compounds such as:</p> <ul style="list-style-type: none"> i. $[\text{Ni}(\text{dmg})_2]$ ii. $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$ iii. Cis-K$[\text{Cr}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2]$ iv. $\text{Na}[\text{Cr}(\text{NH}_3)_2(\text{SCN})_4]$ v. $[\text{Mn}(\text{acac})_3]$ vi. $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$ vii. Prussian Blue, Tumbull's Blue viii. $\text{Co}(\text{NH}_3)_6][\text{Co}(\text{NO}_2)_6]$ ix. Cis-[Co(trien)(NO₂)₂]Cl.H₂O x. Hg [Co(SCN)₄] xi. $[\text{Co}(\text{py})_2\text{Cl}_2]$ xii. $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$ xiii. $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3] \cdot 3\text{H}_2\text{O}$ <p>(B) Quantitative estimation of metal ions by complexometric titration, direct and / or back titration, use of masking agents.</p>	08
Unit III	<p>Organic Chemistry</p> <p>(I) Green Synthesis</p> <ul style="list-style-type: none"> i. Photoreduction of benzophenone to benzopinacol in 2-propanol ii. Conversion of Benzil to Benzilic acid iii. Isomerization of Dimethyl maleate to Dimethyl fumrate <p>(II) Conventional methods of synthesis</p> <ul style="list-style-type: none"> (i) Photochemical synthesis of Benzpinacolone from Benzophenone (ii) Beckmann rearrangement: Benzophenone to Benzanilide (iii) Benzilic acid rearrangement: Benzoin to Benzilic acid (iv) Synthesis of heterocyclic compounds:(a) Skraup synthesis: Preparation of quinoline from aniline (b) Fischer indolesynthesis: Preparation of 2-phenyl indole from phenylhydrazine. <p>(III) Enzymatic synthesis</p> <ul style="list-style-type: none"> (i) Enzymatic reduction: Reduction of ethyl acetoacetate using Baker's yeast to yield enantiomeric excess of S(+)-ethyl-3-hydroxybutanoate and determine its optical purity. (ii) Biosynthesis of ethanol from sucrose. <p>(IV) Microwave synthesis</p>	08



	<p>(i) Synthesis using microwaves (ii) Alkylation of diethyl malonate with benzyl chloride (iii) Synthesis using phase transfer catalyst (iv) Alkylation of diethyl malonate or ethylacetacetate with an alkyl halide.</p> <p>(E) Synthesis based on pharmaceutical intermediates /Drugs for eg. Aspirin</p>	
Unit IV	<p>Physical Chemistry:</p> <p>(i) Validity of Arrhenius equation. (ii) Flowing Clock reactions (Ref. Experiments in Physical Chemistry by Showmaker). (iii) Study of the adsorption of an acid by charcoal.</p> <p>(iv) Validity of Freundlich's Adsorption isotherm. (v) Determination of Partition Coefficients. (vi) Determination of molecular surface energy of a liquid by Stalagmometer method. (vii) Determination of association factor of the given liquid by drop-pipette method.</p>	08

Note: Allocation of marks - External assessment: Total marks 75 (Inorganic exercise 20; Organic exercise 20; Physical exercise 20; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05). Students have to perform one practical from each section.

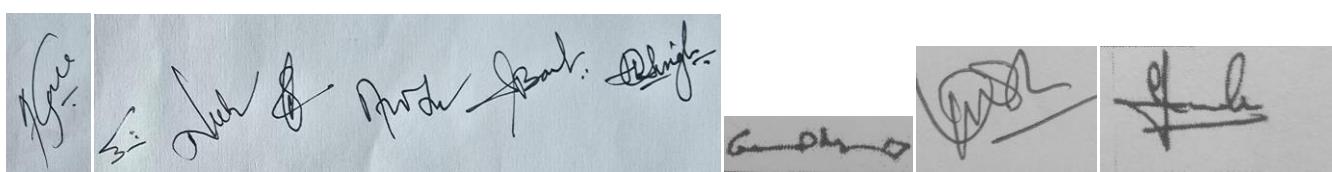
Recommended Readings

- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Suggested equivalent online content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>



Semester-VIII
Bachelor of Chemistry with Honours

DISCIPLINE SPECIFIC ELECTIVE (DSE 8A)
Pericyclic Reactions and Photochemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Pericyclic Reactions and Photochemistry	4	4	-	-	Chemistry in Bachelor of Science	-

BACHELOR OF CHEMISTRY WITH HONOURS

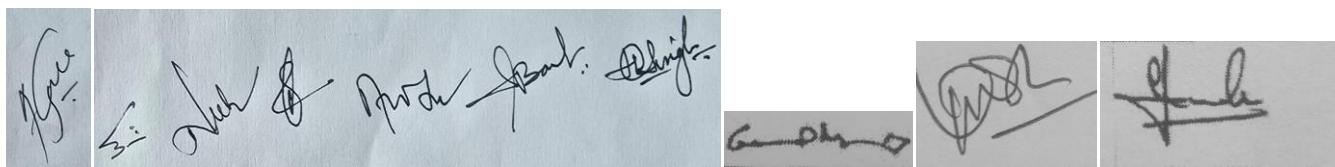
Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: VIII
		Paper: DSE 8A
Subject: Chemistry		
Course: DSE 8A	Course Title: Pericyclic Reactions and Photochemistry	

Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Acquire the knowledge of pericyclic and photochemical reactions.
- Apply laws of photochemistry to different types of photochemical reactions,
- Able to draw the Jablonskii diagram.

Credits:4	Discipline Specific Elective	
Max. Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit Topic		No. of Hours
Unit I Pericyclic Reactions I: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions- conrotatory and disrotatory motions, $4n$, $4n+2$ and allyl system. Cycloadditions- antarafacial and suprafacial additions, $4n$ and $4n+2$ systems.		10
Unit II Pericyclic Reactions II: 2+2 addition of ketenes, 1,3-dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements- suprafacial and antarafacial shifts of H, Sigmatropic shifts involving carbon moieties, 3,3- and 5,5 sigmatropic rearrangements. Claisen, Cope and Aza-Cope rearrangements. Fluxional		10



	tautomerism, Ene reaction.	
Unit III	Basics of Photochemistry: Laws of photochemistry, electronically excited states-life times, Energy dissipation by radiative and non-radiative processes, Franck-Condon principle, Photochemical stages- primary and secondary processes. photo-physical reactions, Jablonskii diagram, photosensitization, quantum yield and its determination, fluorescence, phosphorescence and chemiluminescence with suitable examples.	10
Unit IV	Photochemistry of Organic Compounds: Photochemistry of alkenes; cis-trans isomerization; photochemical additions; reactions of 1,3- and 1,4-dienes; dimerization, Norrish type I & II reactions (cyclic and acyclic); α, β -unsaturated ketones; β, γ -unsaturated ketones; cyclohexenones (conjugated, cyclohexadienones (cross conjugated & conjugated); paterno- Buchi reaction, photoreductions; photochemistry of aromatic compounds, isomerisations reactions, Dewar and prismanes in isomerisations, singlet oxygen reactions, photo Fries rearrangement of ester & anilidets, Barton reaction, Hoffmann-Loeffler-Freytag reaction.	15
Unit V	PROBLEM BASED ON ABOVE SYLLABUS	15

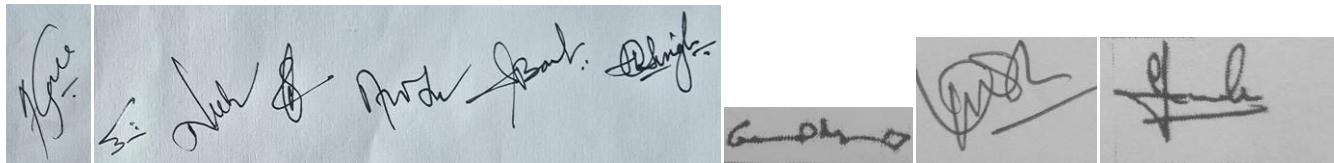
Recommended Readings

- F.A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Parts A & B, Plenum: U.S.
- W. M. Horspool, Aspects of Organic Photochemistry, Academic Press.
- T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry Addison-Wesley Educational Publishers, Inc.
- J. March, Advanced Organic Chemistry, John Wiley & Sons.
- L. Stryer, Biochemistry, W. H. Freeman & Co. vi. P. A. Sykes, Guidebook to Mechanism in Organic Chemistry, Prentice-Hall
- Jerry March, Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley.
- K. Ingold, Structure and Mechanism in Organic Chemistry, Cornell University Press.
- S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan. Page 8 of 42
- Nasipuri, Stereochemistry of Organic Compounds, New Age International
- P. S. Kalsi, Stereochemistry of Organic Compounds, New Age International.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online contents:

<https://nptel.ac.in/courses/104106077>
<https://www.youtube.com/watch?v=Md1GS3vdYdA>
<https://www.youtube.com/watch?v=Ih7tQ7rY2Wc>



Semester-VIII

Bachelor of Chemistry with Honours

DISCIPLINE SPECIFIC ELECTIVE (DSE 8B) Spectroscopic Techniques

No. of Hours- 60

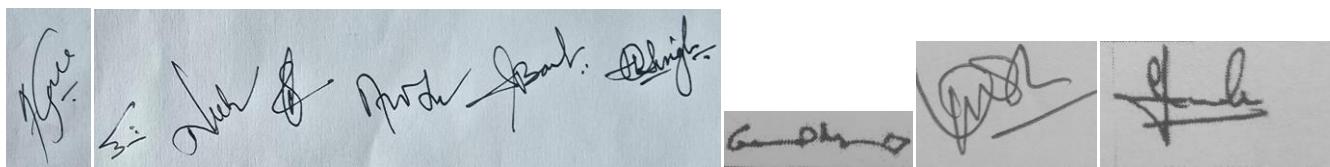
CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)					
		Lecture	Tutorial	Practical/Practice							
DSE: Spectroscopic Techniques	4	4	-	-	Chemistry in Bachelor of Science	-					
BACHELOR OF CHEMISTRY WITH HONOURS											
Programme: Bachelor of Chemistry with Honours		Year: IV		Semester: VIII Paper: DSE 8B							
Subject: Chemistry											
Course: DSE 8B	Course Title: Spectroscopic Techniques										

Course outcomes:

- This course will add on the theoretical aspects of electron spin, nuclear magnetic resonance, infrared and UV spectroscopy along with mass spectrometry which will further help in structure elucidation of various compounds through numerical problems.
- This is essential for structure elucidation of known as well as novel compounds.

Credits:4		Discipline Specific Elective	
Max. Marks: As per University rules		Min. Passing Marks: As per University rules	
Unit	Contents	Number of Lectures	
Unit I	Nuclear Magnetic Resonance Spectroscopy: Nuclear Spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing the chemical shift. Deshielding, spin-spin interaction, factors influencing coupling constant (J). Classification (ABX, AMX, ABC, A ₂ B ₂ etc.), spin decoupling, basic idea about instruments, NMR studies of nuclei other than proton; Advantages of FT NMR. Use of NMR in medical diagnostics. NOE, simplification of complex spectra.	15	



Unit II	Mass Spectrometry: Introduction, ion production-EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Detectors-ECD, TCD and FID, Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule, examples of Mass fragmentation of class of organic compounds.	10
Unit III	Infrared Spectroscopy: Instrumentation and simple handling. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the bond positions and intensities, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines and carbonyl compounds (ketones, aldehydes, esters, amides, acids anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding, solvent effect on IR of gaseous, solids and polymeric materials. Simple applications, vibrational spectra of metal carbonyls.	15
Unit IV	Ultraviolet and Visible Spectroscopy: Various electronic transitions (185 to 800 nm), Lambert-Beer's Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, diens, conjugated polyenes. Fieser-Woodward rules for conjugated diens and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.	5
Unit V	Interpretation of Organic Compounds Problems based on spectroscopic data viz. NMR, IR, UV Spectroscopy and Mass spectrometry.	15

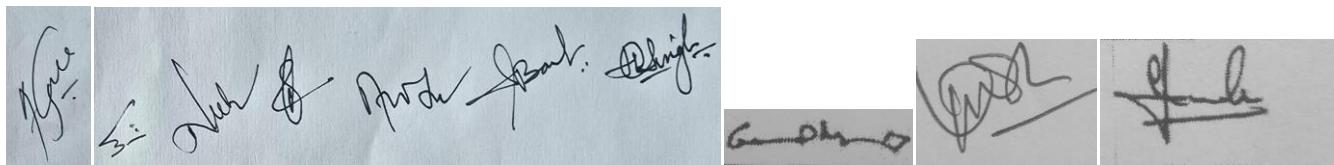
Books Recommended:

- Pavia, Lampman, Kriz, Spectroscopy, Books/Cole; Vyvyan
- PS Kalsi Spectroscopy of Organic Compounds, New Age International Publishers;
- Silverstein, Robert M.; Webster, Francis X.; Kiemle, Spectrometric Identification of Organic Compounds, John Wiley;
- ML Martin, JJ Delpeach and GJ Martin, Heyden, Practical NMR Spectroscopy,
- Colin N. Banwell and Elaine M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
- RJ Abraham, J Fischer and P Loftus, Introduction to NMR Spectroscopy, Wiley.
- DH Williams, I Fleming, Spectroscopic Method in Organic Chemistry: Tata MacGraw Hill.
- Willard Merritt, Dean, Settle, Instrumental Method of Analysis: Seventh Edition, CBS, Publication.

Suggested online links:

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: To study this course, a student must have had passed theory papers of VII semester.

Semester-VIII

Bachelor of Chemistry with Honours

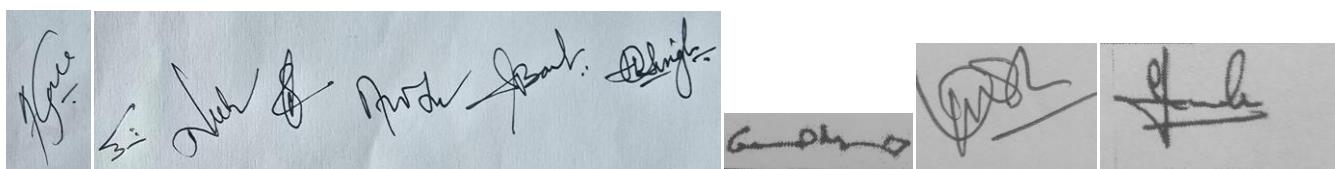
DISCIPLINE SPECIFIC ELECTIVE (DSE 8C) Chemistry of Biological Systems

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 8C: Chemistry of Biological Systems	4	3	-	1	Chemistry in Bachelor of Science	-

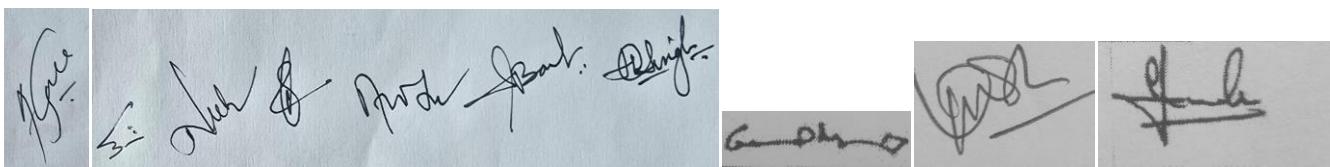
Programme: Bachelor of Chemistry with Honours		Year: IV	Semester: VIII Paper:
Course: DSE 8 C		Course Title: Chemistry of Biological systems	
Course Outcomes:			
Upon successful completion of this course, the students will be able to:		<ul style="list-style-type: none"> Detailed knowledge of bioinorganic, bioorganic and biophysical chemistry. Get information about the synthesis, classification, extraction, purification, uses of enzymes and coenzymes, essential and trace metals and role of metal ions in biological processes. Understand the forces and mechanisms which are essential to sustain all the life on earth. 	
Credits:4		Discipline Specific Elective DSE 8C	
Max. Marks: As per University rules		Min. Passing Marks: As per University rules	



Unit	Topic	No. of Hours
Unit I	Bioinorganic Chemistry: Essential and non-essential elements, toxic elements (Al, Hg, Cd, Pb). Role of metal ions in biological processes: K^+ , Na^+ , Ca^{2+} , Mg^{2+} , Mn^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} , Cu^{2+} , Zn^{2+} . Ion transport through cell membrane: active transport (ionophores and ion channels) and passive transport (ion pumps: Na^+/K^+ pump). Nitrogen fixation: definition, types, mechanism, structure of nitrogenase, factors affecting nitrogen fixation. Metal complexes in transmission of energy: chlorophyll a, chlorophyll b, light dependent reaction, Haeme proteins: definition, porphin, porphyrin, haeme groups, structure and biological functions of cytochrome P450, peroxidase, catalase, myoglobin, haemoglobin, and oxygen uptake. Metalloproteins: function of metalloproteins, electron transfer (cytochrome, rubredoxin, plastocyanin), light harvesting (chlorophyll), catalyst (superoxide dismutase, carbonic anhydrase), oxygen storage and transport	12
Unit II	Bioorganic Chemistry I: Introduction, Nomenclature and classification, extraction, purification and uses of enzymes in food drink industry and clinical therapy. Chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Proximity effects and molecular adaption. Enzyme kinetics, Michaelis-Mentien and Lineweaver-Burk plots, reversible and irreversible inhibition. Transition state theory, Fisher's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by site-directed, mutagenesis.	12
Unit III	Bioorganic Chemistry II: Acid-base catalysis, covalent catalysis, strain or distortion. Example of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme, carboxypeptidase A. Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzymes A, thiamine pyrophosphate, NAD^+ , $NADP^+$, and vitamin B_{12} .	12
Unit IV	Biophysical Chemistry: Forces involved in biopolymer interactions. Electrostatic charge and molecular expansion, hydrophobic forces, osmotic pressure, membrane equilibrium. Bioenergetics: Standard free energy change in biological reactions. Hydrolysis of ATP, synthesis of ATP from ADP. Coupling of ATP cleavage to endergonic processes Size, shape and molecular mass of biopolymer.	9
Unit V	PROBLEM RELATED TO ABOVE UNITS	15

Recommended Readings:

- P.S. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age International.
- L. Stryer, Biochemistry 4th Ed., W. H. Freeman & Co.

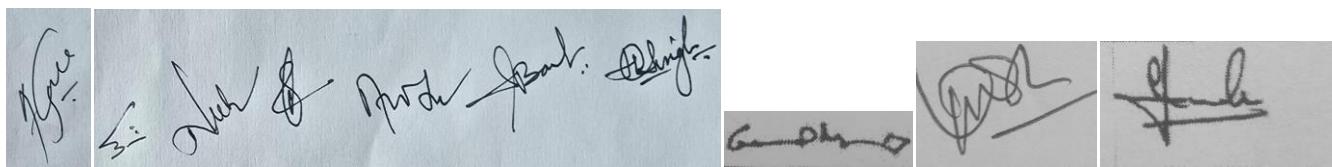


- S. Zubay, Biochemistry Addison-Wesley.
- S. J. Lippard and J. M. Berg, Principles of Bioorganic Chemistry, University Science Books.
- Berteni, H.B. Gray, S.J. Lippard and J.S. Valentine, FBioinorganic Chemistry, , University Science Books.
- Hermann Dugs and C. Penny, Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Springer-Verlag.
- Trevor Palmer, Understanding Enzymes, Prentice Hall.
- Collins J Sucking, Enzyme Chemistry: Impact and Application, Ed. Chapman and Hall.
- M.I. page and A. Williams, Enzyme Mechanisms Ed., Royal Society of Chemistry.
- N.C. Price and L. Stevens, Fundamental of Enzymology, Oxford University Press.
- Michael D. Trevan, Immobilized Enzymes: An Introduction and Application in Biotechnology, John Wiley.
- Alan Fersht. Enzyme Reaction and Mechanism, W H Freeman & Co (Sd).
- A.L. Lehninger, Principles of Biochemistry, Worth Publishers.
- J. M. Berg, J. L. Tymoczko and L. Stryer, Biochemistry, W.H. Freeman.
- Donald Voet, Charlotte W. Pratt, Judith G. Voet, Biochemistry, John Wiley.
- E.E. Conn and P.K. Stumpf, Outlines of Biochemistry, John Wiley.
- L. S. W. H. Freeman, Macromolecules: Structure and Function, Prentice Hall.
- Pramod Pandey, Organic Chemistry, John Wiley

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online content:

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>
https://onlinecourses.nptel.ac.in/noc22_cy06/preview
https://onlinecourses.nptel.ac.in/noc22_cy12/preview
<https://nptel.ac.in/content/storage2/courses/104103018/pdf/mod1.pdf>



Semester-VIII
Bachelor of Chemistry with Honours

GENERAL ELECTIVE (GE 8A)
Solid State Chemistry and Supramolecular Chemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

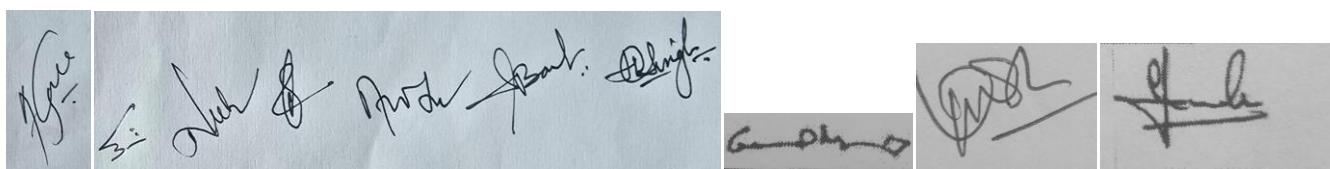
Course Title	Lits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)				
		Lecture	Tutorial	Practical/Practice						
DSE: Solids State Chemistry and supramolecular Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-				
BACHELOR OF CHEMISTRY WITH HONOURS										
Programme: Bachelor of Chemistry with Honours			Year: IV		Semester: VIII					
Paper: GE 8A										
Subject: Chemistry										
Course: GE 8A	Course Title: Solid State Chemistry and Supramolecular Chemistry									

Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Understand basics of solid-state reaction, crystal defects, and their effects on properties of materials.
- Learn the synthesis, preparations and applications of organic solids, fullerenes and molecular devices.
- Understanding the role of supramolecules in catalysis.
- Supramolecular chemistry will help them in understanding the role of supramolecules in catalysis. It will assist them to get a suitable job in the relevant industrial and scientific field.

Credits:4	Discipline Specific Elective	
Max. Marks: As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	Solid State Reactions, Crystal Defects and Non-stoichiometry: General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid-state reactions, Perfect and imperfect crystals, intrinsic and extrinsic defects- point defects, line and plane defects, vacancies- Schottky defects and Frenkel defects	15
Unit II	Electronic Properties and Band Theory: Metals, insulators and semiconductors, electronic structure of solids-band theory. Band structure of metals, insulators and	



	semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors.	15
Unit III	Organic Solids, Fullerenes, Molecular Devices: Electrically conducting solids, organic charge transfer complexes, organic metals, new super conductors, magnetism in organic materials, fullerenes-doped, fullerenes as superconductors. Molecular rectifiers and transistors, artificial photosynthetic devices.	15
Unit IV	Supramolecular Chemistry I: Molecular recognition: molecular receptors for different types of molecules including aromatic substrates, design and synthesis of co-receptor molecules and multiple recognition. Strong, weak and very weak H-bonds, utilization of H-bonds to create supramolecular structures. Chelate and macrocyclic effects. Cation binding hosts, binding of anions, binding of neutral molecules, binding of organic molecules. Supramolecular reactivity and catalysis. Supramolecular devices, supramolecular photochemistry, supramolecular switching devices. Some examples of self-assembly in supramolecular chemistry.	15

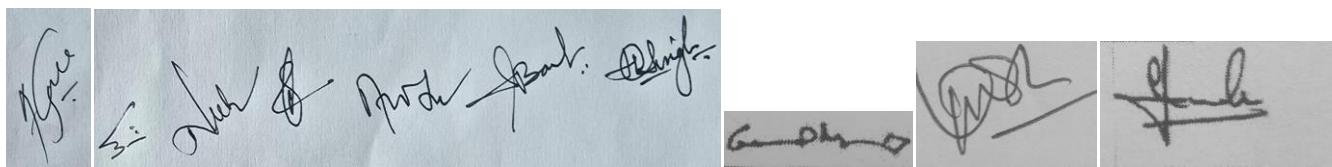
Recommended Readings:

- G.W. Castellan, Physical Chemistry, 4 th Ed. Narosa.
- R.G. Mortimer, Physical Chemistry, 3 rd Ed. Elsevier: NOIDA, UP.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online courses:

<https://www.ias.ac.in/article/fulltext/reso/023/03/0277-0290>



Semester-VIII

Bachelor of Chemistry with Honours

GENERIC ELECTIVES (GE 8 B)

Analytical and Separation Techniques

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Analytical and Separation Techniques	4	4	-	-	Chemistry in Bachelor of Science	-

BACHELOR OF CHEMISTRY WITH HONOURS		
Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: VIII Paper: GE 8B
Subject: Chemistry		
Course: GE 8B	Course Title: Analytical and Separation Techniques	

Course outcomes:

- This paper provides detailed knowledge of X-ray diffraction and electron diffraction techniques as well as students will learn chromatographic methods, radio analytical methods and extraction methods used in analysis of compounds.
- On completion of this course students will have detailed knowledge on TLC, HPLC, GLC, GSC, Ion exchange and gas chromatography.

Unit	Content	No. of
Hours		
1	<p>X-ray Diffraction Methods:</p> <p>(I) Bragg condition, Miller indices, Laue's method, Bragg's method, Debye- Scherrer method of X-ray structural analysis of crystals. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules. Ramchandran diagram.</p> <p>(II) General Introduction of Electron Diffraction: Scattering intensity vs scattering angle, Wierl equation.</p>	15
2	<p>Chromatographic methods:</p> <p>I. AnIntroduction to Chromatography, Principle, instrumentation and Applications of gas and liquid chromatography, Partition Chromatography, Adsorption Chromatography</p> <p>II. Principle and application of TLC, paper, column and HPLC, Migration Rates of</p>	30

Yours
W. H. Brewster
B. M. Peabody
Mass. Acad. of
Sciences

	<p>Solutes, and Broadening and Column Efficiency.</p> <p>III. Principles of GLC, Instruments for GLC, Gas Chromatographic Columns and Stationary Phases, Applications of GC and advances in GC, Column Efficiency in LC, Van-Demeter equation (no derivation), concept about HETP- Applications.</p> <p>IV. Gas-Solid Chromatography</p> <p>V. Ion Exchange chromatography: Cationic, anionic exchangers and their applications.</p> <p>VI. Gas Chromatography: Theory of gas chromatography, parts of gas chromatography, Detectors (TCD, FID, ECD).</p>	
3	Radio Analytical Methods: Basic principles and types of measuring instrument, isotope dilution techniques- principle of operations and uses. Applications. Neutron Activation Methods, Isotope Dilution Methods	10
4	Types of Extraction: Introduction, principle, techniques, factors affecting solvent extraction	5

Books Recommended

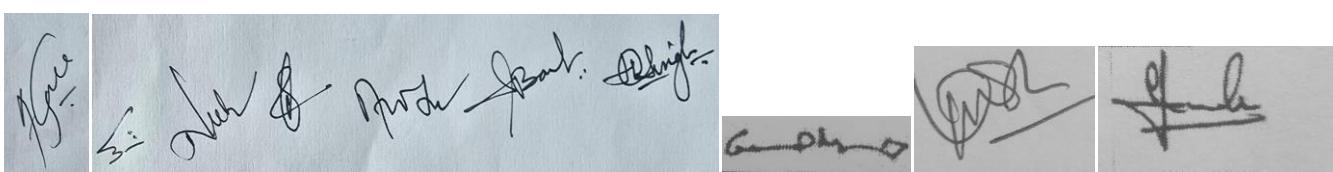
- Skoog et al principles of Instrumental Analysis 2017 Brooks/ Cole Publisher
- Vogels Analytical Chemistry. Sultan Chand & Sons publishers 2005.
- B.K. Sharma, Instrumental methods of chemical analysis; Krishna Prakashan India 1972
- R. Puri, L. R. Sharma and M. S. Pathnia, Advanced Physical Chemistry, Milestone Publisher & Distributors, New Delhi

Suggestive digital platforms web links

https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000944...

<https://egyankosh.ac.in/handle/123456789/43341>

Semester-IX



MASTER'S IN CHEMISTRY

DISCIPLINE SPECIFIC COURSE (DSC 9)
Advanced Spectroscopic Techniques I
Advanced Experimental Chemistry-III

No. of Hours- 45

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Advanced Spectroscopic Techniques-I Advanced Experimental Chemistry-IV	4	3	-	1	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry	Year: V	Semester: IX Paper: DSC 9
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Subject: Chemistry

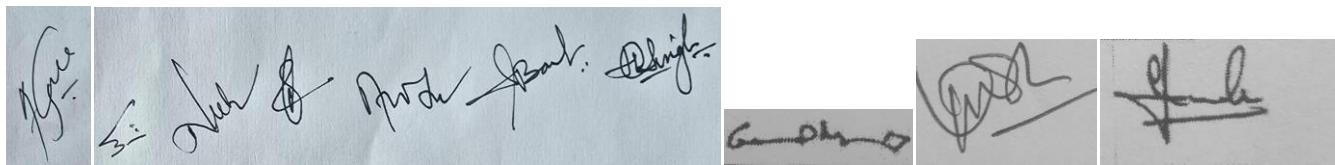
Course: DSC 9	Course Title: Advanced Spectroscopic Techniques I
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Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Develop a comprehensive understanding of Nuclear Magnetic Resonance (NMR) spectroscopy, including nuclear spin, chemical shift, spin-spin interaction, instrumentation with applications to nuclei such as ^{13}C , ^{19}F and ^{31}P .
- Master the principles and techniques of Mass Spectrometry, including ion production methods, fragmentation patterns and interpretation of mass spectra for organic compounds.
- Gain proficiency in Microwave and Raman Spectroscopy, diatomic vibrating rotator, anharmonicity, selection rules, CARS and their applications.
- Understand structure elucidation of various compounds through numerical problems.
- To know about the electromagnetic spectrum, born oppenheimer approximation, and fourier transform spectroscopy

Credits:3	Discipline Specific Course	
Max. Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	No. of Hours
Unit I	<p>Nuclear Magnetic Resonance Spectroscopy: Instrumentation and principle of NMR, Nuclear Overhauser effect, Factors affecting Signal to noise ratio, Simplification of complex spectra by the use of Shift reagent and field strength. ^{13}C NMR spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne and aromatic hetero aromatic and</p>	12



	carbonyl carbon), shielding and deshielding. Coupling constants, First order and second order spectra, Long range coupling. Effect of solvents on chemical shift. ^{13}C , ^{31}P , ^{19}F NMR.	
Unit II	Two-dimensional NMR spectroscopy: Pulse sequence, Pulse width- Principle, COSY, HETCOR, HMQC, NOESY, COSY, DEPT, INEPT, APT and INADEQUATE techniques. Problem solving using spectral graphs and data.	9
Unit III	Electromagnetic spectrum: Characterization of Electromagnetic radiation, Quantization of energy, Born Oppenheimer approximation, Lambert beer's law, Zeeman and Stark effect, Representation of spectra, Signal to Noise resolution, Factors affecting line width and intensity of spectral transitions, Fourier transform spectroscopy.	8
Unit IV	Microwave Spectroscopy: Diatomic vibrating rotator, Zero point energy, Force constant and bond strength, anharmonicity, Morse potential energy diagram, P, Q, R branches, Breakdown of Born Oppenheimer approximation, Interaction of rotations and vibrations, Vibrations of polyatomic molecule. Simple applications. Problem solving.	8
Unit V	Raman Spectroscopy: Classical and quantum theories of Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual principles. Resonance Raman spectroscopy, CARS. Structure determination of AB ₂ , AB ₃ molecule by IR and Raman spectroscopy.	8

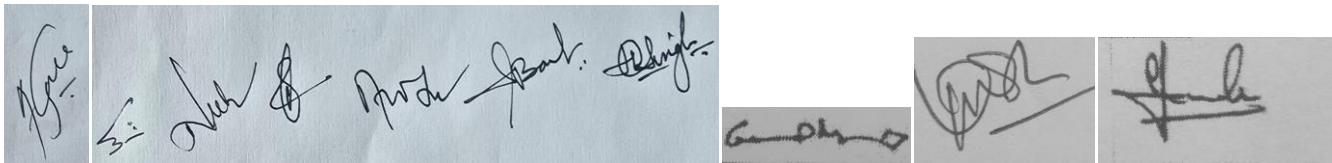
Recommended Readings

- Pavia, Lampman, Kriz, Spectroscopy, Books/Cole; Vyvyan
- P.S. Kalsi, Spectroscopy of Organic Compounds, New Age International Publishers;
- Silverstein, Robert M.; Webster, Francis X.; Kiemle, Spectrometric Identification of Organic Compounds.
- M. L. Martin, J.J. Delpeach and G.J. Martin, Heyden, Practical NMR Spectroscopy,
- Colin N. Banwell and Elaine M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
- R.J. Abraham, J. Fischer and P. Loftus, Introduction to NMR Spectroscopy, Wiley

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online content:

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>

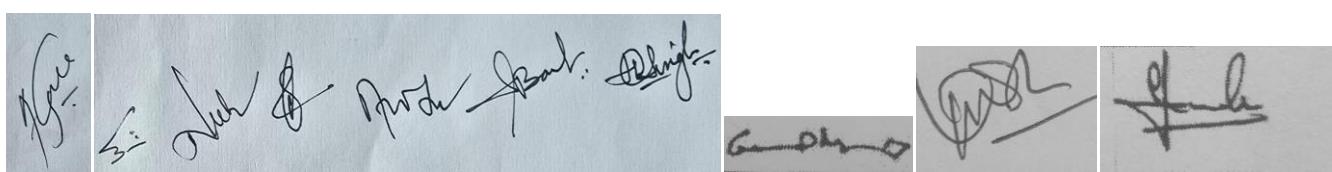


MASTER'S IN CHEMISTRY				
Programme: Master's in Chemistry	Year: V	Semester: IX Paper: DSC		
Subject: Chemistry				
Course: DSC	Course Title: Advanced Experimental Chemistry – III (Practical)			
Course Outcomes:				
Upon completion of this course, the students will have the knowledge and skills to: understand the laboratory methods and tests related to inorganic, organic and physical experiments. The students will be able to				
<ul style="list-style-type: none"> • Determine the concentrations of inorganic compounds through complexometric titration and gravimetric estimation. • Synthesize organic compounds via two steps. This will include photochemical and enzymatic synthesis of various organic compounds. • Learn the experiments of chemical kinetics for the determination of the velocity constant, activation energy, effect of temperature and concentration on the rate constant, partition coefficients etc. • Experiments to physically verify different adsorption isotherms. 				
Credits:1	Discipline Specific Course			
Max. Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours		
Unit I	Laboratory hazards and safety precautions	4		
Unit II	(A). Synthesis and interpretation of organic / inorganic compounds using various spectroscopic techniques i). U.V ii). I.R iii). NMR iv). Raman (B). Estimation of amino acid(s) using U.V. Spectroscopy. (C). Analysis of compounds using Raman/I.R. spectroscopy	26		

Note: Allocation of marks - External assessment: Total marks 75 (Each practical carries 30 marks; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05). Students have to perform two practicals.

Recommended Readings

- J. Mendham, Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- D. C. Harris, Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
- S.M. Khopkar, Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
- D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, Cengage Learning India Edition



Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>

Semester-IX

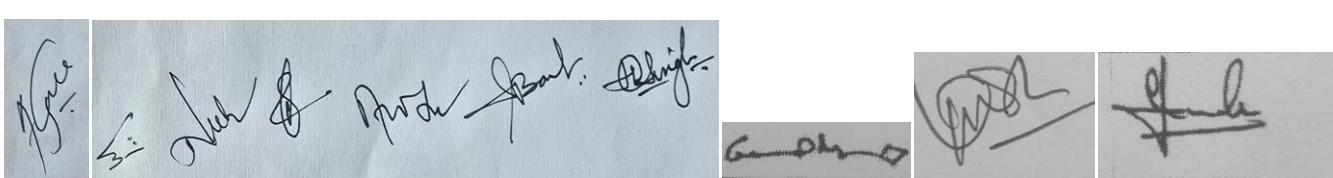
MASTER'S IN CHEMISTRY

DISCIPLINE SPECIFIC ELECTIVE (DSE 9A)
Applied Photochemistry and Nuclear Chemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

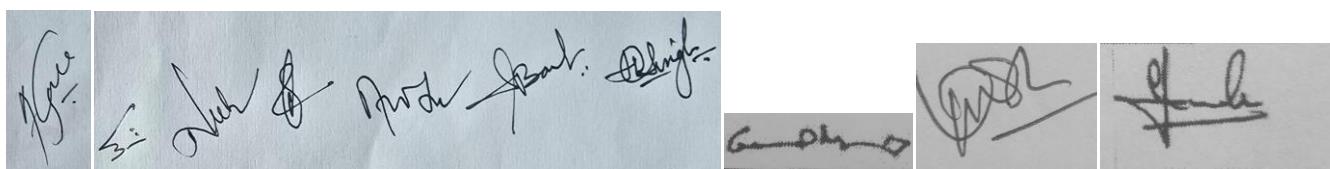
Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)											
		Lecture	Tutorial	Practical/Practice													
DSE: Applied Photochemistry and Nuclear Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-											
MASTER'S IN CHEMISTRY																	
Programme: Master's in Chemistry		Year: V		Semester: IX Paper: DSE 9A													
Subject: Chemistry																	
Course: DSE 9A	Course Title: Applied Photochemistry and Nuclear Chemistry																
Course Outcomes:																	
Upon successful completion of this course, the students will be able to:																	
<ul style="list-style-type: none"> • Understand the interaction of electromagnetic radiation with matter, quantum yield and photochemical reaction mechanisms. • Learn about singlet molecular oxygen reactions, smog formation, photodegradation of polymers and energy state transitions. • Gain proficiency in determining rate constants, effects of light intensity and molecular photochemistry including fluorescence and phosphorescence. • Master advanced nuclear chemistry concepts including radioactive decay, nuclear reactions, fission processes and energy production in stars. 																	
Credits:4	Discipline Specific Course																
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules																



Unit	Topic	No. of Hours
Unit I	Photochemical Reactions: Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry. Singlet molecular oxygen reactions, photochemical formation of smog and photodegradation of polymers.	10
Unit II	Determination of Reaction Mechanism: Classification, rate constants and life times of reactive energy states, determination of rate constants, effect of light intensity on the rate of photochemical reactions. Molecular Photochemistry: Transitions between states (Chemical, classical and quantum dynamics, vibronic states). Potential energy surfaces; transitions between potential energy surfaces, radiative transitions. A classical model of radiative transitions. The absorption and emission of light-state mixing, spinorbit coupling and spin forbidden radiative transitions, absorption complexes, fluorescence, phosphorescence and chemiluminescence.	20
Unit III	Nuclear Models Atomic structure, Nuclides, Nuclear stability, mechanical effects due to orbiting and spinning nucleons, quarks and gluons. Franck -Condon principle. Radiation Chemistry Interaction of neutrons, gamma radiation with matter. Units, Radiolysis. Radiochemical, and radiometric analysis in chemistry.	5
Unit IV	Advanced Nuclear Chemistry: Radioactive equilibrium, nuclear reaction, Q value cross section, types of reaction. Theory of Nuclear forces. Radioactive decay, alpha, beta, gamma, nuclear reactions; characteristics and similarities with chemical reactions, threshold and cross section, nuclear reaction due to neutron, proton, deuteron and gamma irradiation, Nuclear fission, fission cross section, chain fission and resonance capture. Fission products and fission yields, mass and charge distribution in fission and spallation reaction, nuclear reactor. Nuclear fission and stellar energy.	10
Unit V	PROBLEM BASED ON ABOVE THEORY	15

Recommended Readings

- N.J. Turro Modern Molecular Photochemistry, University Science Books
- A Gilbert, J Baggot, Essentials of Molecular Photochemistry, Blackwell Scientific
- K.K. Rohtagi-Mukharji, Fundamentals of Photochemistry, Wiley- Eastern.
- A Cox and T. Champ, Introductory Photochemistry, McGraw-Hill.
- R.P. Kundall and A. Gilbert, Thomson Nelson, Photochemistry



- J. Coxon and B. Halton, Organic Photochemistry, Cambridge University Press.
- N.J. Turro, Modern molecular photochemistry, University Science Books.
- Arnikar, Nuclear chemistry
- D. N. Bajpai, Advanced Physical Chemistry, S. Chand and Co.
- Kundu and Jain, Modern Physical Chemistry, S. Chand and Co.

Suggested Continuous Evaluation Methods: Since the class is conceived as learner-centric and built around tasks that require learners to actively use various language skills, formative assessment can and should be used extensively. Oral presentations, peer interviews, and group tasks can be used for this purpose. The end-semester written examination will test all the areas targeted in the course.

Semester-IX

MASTER'S IN CHEMISTRY

DISCIPLINE SPECIFIC ELECTIVE (DSE 9B)- Organic Synthesis

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Organic Synthesis	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry	Year: V	Semester: IX Paper: DSE 9B
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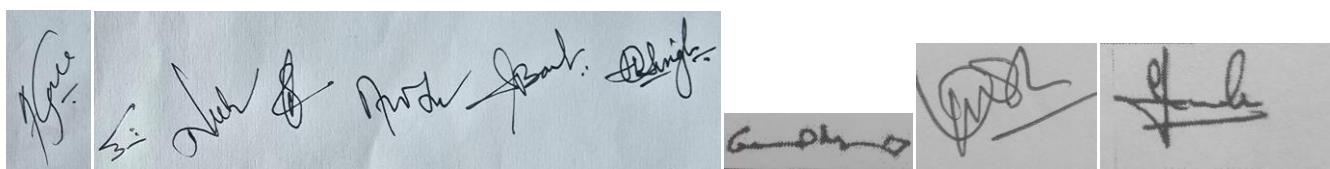
Subject: Chemistry

Course: DSE 9B Course Title: Organic Synthesis

Course Outcomes:

Upon successful completion of this course, the students will be able to:

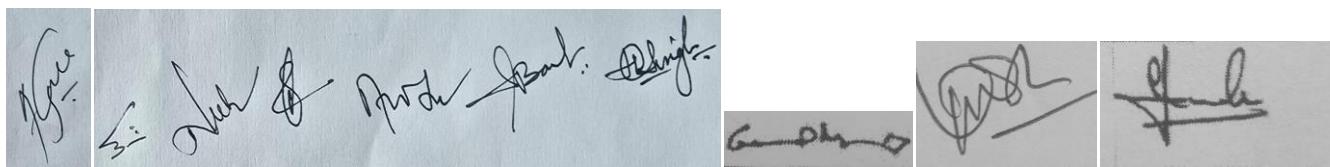
- Understand use of the reagents in organic synthesis, oxidation, reduction of different organic compounds.
- Learn and appreciate the concepts of disconnection approach and protection of groups.
- Understand the applications of these concepts in drug designing. Develop expertise in oxidation and reduction techniques for transforming hydrocarbons, alcohols, carbonyls and amines.
- Apply the disconnection approach and synthons in planning organic synthesis, ensuring



<p>correct order of functional group transformations.</p> <ul style="list-style-type: none"> Understand and utilize protecting groups to safeguard functional groups such as alcohols, amines, carbonyls and carboxylic during synthesis. Gain knowledge of organometallic reagents, including preparation and application of compounds from Group I and II metals, transition metals and elements like sulfur, silicon and boron. 		
Credits:4		Discipline Specific Course
Max. Marks: As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	Oxidation: Introduction. Different oxidative processes. Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated & nonactivated). Alcohols, diols, aldehydes, ketones and carboxylic acids. Amines. Oxidation with ruthenium tetroxide, iodobenzene diacetate and thallium (III) nitrate. Reduction: Introduction, Different reductive process. Hydrocarbons-alkanes, alkenes, alkynes and aromatic rings. Carbonyl compounds-aldehydes, ketones, acids. Epoxides, Nitro and azo, Hydrogenolysis.	20
Unit II	Disconnection Approach: An introduction to synthons and synthetic equivalents, disconnection approach, functional group interconversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, One group and two group C-C disconnections. Aliphatic nitro compounds in organic synthesis. Application in chemical synthesis and name reactions, Diels alder reaction, Michael addition, Robinson annelation	10
Unit III	Protecting Group: Principle of protection of alcohol, amine, carbonyl and carboxyl groups. Ring Synthesis: Saturated heterocycles, synthesis of 3,4,5 and 6 membered rings.	5
Unit IV	Organometallic Reagents: Principle, preparations, properties and applications of the following in organic synthesis: Group I and II metal organic compounds Li, Hg and Zn compounds. Transition metals: Pd, Ni, Fe and Cu compounds; Other elements; Si and B compounds.	10
Unit V	Problems based on above theory	15

Recommended Readings

- H.O. House, W.A. Benjamin, Modern Synthetic Reaction,
- W. Carruthers, Some Modern Methods of Organic Synthesis. Cambridge Univ. Press.
- J. March Advanced Organic Chemistry, Reactions Mechanisms and Structure.
- F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part B, Plenum Press.



- Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
- S. Warren, Designing Organic Synthesis, Wiley.
- J. Fuhrhop and G. Penzillin, Organic Synthesis- Concept, Methods and Starting Materials Verlage VCH.
- W. A. Benjamin, Modern Synthetic Reactions, H.O. House

Suggested Continuous Evaluation Methods: Since the class is conceived as learner-centric and built around tasks that require learners to actively use various language skills, formative assessment can and should be used extensively. Oral presentations, peer interviews, and group tasks can be used for this purpose. The end-semester written examination will test all the areas targeted in the course.

Suggested equivalent online courses:

https://onlinecourses.nptel.ac.in/noc22_cy30/preview

<https://nptel.ac.in/courses/104/105/104105087/>

<https://nptel.ac.in/courses/104/103/104103111/>

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>

<https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2013.pdf>

<https://nptel.ac.in/content/storage2/courses/104103023/download/module2.pdf>

<https://nptel.ac.in/courses/104/103/104103111/>

Semester-IX

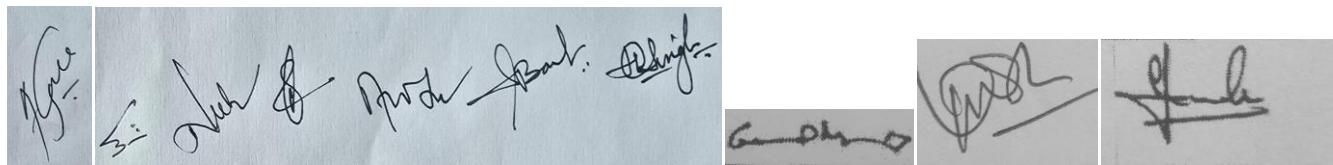
MASTER'S IN CHEMISTRY

DISCIPLINE SPECIFIC ELECTIVE (DSE 9C) Advanced Chromatography

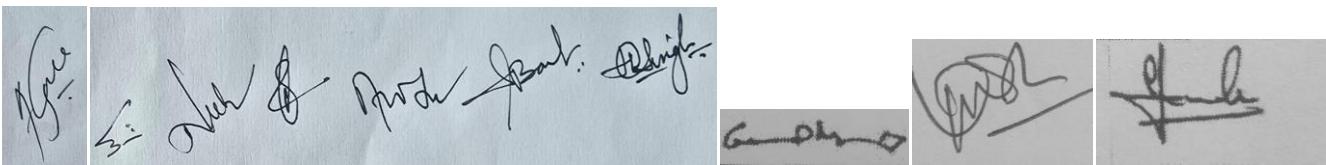
No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 9C: Advanced Chromatography	4	4	-	-	Chemistry in Bachelor of Science	-



MASTER'S IN CHEMISTRY				
Programme: Master's in Chemistry	Year: V	Semester: IX Paper: DSE 9C		
Subject: Chemistry				
Course: DSE	Course Title: Advanced Chromatography			
Course Outcomes:				
Upon successful completion of this course, the students will be able to:				
<ul style="list-style-type: none"> Understand the chromatographic methods and their industrial applications. Gain a comprehensive understanding of various chromatographic techniques, including adsorption, paper, thin layer, and column chromatography and their principles and applications. Master the theory and practice of gas chromatography, including knowledge of detectors and chromatographic efficiency concepts like the Van-Deemter equation and plate theory. Understand the features and instrumentation of high-performance liquid chromatography (HPLC) and its applications in complex sample analysis. Learn the principles of ion exchange chromatography, including ion exchange resins, equilibria with their applications in separating ionic species. 				
Credits:4	Discipline Specific Course			
Max. Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours		
Unit I	Chromatography Introduction, Definition, Classification of Chromatographic Techniques.	05		
Unit II	Adsorption Chromatography Paper Chromatography: Principle, Types and theory of paper chromatography, R_f , R_X and R_G values, Techniques of paper chromatography, Two-dimensional paper chromatography, Applications. Thin Layer Chromatography: Theory of TLC, Quantitative evolution of separated solutes, Various types of TLC, High performance thin layer chromatography, Applications Column Chromatography: Principle of adsorption chromatography, Separation of the compounds, Chiral chromatography, Applications	15		
Unit III	Gas Chromatography: Theory of gas chromatography, parts of gas chromatograph, detectors (TCD, FID, ECD), Van-Deemter equation (no derivation), concept about HEPT- plate theory and rate theory. Applications. High Performance Liquid Chromatography Characteristics feature of HPLC, Instrumentation for HPLC, Applications.	10		
Unit IV	Ion Exchange Chromatography Ion Exchangers, Cation Exchange resins, Ions Exchange equilibria, Anion Exchange resins, Factor affecting ion exchange equilibria, Application of IEC.	15		
Unit V	PROBLEMS RELATED TO CHROMATOGRAPHIC TECHNIQUES	15		



Recommended Readings

- Vogel's Quantitative Chemical Analysis by J. Mendham.
- Instrumental Methods of Analysis by H. H. Willard.
- Analytical Chemistry by G. D. Christian.
- Exploring Chemical Analysis by D. C. Harris.
- Basic Concepts of Analytical Chemistry by S. M. Khopkar.
- Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman.
- Laboratory Handbook of Chromatographic & Allied Methods by O. Mikes and R. A. Chalmes.
- Analytical Chemistry: Methods of separation by R. V. Ditts.
- Skoog et al principles of Instrumental Analysis 2017 Brooks/ Cole Publisher
- Vogels Analytical Chemistry. Sultan Chand & Sons publishers 2005.
- B.K. Sharma, Instrumental methods of chemical analysis; Krishna Prakashan India 1972
- B. R. Puri, L. R. Sharma and M. S. Pathnia, Advanced Physical Chemistry, Milestone Publisher & Distributors, New Delhi

Suggested Continuous Evaluation Methods: Since the class is conceived as learner-centric and built around tasks that require learners to actively use various language skills, formative assessment can and should be used extensively. Oral presentations, peer interviews, and group tasks can be used for this purpose. The end-semester written examination will test all the areas targeted in the course.

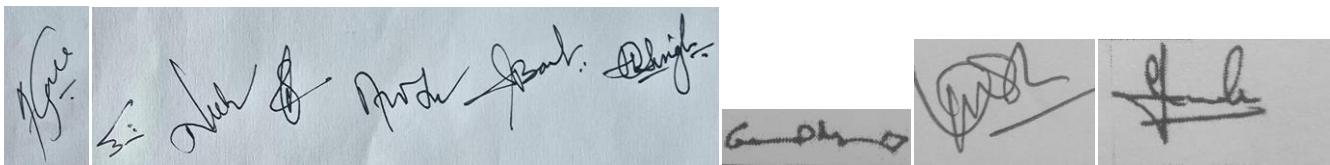
Semester-IX Masters of Chemistry

GENERIC ELECTIVES (GE 9A) Basic Physical Chemistry and Industrial Chemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Basic Physical Chemistry and Industrial Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-



BACHELOR OF CHEMISTRY WITH HONOURS

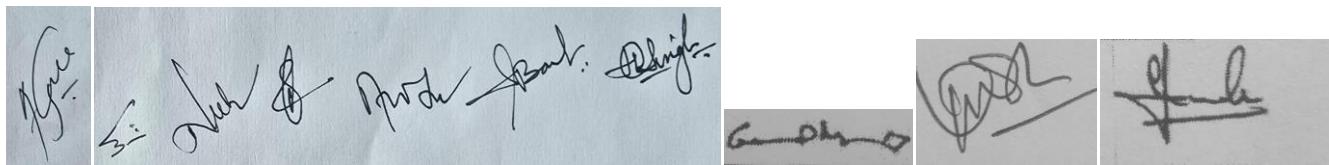
Programme: Bachelor of Chemistry with Honours	Year: IV	Semester: IX Paper: GE 9A
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Subject: Chemistry**Course: GE 9A Course Title: Basic Physical Chemistry and Industrial Chemistry****Course Outcomes:**

Upon successful completion of this course, the students will be able to:

- Understand about Gas laws, ideal and real gas.
- Acquire knowledge about rate laws and order of reaction.
- Know about polymer industrial chemistry.

Credits:4	Generic Elective 1	
Max. Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	No. of Hours
Unit I	Basic physical chemistry I Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature, Maxwell's distribution law of molecular speeds (without derivation), most probable, average and root mean square speed of gas molecules, principle of equipartition of energy (without derivation). Mean free path and collision frequencies. Heat capacity of gases (molecular basis); viscosity of gases. Real gases, compressibility factor, deviation from ideality, van der Waals equation of state, critical phenomena, continuity of states, critical constants. Liquid state: physical properties of liquids and their measurements: surface tension and viscosity.	15
Unit II	Basic Physical Chemistry II Chemical kinetics and catalysis: order and molecularity of reactions, rate laws and rate equations for first order and second order reactions (differential and integrated forms); zero order reactions. Determination of order of reactions. Temperature dependence of reaction rate, energy of activation. Catalytic reactions: homogeneous and heterogeneous catalytic reactions, autocatalytic reactions, catalyst poisons, catalyst promoters (typical examples).	15
Unit III	Industrial chemistry I Fuels: Classification of fuel, heating values. Origin of coal, carbonization of coal, coal gas, producer gas, water gas, coal-based chemicals. Origin and composition of petroleum, petroleum refining, cracking, knocking, octane number, anti-knock compounds, Kerosene, liquefied petroleum gas (LPG), liquefied natural gas (LNG), petrochemicals (C1 to C3 compounds and their uses). Fertilizers: Manufacture of ammonia and ammonium salts, urea, superphosphate, biofertilizers. Glass and Ceramics: Definition and manufacture of glasses, optical glass and coloured glass. Clay and feldspar, glazing and vitrification, glazed porcelain, enamel. Portland cement: composition and setting of cement, white cement.	15



Unit IV	<p>Industrial Chemistry II Polymers: Basic concept, structure and types of plastics, polythene, polystyrene, phenol-formaldehydes, PVC; manufacture, physical properties and uses of natural rubber, synthetic rubber, silicone rubber; synthetic fibres: Nylon-6,6, polyester, terylene, rayon; foaming agents, plasticizers and stabilizers.</p> <p>Paints, Varnishes and Synthetic Dyes: Primary constituents of a paint, binders and solvents for paints. Oil based paints, latex paints, baked-on paints (alkyd resins). Constituents of varnishes. Formulation of paints and varnishes. Synthesis of Methyl orange, Congo red, Malachite green, Crystal violet.</p> <p>Drugs and pharmaceuticals: Concept and necessity of drugs and pharmaceuticals. Preparation, and uses of Aspirin, Paracetamol, Sulphadiazine, Quinine, Chloroquine, Phenobarbital, Metronidazole.</p> <p>Fermentation Chemicals: Production, and purification of ethyl alcohol, citric acid, lactic acid, Vitamin B12, Penicillin.</p>	15
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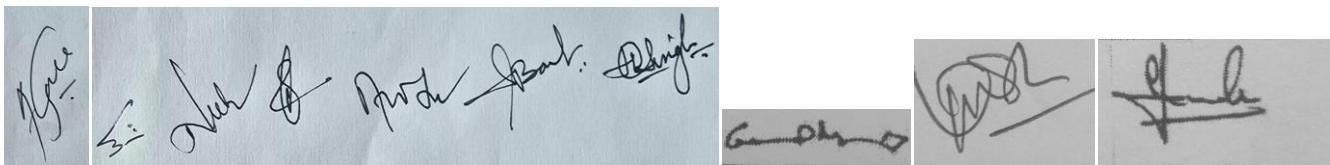
Recommended Readings:

- N. Levine: Physical Chemistry
- G. W. Castellan: Physical Chemistry
- P. W. Atkins: Physical Chemistry
- R. S. Berry, S. A. Rice and J. Ross: Physical Chemistry
- T. Engel and P. Reid: Physical Chemistry
- W. J. Moore: Physical Chemistry
- F. Maqdoom: A Textbook for Industrial Chemistry
- Kent J. A.: Riegels Handbook of Industrial Chemistry

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

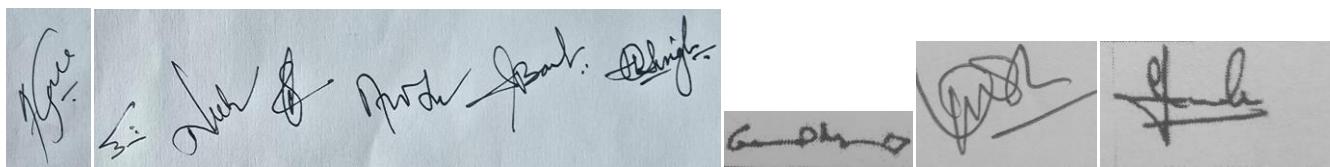
Suggested equivalent online content:

<https://caluniv.ac.in/syllabus/chemistry.pdf>



Semester-IX**Master's in Chemistry****GENERIC ELECTIVES (GE 9 B)- Computer For Chemists****No. of Hours- 60****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)									
		Lecture	Tutorial	Practical/Practice											
GE 9B: Computer for Chemists	4	4	-	-	Passed Class XII	-									
MASTER'S IN CHEMISTRY															
Programme: Master's in Chemistry			Year: V		Semester: IX Paper: GE 9 B										
Subject: Chemistry															
Course: GE9B		Course Title: Computer for Chemists													
Course Outcomes:															
Upon successful completion of this course, the students will be able to:															
<ul style="list-style-type: none"> Understand about history and development of different types of Computers. Acquire knowledge about Software's and languages 															
Credits:4				Generic Elective 2											
Max. Marks: As per University rules				Min. Passing Marks: As per University rules											
Unit	Topic														
Unit I	History of Development of Computer, Classification of Computer, Generation of Computers, General Awareness of Computer Hardware- CPU and other Peripheral devices, Input, Output and Auxiliary Storage Devices														
Unit II	Software and their types (System Software and Application Software) Computer Language and their types (Low Level and HighLevel Languages), Operating System, Requirement of OS, Types of OS: Single User and Multi-user OS with examples.														
Unit III	MS Word, Facilities in MS Word, MS Excel, Facilities in MS Excel, MS PowerPoint, Facilities in MS PowerPoint, Oral Presentations using visual aids such as PowerPoint etc.														
Unit IV	Computer Applications in Chemistry: Introduction to Computers, General Information, Some related terminology, Flow Charting- Concept, Some flow charts- examples, Concept of Programming- BASIC language, Some Programmes in BASIC.														



Recommended Readings:

- Computer Fundamentals by P K Sinha.
- Computer Fundamentals by Goel.
- Computer Fundamentals and Programming in C by Reema Thareja.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Semester- IX

MASTER'S IN CHEMISTRY

GENERIC ELECTIVE (GE 9C)

Essentials of Medicinal and Aromatic Plant Science

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE 9C: Essential of Medicinal and Plant Science	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry

Year: V

Semester: IX

Paper: GE 9C

Subject: Chemistry

Course: GE 9C Course Title: Essentials of Medicinal and Aromatic Plant Science

Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Proficiency in identifying and utilizing medicinal plant parts for therapeutic purposes in diverse forms.
- Mastery of extraction techniques including hydrodistillation and solvent extraction.
- Comprehensive understanding of cultivation practices, post-harvest handling, and industrial applications of medicinal plants.

Credits:4

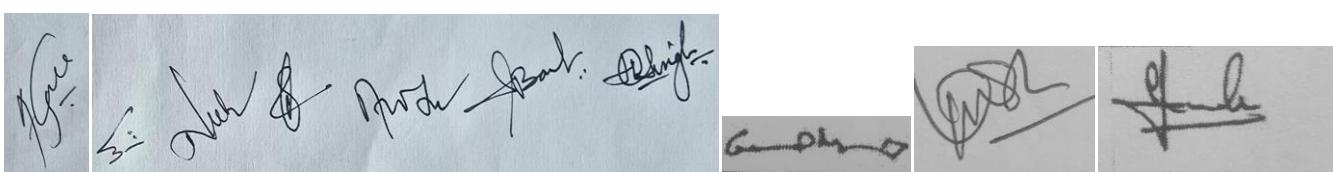
Generic Electives 2

Max. Marks: As per University rules

Min. Passing Marks: As per University rules

Unit	Topic
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No. of Hours



Unit I	Introduction to Medicinal and Aromatic Plants: General aspects, occurrence, history, present and future need introduction of rich sources, quality control, contributions of research labs.	15
Unit II	Utilization of Medicinal Plant Parts: Plant parts used as powder, juice/decoction, lotion and ointments, oil, surgical fibers, sutures and dressings, poultice.	15
Unit III	Extraction Techniques and Phytochemical Isolation Extraction methods for terpenoids, hydrodistillation, steamdistillation, solvent extraction, isolation methods, factors affecting yield and quality.	20
Unit IV	Cultivation, Processing, and Industrial Applications: Cultivation, aromatic plant standards and grades, post-harvest handling, value addition, industrial applications, pharmaceutical and biological activities, health benefits.	10

Recommended Readings:

- Shiva, M.P., Aromatic and Medicinal Plants: Yielding Essential oil for Pharmaceutical Perfumery and Cosmetic Industry and Trade.
- Verma and Joshi, Post Harvest Technology of Fruits and Vegetables, Handling, Processing, Fermentation and Waste Management.
- C. Shukla, Plant Constituents and their Mechanism of Action as Pesticide, Lambert Academic Publishing, Germany
- Egbuna, J. Chinenye Ifemeje, S. C. Udedi, S. Kumar, Phytochemistry: Vol. 1, Fundamentals, Modern Techniques, and Applications,
- Atta-ur-Rahman, Studies in Natural Products Chemistry, Elsevier.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Semester-X

MASTER'S IN CHEMISTRY

DISCIPLINE SPECIFIC COURSE (DSC 10)
Advanced Spectroscopic Techniques II
Advanced Experimental Chemistry-IV

No. of Hours- 45

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Advanced Spectroscopic Techniques II Advanced Experimental Chemistry-IV	4	3	-	1	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry	Year: V	Semester: X Paper: DSC 10
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Subject: Chemistry

Course: DSC 10 **Course Title: Advanced Spectroscopic Techniques II**

Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Understand structure elucidation of various compounds through numerical problems.
- Master the principles and techniques of Mass Spectrometry, including ion production methods, fragmentation patterns and interpretation of mass spectra for organic compounds.
- Understand the principle and applications of Electron Spin Resonance (ESR) and Mossbauer Spectroscopy, including zero field splitting, hyperfine coupling, spectral parameters and structure elucidation through spectral analysis.
- Gain proficiency in Mossbauer spectroscopy and X-ray diffraction methods and their applications.

Credits:3	Discipline Specific Course	
Max. Marks: As per University rules	Min. Passing Marks: As per University rules	
Unit	Topic	No. of Hours
Unit I	Molecular dissymmetry and chiroptical properties: Linear and circularly polarised lights, circular birefringence and circular dichroism, ORD and CD curves, Cotton effect. The axial haloketone rule, octant diagrams, helicity. Application of ORD and CD to structural and stereochemical problems.	5

Unit II	Mass Spectrometry: Introduction, ion production-EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule, isotopic mass peaks, relative intensity, FTMS, etc.; General fragmentation rules: α -, β -, allylic and benzylic cleavage; ESI, APCI and MALDI, etc. Fragmentation of various classes of organic molecules, including compounds containing oxygen, sulphur, nitrogen and halogens.	10
Unit III	Electron Spin Resonance Spectroscopy: Basic Principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Hyperfine coupling isotopic and anisotropic hyperfine coupling constants spin Hamiltinian, spin-orbit coupling and significance of g-tensors.	10
Unit IV	Mossbauer Spectroscopy: Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of bonding and structure of Fe^{++} and Fe^{+++} compounds, nature of M-L bond, coordination number, structure and detection of oxidation state and inequivalent MB atoms. Structure elucidation through problems.	10
Unit V	X-ray Diffraction Methods and Electron Microscopy: Bragg condition, Miller indices, Laue's method, Bragg's method, Debye- Scherrer method of Xray structural analysis of crystals. Ramchandran diagram. General Introduction of Electron Diffraction: Scattering intensity vs scattering angle. Electron Microscopy: TEM, SEM	05

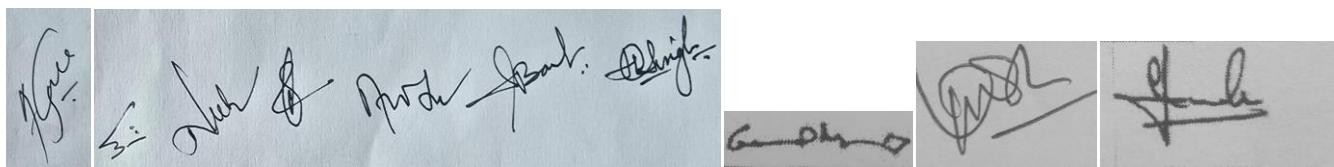
Recommended Readings

- Pavia, Lampman, Kriz, Spectroscopy, Books/Cole; Vyvyan
- P.S. Kalsi, Spectroscopy of Organic Compounds, New Age International Publishers;
- Silverstein, Robert M.; Webster, Francis X.; Kiemle, Spectrometric Identification of Organic Compounds.
- M. L. Martin, J.J. Delpeach and G.J. Martin, Heyden, Practical NMR Spectroscopy,
- Colin N. Banwell and Elaine M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
- R.J. Abraham, J. Fischer and P. Loftus, Introduction to NMR Spectroscopy, Wiley

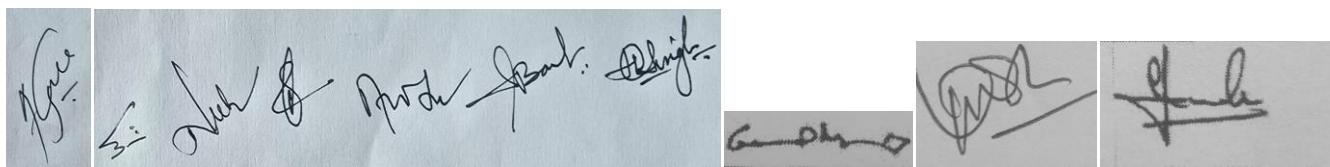
Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online content:

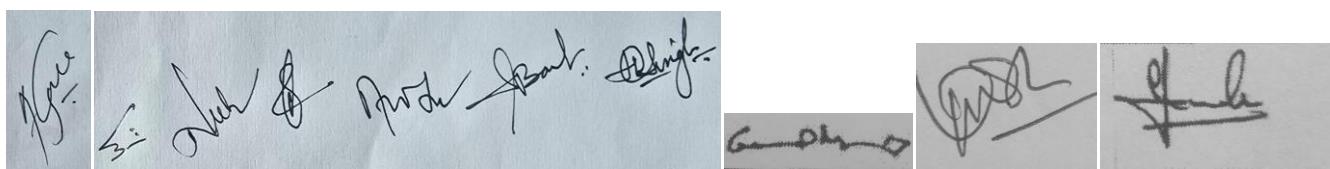
<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>



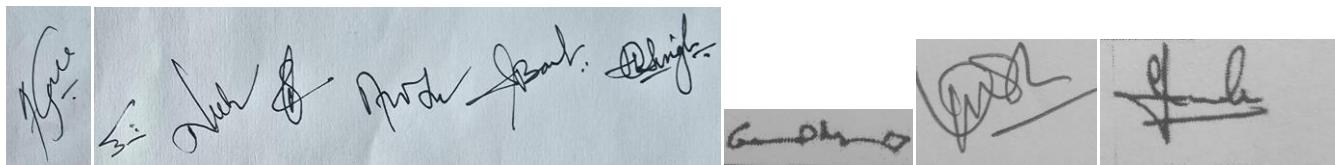
MASTER'S IN CHEMISTRY				
Programme: Master's in Chemistry	Year: V	Semester: X Paper: DSC		
Subject: Chemistry				
Course: DSC	Course Title: Advanced Experimental Chemistry – IV (Practical)			
Course Outcomes:				
<ul style="list-style-type: none"> Upon completion of this course, the students will perform the inorganic exercise related to semimicro analysis and preparation of various coordination compounds. They will also learn to determine stability constant of metal complexes by Job's method. They can separate metal ions using paper chromatography. They will have the knowledge and skills to separate and identify three components in the given organic mixture. They will be able to learn the extraction of organic compounds from natural sources. Spectroscopic exercise will train them to interpret the spectral data organic compounds and will make them job ready for suitable industries. The students of physical chemistry group will learn the experimental setting up and determination of stability constant, transport number, liquid junction potential by different methods. They will learn the conductometric determination of equivalent conductivity, determination of degree of dissociation, pH determination. They will be able to check the validity of Ostwald dilution law, Langmuir adsorption isotherm. 				
Credits:4	Discipline Specific Course			
Max. Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours		
Unit I	Laboratory hazards and safety precautions	5		
Unit II	Inorganic Chemistry <p>A. To determine the composition of Cu-EDTA complex by Job's method</p> <p>B. Inorganic synthesis</p> <p>Synthesis of selected inorganic compounds/ complexes and their characterization by IR, electronic spectra (UV & Visible), NMR, Mossbauer, ESR and magnetic susceptibility etc. measurements. Selection can be made from the following or any other from the existed literature.</p> <p>(i) cis-and trans- isomers of <i>trans</i>-dichlorobis (ethylenediamine)cobalt(III) chloride: $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$.</p> <p>(ii) Metal acetylacetones: $[\text{Cr}(\text{acac})_3]$; Vanadyl acetylacetone, $[\text{Cu}(\text{acac})_2 \cdot \text{H}_2\text{O}$ etc.</p> <p>(iii) Ferrocene</p> <p>(iv) Cr(II) complexes: $[\text{Cr}(\text{H}_2\text{O})_6](\text{NO}_3)_3 \cdot 3\text{H}_2\text{O}$; $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}_2 \cdot 2\text{H}_2\text{O}$; $[\text{Cr}(\text{en})_3]\text{Cl}_3$</p> <p>(v) Tin(IV) iodine, Tin(IV) choride, Tin(II) iodine.</p> <p>(vi) Mixed valence dinuclear complexes of manganese (III, IV).</p>	25		



	<p>(viii) Tris(thiourea) copper (I) sulphate: $[\text{Cu}[(\text{NH}_2)_2\text{CS}]_3]_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$</p> <p>(ix) <i>Cis</i>-bis(glycinato) copper (II) monohydrate: <i>Cis</i>-$[\text{Cu}(\text{glyo})_2(\text{H}_2\text{O})]$</p> <p>(x) <i>Trans</i>-potassium-dioxalatodiaquachromate(III) dihydrate: $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2] \cdot 2\text{H}_2\text{O}$</p> <p>(xi) Synthesis of iron oxide nano particles and its possible characterization</p> <p>(C) Chromatography: separation of cations and anions by paper/TLC/Ion Exchange chromatography</p> <p>(D) Quantitative analysis of metal ions involving volumetric (by complexometric titration) and gravimetric analysis (Copper, Nickel, Zinc, Silver, Magnesium).</p>	
Unit III	<p>Organic chemistry</p> <p>A. Qualitative analysis</p> <p>Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid), using TLC for checking the purity of the separated compounds, chemical analysis, IR, PMR and Mass Spectral data (sets of spectra may be provided to Students for characterization of components).</p> <p>(B) Extraction of Organic Compounds from Natural Sources</p> <p>I) Isolation of caffeine from tea leaves.</p> <p>II) Isolation of casein from milk (the students are required to try some typical colour reactions of proteins).</p> <p>III) Isolation of lactose from milk (purity of sugar should be checked by TLC, PC and Rf value reported).</p> <p>IV) Isolation of nicotine dipicrate from tobacco.</p> <p>V) Isolation of cinconine from cinchona bark.</p> <p>VI) Isolation of piperine from black pepper.</p> <p>VII) Isolation of lycopene from tomatoes.</p> <p>VIII) Isolation of β-carotene from carrots.</p> <p>IX) Isolation of oleic acid from olive oil (involving the preparation complex with urea and separation of linoleic acid).</p> <p>X) Isolation of eugenol from cloves.</p> <p>XI) Isolation of limonene from citrus fruits</p> <p>(C) Extraction, TLC, GC/ HPLC of essential oils from natural products</p> <p>I). Extraction from Coriander Seeds</p> <p>II). Extraction from Ajwain Seeds</p> <p>III. Spectroscopy Identification of organic compounds by the analysis of the spectral data (UV, IR, PMR, CMR & MS)</p>	25
Unit-IV	<p>Physical Chemistry</p> <p>1. Study of complex formation by the following methods and</p>	



<p>determination of stability constant wherever practicable:</p> <ol style="list-style-type: none"> 2. Cryoscopy 3. Electrical Methods 4. E.M.F. 5. Determination of transport number. 6. Determination of liquid junction potential. 7. Determination of the charge on colloidal particle. 8. Determination of λ (max) of compounds and verification of Beer's law. 9. Validity of Langmuir's adsorption isotherm. 10. Determination of partial molar volume of solute. 11. Determination of the following thermodynamic parameters of a reaction 12. Enthalpy of activation. 13. Entropy of activation. 14. Free energy change. 15. Equilibrium constant. 16. Frequency factor 17. Conductometric determination of the equivalent conductivity at infinite dilution of a strong electrolyte. 18. Determination of the dissociation constant of a weak acid by conductivity method. 19. Conductometric determination of the equivalent conductivity at infinite dilution of a weak electrolyte. 20. Validity of Ostwald's dilution law. 21. Determination of the degree of dissociation/ association conductometrically. 22. Determination of the formula of silver ammonia complex & copper ammonia complex. 23. Kinetic Study of the primary salt effect 24. Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically. 25. Determination of pH by EMF. 26. Hydrolysis of the salts by cryoscopic method. 27. Determination of strengths of halides in a mixture potentiometrically. 28. Determination of the valency of mercurous ions potentiometrically. 29. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter. 30. Verification of the law of photo-chemical equivalence. 31. Determination of the velocity constant of acid catalyzed hydrolysis of an ester. 32. Determination of activation energy of a reaction. 33. Determination of Frequency factor of a reaction by kinetic studies. 34. Validity of Arrhenius equation. 	25
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35. Determination of the effect of change in temperature on rate constant of a reaction. 36. Determination of the effect of change in concentration of the reactants on rate constant of a reaction. 37. Determination of the effect of change in concentration of the catalyst on rate constant of a reaction. 38. Determination of the effect of change in ionic strength on the rate constant of a reaction. 39. Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide. 40. Flowing Clock reactions (Ref. Experiments in Physical Chemistry by Showmaker). 41. Study of the adsorption of an acid by charcoal. 42. Validity of Freundlich's Adsorption isotherm. 43. Determination of Partition Coefficients. 44. Determination of molecular surface energy of a liquid by Stalagmometer method. 45. Determination of association factor of the given liquid by drop-pipette method.	
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Note: Choice of practical as per specialization each 30 Hrs. Allocation of marks - External assessment: Total marks 75 (Each exercise carries 20 marks; Viva 15); Internal assessment: Total marks 25 (Record and viva 20; attendance 05). It is compulsory to perform three experiments from any one of the special papers.

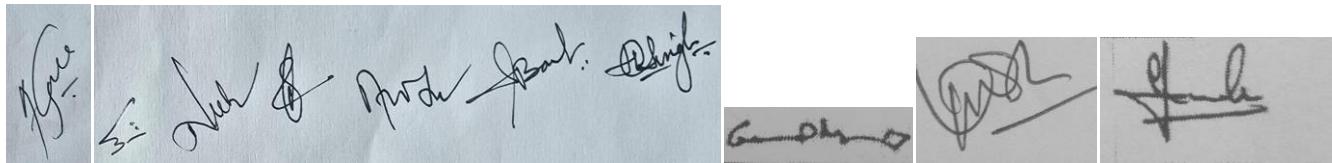
Recommended Readings

- J. Mendham, Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- D. C. Harris, Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
- S.M. Khopkar, Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, Cengage Learning India Edition

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online content:

<https://www.labster.com/chemistry-virtual-labs/>
<https://www.vlab.co.in/broad-area-chemical-sciences>
<http://chemcollective.org/vlabs>



Semester-X

Master's in Chemistry

DISCIPLINE SPECIFIC ELECTIVE (DSE 10 A) Organometallic Chemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 10 E: General and Organometallic Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry	Year: V	Semester: X Paper: DSE 10 A
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Subject: Chemistry

Course: DSE 10 A Course Title: Organometallic Chemistry

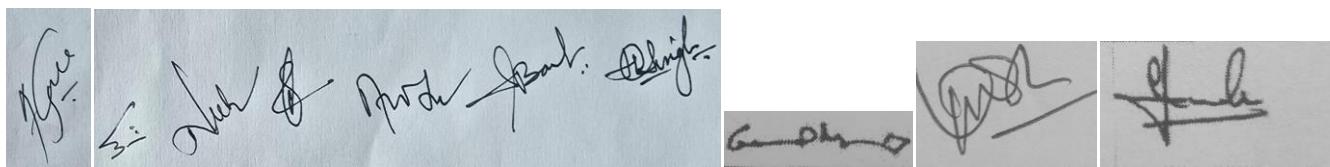
Course Outcomes:

Upon successful completion of this course, the students will be able to:

- Understand the organometallic compounds of transition metals with sigma and pi bonding ligands.
- They will also get acquainted with the chemistry of fluxional molecules.
- The students will learn about chemistry and mechanism of homogeneous catalytic reactions. It will assist them to get a suitable job in the relevant industrial and scientific field. .

Credits:4	Discipline Specific Elective
Max. Marks: As per University rules	Min. Passing Marks: As per University rules

Unit	Topic	No. of Hours
Unit I	Organic Derivatives of Transition Metals: Alkyls, aryls and acyls of transition metals, nature of metal carbon bond, routes of synthesis, stability, decomposition pathways, stabilization, Alkyls, aryls and acyls of s-block and p-block elements, synthesis, stability, reactivity. Comparison between transition and non-transition element derivates.	10
Unit II	Compounds of Metal-Carbon Multiple Bonds and Fluxional Organometallic Compounds: Synthesis, properties, nature of bonding and structural features of π -bonded organo-metallic compounds (π -complexes) with unsaturated organic molecules: alkenes, alkynes, chelating olefinic ligands, allyl, dienes-butadiene,	



	cyclobutadiene, cyclopentadiene, dienyl-cyclopentadienyl, cyclohexadienyl and arene complexes. Important reactions relating to nucleophilic and electrophilic attack on ligands, role in organic synthesis. Fluxionality and dynamic equilibria in compounds such as η^3 - allyl and dienyl complexes, their characterization.	15
Unit III	Mechanism of Some Catalytic Reactions: Stoichiometric reactions for catalysis, oxidative-addition, migratory insertion, reductive elimination, homogeneous catalytic Hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydroformylation of olefins (oxo-reaction), Wacker's process.	10
Unit IV	Silicates and Aluminosilicates: Silicates: Classification, properties, structure and applications of naturally occurring silicates. Aluminosilicates: chemistry of feldspars, ultramarine, zeolites, classification, structure and applications of zeolites. Clays: montmorillonite clay, synthesis of pillared clays, characterization and applications of clays and pillared clays as catalysts.	10
Unit V	PROBLEM BASED ON THE THE ABOVE	15

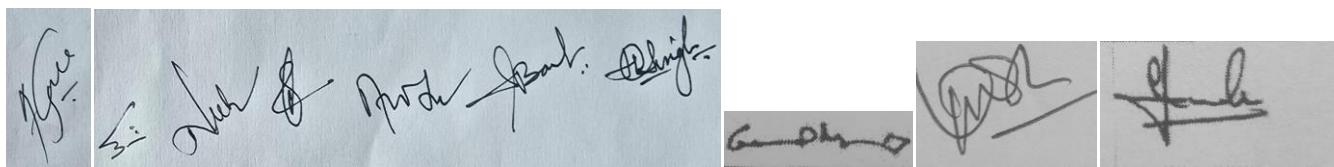
Recommended Readings

- J. P. Collman, L. S. Hegsdsus, J. P. Norton and R. G. Finke, Principle and Application of Organotransition Metal Chemistry, University Science Books.
- R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, John Wiley
- J. Person, Metallo-organic Chemistry, Wiley.
- R. C. Mehrotra and A. singh, Organometallic Chemistry, New Age International.
- J. E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry: Principle of structure and Reactivity, Pearson Education.
- N. L. H. Green, Organometallic Compounds, Chapman & Hall, U.K.
- G. E. Coates, M. L. H. Green., P. Pwell,Principles of Organometallic Chemistry, Chapman & Hall, U.K.
- <https://tech.chemistrydocs.com/Books/Organic/A-Guidebook-of-Organic-Reaction-Mechanism-by-Peter-Sykes.pdf>

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online courses:

- <https://nptel.ac.in/courses/104/101/104101079/>
- https://onlinecourses.nptel.ac.in/noc21_cy12/preview
- <https://nptel.ac.in/courses/104/108/104108062/>
- https://onlinecourses.nptel.ac.in/noc21_cy36/preview
- https://onlinecourses.nptel.ac.in/noc22_cy05/preview
- https://onlinecourses.nptel.ac.in/noc22_cy05/preview
- <https://nptel.ac.in/courses/104/101/104101100/>



Semester-X**Master's in Chemistry**

DISCIPLINE SPECIFIC ELECTIVE (DSE 10B)
Metal Ligand Bonding and Polymer Chemistry

No. of Hours- 60**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 10B: Metal Ligand Bonding and Polymer Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry	Year: V	Semester: X
Paper: DSE 10B		

Subject: Chemistry

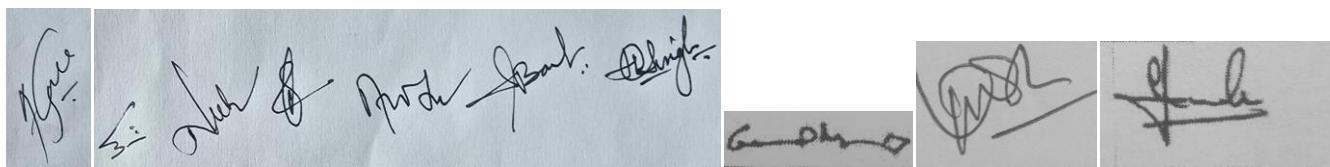
Course: DSE 10B	Course Title: Metal Ligand Bonding and Polymer Chemistry
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Course Outcomes:

- Upon successful completion of this course, the students will be able to:
- Explain the molecular orbital theory of transition metal complexes.
- Gain an understanding of Sigma and pi bonding in transition metal complexes through molecular orbital energy diagrams.
- Acquire knowledge about the chemical analysis of polymers.

Credits:4	Discipline Specific Elective
Max. Marks: As per University rules	Min. Passing Marks: As per University rules

Unit	Topic	No. of Hours
Unit I	Metal-Ligand Bonding: Sigma bonding in octahedral complexes: Classification of metal valence orbitals into sigma symmetry, formation of ligand group orbitals (LGOS) of sigma symmetry, Formation of molecular orbitals of sigma symmetry, construction of molecular orbital energy level diagram involving only sigma bond contribution from ligands, pi bonding in octahedral complexes: Classification of metal valence orbital into pi symmetry, Formation of LGOS of pi symmetry. Formation of pi MOs and construction of molecular orbital energy level diagram involving sigma and pi contribution from pi donor ligands, Sigma and pi bonding in tetrahedral complexes and square planar	10

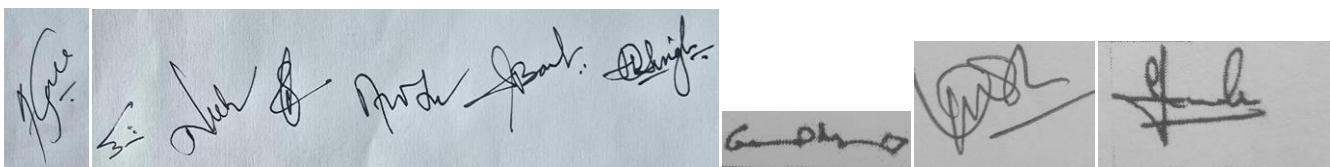


	complexes.	
Unit II	Basics of Inorganic Polymers: Importance of polymers, basic concepts: monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers, polymerization: condensation, addition, radical chain-ionic and co-ordination and co-polymerization. Polymerization conditions and polymer reactions Kinetics of polymerization. Stereochemistry and mechanism of polymerization. Polymerization in homogeneous and heterogeneous systems.	10
Unit III	Structure and Properties: Morphology and order in crystalline polymers-configurations of polymer chains: Crystal structures of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point (TM); melting points of homogeneous series, effect of chain, flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature (Tg), relationship between Tm and Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking.	10
Unit IV	Polymer Characterization: Polydispersion, average molecular weight concept: number average, weight average and viscosity average molecular weights. Polydispersity and molecular weight distribution. Measurement of molecular weight: end-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers, chemical analysis of polymers, spectroscopic methods, X-ray diffraction study. Microscopy. Thermal analysis and physical testing- tensile strength. Fatigue impact. Tear resistance. Hardness and abrasion resistance.	15
Unit V	PROBLEM BASED ON THE THE ABOVE	15

Recommended Readings:

- F. A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, John Wiley & Sons, New York, 2003.
- J. D. Lee, Concise Inorganic Chemistry, Fifth Edition, Wiley India, 2012.
- Atkins, Overton, Rourke, Weller and Armstrong, Inorganic Chemistry, Oxford University Press.
- J. E. Huheey, E. A Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, Fourth Edition, Pearson Education, 2003.
- W. W. Porterfield, Inorganic Chemistry: A Unified Approach, Elsevier.
- G. Wulfsberg, Inorganic Chemistry, Viva Books.
- G. L. Miessler and D. A. Tarr, Inorganic Chemistry, Pearson Education.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



Suggested equivalent online contents:

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>
<https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cy19/>
https://onlinecourses.nptel.ac.in/noc22_cy02/preview
<https://nptel.ac.in/courses/104/105/104105033/>
<https://nptel.ac.in/courses/104/106/104106089/>
http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000658/M014009/ET/1456899566CHE_P3_M5_etext.pdf
http://ddugu.ac.in/epathshala_content1.aspx
<https://www.uou.ac.in/sites/default/files/slms/BSCCH-301.pdf>

Semester-X

Master's in Chemistry

DISCIPLINE SPECIFIC ELECTIVE (DSE 10C)

Photo Inorganic Chemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)						
		Lecture	Tutorial	Practical/Practice								
DSE 10C: Photo Inorganic Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-						
MASTER'S IN CHEMISTRY												
Programme: Master's in Chemistry				Year: V	Semester: X	Paper: DSE 10C						
Subject: Chemistry												
Course: DSE 10C	Course Title: Photo Inorganic Chemistry											
Course Outcomes:												
Upon successful completion of this course, the students will be able to:												
<ul style="list-style-type: none"> • Explain the basics of photochemistry. • Gain an understanding of photochemical reactions. • Acquire knowledge about the chemical analysis of polymers. 												
Credits: 4	Discipline Specific Elective											
Max. Marks: As per University rules				Min. Passing Marks: As per University rules								

Upon successful completion of this course, the students will be able to:

- Explain the basics of photochemistry.
- Gain an understanding of photochemical reactions.
- Acquire knowledge about the chemical analysis of polymers.

Credits: 4

Max. Marks: As per University rules

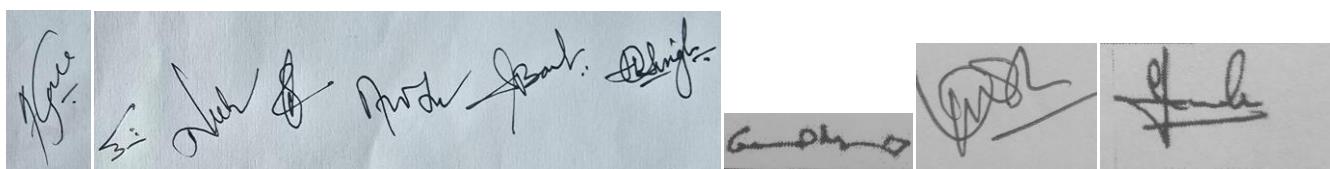
Discipline Specific Elective

Min. Passing Marks: As per University rules

Unit	Topic	No. of Hours
Unit I	Basics of Photochemistry: Absorption, excitation, photochemical laws, electronically excited states-life times, measurements of the times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck-Condon principle, photochemical stages- primary and secondary processes. Photochemical Reactions: Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry. Singlet molecular oxygen reactions. Photochemical formation of smog. Photo- degradation of polymers. Photochemistry of vision.	10
Unit II	Properties of Excited States and Excited States of Metal Complexes: Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Biomolecular deactivation-quenching. Excited states of metal complexes: comparison with organic compounds, electronically excited states of metal complexes. Charge-transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.	10
Unit III	Ligand Field Photochemistry: Photosubstitution, photo-oxidation and photo-reduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.	10
Unit IV	Redox Reactions by Excited Metal Complexes: Energy transfer under conditions of weak interaction and strong interaction-exciplex formation, conditions of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2'-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidizing character of Ru^{2+} bipyridyl complex (comparison with $[\text{Fe}(\text{bipy})_3]$); role of spin-orbit coupling- life time of these complexes. Application of redox processes of electronically excited states for catalytic purpose, transformation of low energy reactants into high energy products, chemical energy	15
Unit V	PROBLEM BASED ON THE THE ABOVE	15

Recommended Readings:

- A.W.Adamson and P.D. Fleischauer, Concept of Inorganic Photochemistry, Wiley.
- Inorganic Photochemistry, J. Chem. Educ., vol. 60, no. 10, 1983.



- J.Lippard, Progress in Inorganic Chemistry, Vol. 30,ed. Wiley.
- CoordinationChem. Revs., 1981, Vol. 39, 121,131; 1975, 15,321; 1990, 97, 313.
- V.Balzari and Carassiti, Photochemistry of Coordination Compounds, Academic Press.
- G.J.Ferraudi, Elements of Inorganic Photochemistry, Wiley-Eastern.
- K.K.Rohtagi-Mukherji, Fundamentals of Photochemistry, Wiley-Eastern.
- A.Gilbert and J.Baggott, Essentials of Molecular Photochemistry, Blackwell Scientific Publication.
- N.J.Turro, W.A.Benjamin, Molecular Photochemistry,
- A.Cox and T.Camp, Introductory Photochemistry, McGraw-Hill.
- R.P.Kundall and A.Gilbert, Photochemistry, Thomson Nelson.
- J.Cox and B.Halton, Organic Photochemistry, Cambridge University Press.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Semester-X

MASTER'S IN CHEMISTRY

DISCIPLINE SPECIFIC ELECTIVE (DSE 10 D) Heterocyclic Chemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 10 D: Heterocyclic Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry	Year: V	Semester: X Paper: DSE 10D
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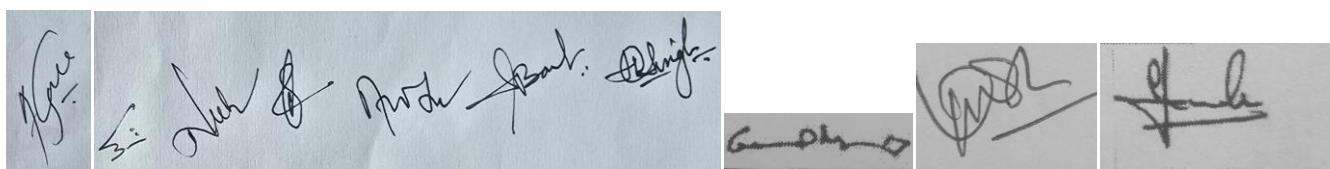
Subject: Chemistry

Course: DSE 10 D Course Title: Heterocyclic Chemistry

Course Outcomes:

Upon successful completion of this course, the students will be able to:

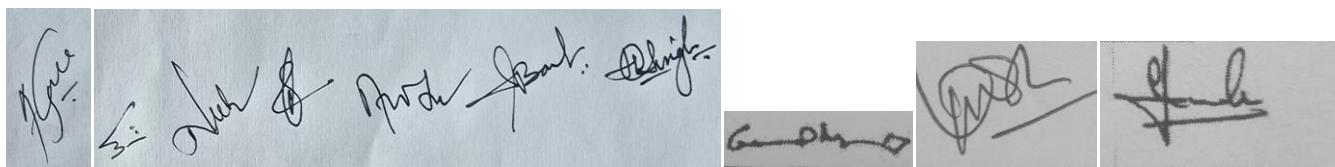
- Understand the advanced aspects of heterocyclic chemistry.
- This will provide broader areas of opportunities in these related industries.



Credits:4		Discipline Specific Elective
Max. Marks: As per University rules		Min. Passing Marks: As per University rules
Unit	Topic	No. of Hours
Unit I	Aromatic and Non aromatic heterocycles- Systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles. General chemical behaviour of aromatic heterocycles, classification, Strain -hood angle and torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion, Stereo-electronic effects, aromatic and related effects. Attractive interactions hydrogen bonding and intermolecular nucleophilic, electrophilic interaction	15
Unit II	Small ring and benzo-fused five membered heterocycles- Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxetanes and thietanes. Synthesis and reactionds including medicinal applications of benjoapyrroles, benzofurans andbenzothiophenes	10
Unit III	Six membered heterocycles Sythesis and reactions of pyrylinum salts and pyrones, coumarins and chromomes. Synthesis and reactions of diazines.	10
Unit IV	Seven or large membered heterocycles Synthesis and reactions of azepines, oxepines, thiopines, diazepines thiaropines, arocines, diazocines, dictopines and dithiocines	10
Unit V	PROBLEMS REATED TO THE ABOVE	15

Recommended Reading

- R.R. Gupta, M. Kumar and V. Gupta, Heterocyclic Chemistry Vol. 1-3, Springer Verlag.
- G.R. Newkome and W.W. Paudler, Contemporary Heterocyclic Chemistry, Wiley-Inter Science.
- R.M. Acheson, An Introduction to the Heterocyclic Compounds, John Wiley.
- A.R. Katritzky and C.W. Rees, Comprehensive Heterocyclic Chemistry, eds. Pergamon press.
- Heterocyclic Chamuty Vol. 1 & R.K. Gupta, M. Kumar and V. Taupta, Sponger Verlag
- The Chemistry of Heterocycles. 7. Elcher and S. Hauptmann. Thieme.
- Heterocyclic Chemistry, L.A. Jouke, K. Mills and GF. Smith, Chapman and Hall.
- Heterocyclic Chemistry, TL Gilchrist, Longman Scietific Technical
- Contemporary HuterocyclicChennistry, UK. Newkome and W.W. Pauller, Wiley-Inter Science



- An introduction to the Heterocyclic Compounds, R.M. Acheson, John Wiley
- Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon
- Natural Products: Chemistry and Biological Significance, J. Mann, R.S. Davidson, 1
- Hebba, DV. Banthrope and J.R. Harborne, Longman. Essex
- Organic Chemistry, Vol 2, 1.1. Finar, ELBS.
- Stereoselective Synthesis A Practical Approach, M. Nagradi, VCI

Suggested equivalent online courses:

<https://swayam.gov.in/>

<https://www.coursera.org/learn/physical-chemistry>

Semester-X

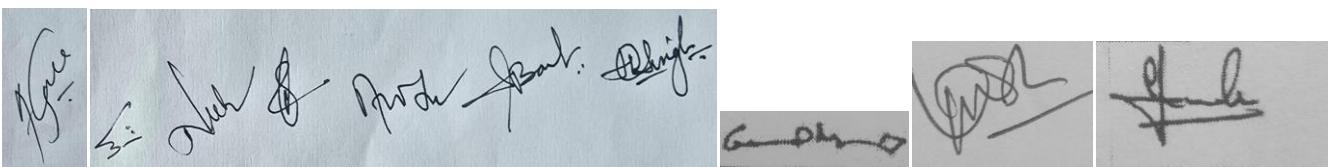
MASTER'S IN CHEMISTRY

DISCIPLINE SPECIFIC ELECTIVE (DSE 10 E)
Chemistry of Natural Products

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)										
		Lecture	Tutorial	Practical/Practice												
DSE 10 E: Chemistry of Natural Products	4	4	-	-	Chemistry in Bachelor of Science	-										
MASTER'S IN CHEMISTRY																
Programme: Master's in Chemistry			Year: V		Semester: X											
Paper: DSE 10 E																
Subject: Chemistry																
Course: DSE 10 E	Course Title: Chemistry of Natural Products															
Course Outcomes:																
Upon successful completion of this course, the students will be able to:																
<ul style="list-style-type: none"> • Acquire knowledge of all the natural products and heterocyclic compounds such as terpenoids, alkaloids, carotenoids, steroids and plant pigments which form the back bone of natural systems of medicines such as Ayurveda, Homeopathy and Yunani system of medicine. 																
Credits:4		Discipline Specific Elective														
Max. Marks: As per University rules		Min. Passing Marks: As per University rules														
Unit	Topic	No. of Hours														
Unit I	Vitamins: Classification, occurrence, chemistry of Vitamins A, C and E, structure elucidation and synthesis, deficiency syndromes.	10														



Unit II	Terpenoids and Carotenoids: Classification, occurrence, isolation, general methods of structure determination, Synthesis of citral, menthol and β -carotene. Plant Pigments: Occurrence, nomenclature, synthesis of Quercetin and cyanidine. Biosynthesis of flavonoids.	10
Unit III	Steroids: Occurrence, physiological action, basic skeleton, diel's hydrocarbons, stereochemistry, structure determination of cholesterol, synthesis of cholesterol and testosterone, estrone.	10
Unit IV	Alkaloids: Occurrence, isolation, general method structure elucidation, classification based on nitrogen heterocyclic ring structure, stereochemistry, synthesis of morphine, reserpine, Applications.	10
Unit V	Enzymes: Techniques and methods of immobilization of enzymes, effect of immobilization on enzyme activity, application of immobilized enzymes, use of enzymes in food and drink industry- brewing and cheese-making, syrups from corn starch, enzymes as targets for drug design. Clinical uses of enzymes,	05
Unit VI	PROBLEMS RELATED TO THE ABOVE	15

Recommended Reading

- B.A.NagaSampagi, S. Minakshi, S. V. Bhat. Chemistry of Natural products
- L. Finar, Vol. I & II, ELBS.

Semester-X

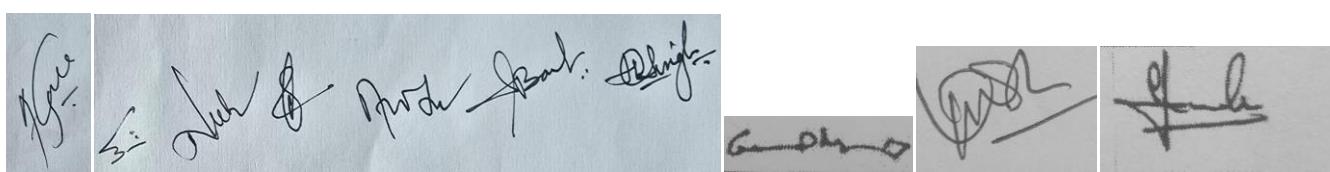
Master's in chemistry

DISCIPLINE SPECIFIC ELECTIVE (DSE 10 F) Medicinal Chemistry

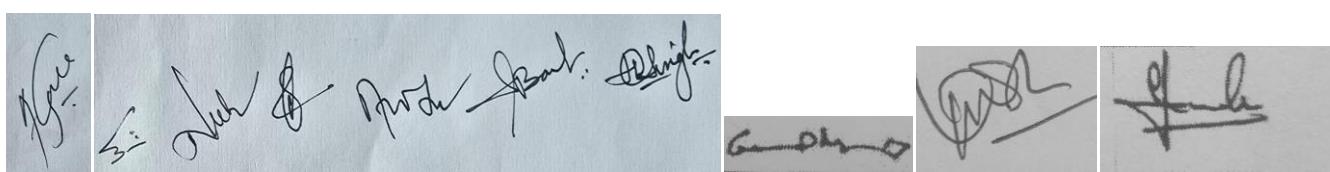
No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 10 F: Medicinal Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-



MASTER'S IN CHEMISTRY				
Programme: Master's in Chemistry	Year: V	Semester: X Paper: DSE 10 F		
Subject: Chemistry				
Course: DSE 10 F	Course Title: Medicinal Chemistry			
Course Outcomes:				
Upon successful completion of this course, the students will be able to:				
<ul style="list-style-type: none"> After completion of this course, the students will be able to understand the process of drug designing and to have some information about antineoplastic Agents, cardiovascular drugs, local anti-infective drugs and antibiotics and psychoactive drugs. 				
Credits:4	Discipline Specific Elective			
Max. Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours		
Unit I	Drug Design : Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drug, structure-activity relationship (SAR), factors affecting bioactivity. Theories of drug activity: general discussion. Quantitative structure activity relationship. History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-chemical parameters: Lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials. Free-Wilson analysis, Hansch analysis, relationships between Free-Wilson and Hansch analysis. LD-50, ED-50 (Mathematical derivations of equations excluded).	15		
Unit II	Pharmacokinetics & Pharmacodynamics: Introduction to drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process. Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotics, biotransformation, significance of drug metabolism in medicinal chemistry.	10		
Unit III	Antineoplastic Agents: Introduction, cancer chemotherapy, special problems, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antibiotic and mitotic inhibitors. Synthesis of mechlorethamine, cyclophosphamide, melaphalan, uracil, mustards and 6- mercaptopurine. Recent development in cancer chemotherapy. Hormone and natural products.	10		
Unit IV	Psychoactive Drugs-The Chemistry of Mind : Introduction, neurotransmitters, CNS depressants, general anaesthetics, mode of action of hypnotics, sedatives, anti-anxiety			



	drugs, benzodiazepines, buspirone, neurochemistry of mental diseases. Antipsychotic drugs –the neuroleptics, antidepressants, butyrophenones, serendipity and drug development, stereochemical aspects of psychotropic drugs. Synthesis of diazepam, oxazepam, clonazepam, alprazolam, phenytoin, ethosuximide, trimethadione, barbiturates, thiopental sodium, glutethimide.	10
Unit V	PROBLEMS RELATED TO THE ABOVE	15

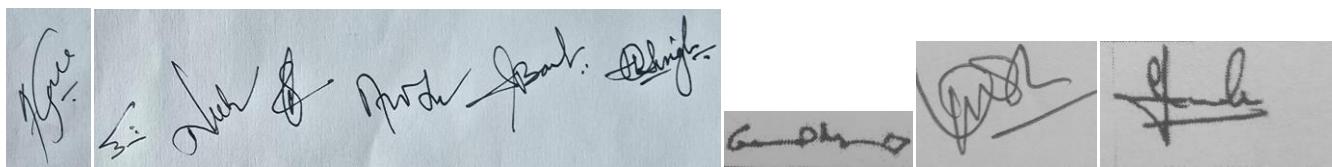
Recommended Readings

- Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH
- Wilson and Gisvold's Text –Book of Organic Medicinal and Pharmaceutical Chemistry, Ed. Robert F. Dorge.
- An introduction to Drug Design, S.S. Pandeya and U.R. Diiock, New Age International.
- Burger's Medicinal Chemistry and Drug Discovery, Vol.- 1 (Chapter 9 and Ch-14), Ed. M.E. Wolf, John Wiley.
- Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
- The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
- Strategies for Organic Synthesis and Design, D. Lednicer, John Wiley.
- Pharmaceutical drug analysis, Ashutosh Kar

Suggested online links:

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>
<https://nptel.ac.in/courses/104/106/104106106/>
https://onlinecourses.nptel.ac.in/noc20_cy16/preview
<https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cy16/>
<https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-cy05/>

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.



Semester-X**MASTER'S IN CHEMISTRY**

DISCIPLINE SPECIFIC ELECTIVE (DSE 10 G)
Advanced Chemical Dynamics and Statistical Thermodynamics

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE
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Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 10 G: Advanced Chemical Dynamics and Statistical Thermodynamics	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

Programme: Master's in Chemistry	Year: V	Semester: X
Paper: DSE10 G		
Subject: Chemistry		

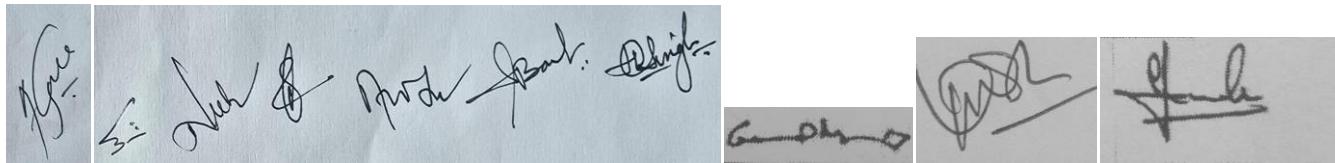
Course: DSE 10 G	Course Title: Advanced Chemical Dynamics and Statistical Thermodynamics
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Course Outcomes:	
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Upon successful completion of this course, the students will be able to:

- Acquire knowledge on chemical dynamics, kinetics in solution, fast chemical reactions, statistical thermodynamics and thermodynamic equilibrium. Develop expertise in advanced chemical dynamics, encompassing reaction rate theories, unimolecular reactions, chain reactions and kinetic isotope effects.
- Master statistical thermodynamics principles, including thermodynamic probability, partition functions and statistical distributions for diatomic molecules.
- Understand kinetics in solution, fast chemical reactions and enzyme catalysis, employing experimental techniques like stopped flow and flash photolysis.
- Gain proficiency in thermodynamic equilibrium concepts, including free energy, entropy, chemical potential, fugacity, ideal solutions and applications of the Duhem-Margules and Gibbs-Helmholtz equations.

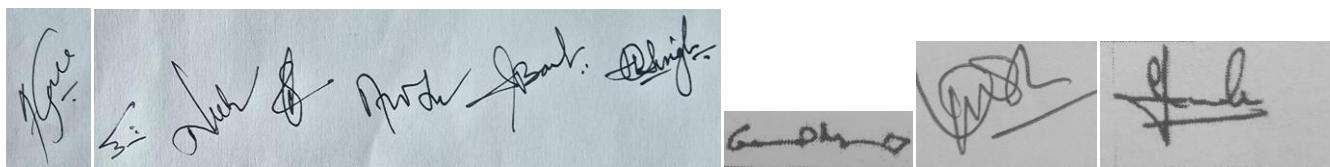
Credits:4	Discipline Specific Elective 10 A
Max. Marks: As per University rules	Min. Passing Marks: As per University



Unit	Topic	rules	No. of Hours
Unit I	Advanced Chemical Dynamics: Theories of reaction rates: Partition functions (translational, vibrational and rotational) for diatomic molecules and application to rate processes, statistical mechanics of chemical equilibrium, theory of absolute reaction rates, thermodynamical formulation of reactions rates, theories of unimolecular reactions: Lindemann's theory, Hinshelwood's treatment, RRK treatment, Slater's theory (no derivation), Rice-Ramsperger-Kassel-Marcus (RRKM) theory (no derivation), general treatment of chain reactions, branching chains, explosive reactions between hydrogen and oxygen, oxidation of hydrocarbons, polymerization reactions (molecular and free radical), oscillatory reactions, kinetic isotope effect.		12
Unit II	Statistical Thermodynamics: Introduction to Statistical Thermodynamics, Thermodynamic probability and entropy, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Partition function: Translational, rotational, vibrational and electronic partition functions for diatomic molecules, relation between partition function and various thermodynamic quantities.		6
Unit III	Kinetics in Solution and Fast Chemical Reactions: Kinetics in Solution: Influence of solvent reactions between ions, reactions between ions and molecules, reactions involving dipoles, influence of ionic strength, primary and secondary salt effects, homogeneous and heterogeneous catalysis, absolute rate theory of heterogeneous reactions. Enzyme Catalysis: Michaelis-Menton mechanism, single and double intermediates, general methods for working out the kinetics of complex enzymatic reactions. Fast Chemical Reactions: Study of kinetics by stopped flow techniques, relaxation methods, flash photolysis and magnetic resonance methods and temperature jump method.		15
Unit IV	Thermodynamic Equilibrium: Free energy and entropy of mixing, chemical potential and its use in heterogeneous equilibrium, fugacity, its significance and determination, Ideal solutions and their properties, Duham-Margules equation and its applicability, Gibb's-Helmholtz equation and its uses, Nernst heat theorem, third law of thermodynamics, entropy determination from the third law of thermodynamics.		12
Unit V	PROBLEM RELATED TO THE ABOVE		15

Recommended Readings

- B. R. Puri, L. R. Sharma and M. S. Pathria, Physical Chemistry, Milestone Publisher & Distributors, New Delhi
- K. L. Kapoor, Physical Chemistry. Macmillan Publishers India Limited.



- K. J. Laidler, Kinetics, Pearson Education India.

Suggested Continuous Evaluation Methods: Since the class is conceived as learner-centric and built around tasks that require learners to actively use various language skills, formative assessment can and should be used extensively. Oral presentations, peer interviews, and group tasks can be used for this purpose. The end-semester written examination will test all the areas targeted in the course.

Suggested equivalent online courses:

<https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>

<https://www.classcentral.com/course/swayam-concepts-of-thermodynamics-13015>

https://onlinecourses.nptel.ac.in/noc20_me20/preview

<https://www.coursera.org/learn/thermodynamics-intro>

https://onlinecourses.nptel.ac.in/noc22_cy14/preview

https://onlinecourses.nptel.ac.in/noc20_cv22/preview

Semester-X

Master's in chemistry

DISCIPLINE SPECIFIC ELECTIVE (DSE 10H)

Molecular Orbital Theory and Quantum Mechanics

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)				
		Lecture	Tutorial	Practical/Practice						
DSE 10H: Molecular Orbital Theory and Quantum Mechanics	4	4	-	-	Chemistry in Bachelor of Science	-				
MASTER'S IN CHEMISTRY										
Programme: Master's in Chemistry			Year: V		Semester: X Paper: DSE 10H					
Subject: Chemistry										
Course: DSE 10H	Course Title: Molecular Orbital Theory and Quantum Mechanics									

Yours
W. H. D. Bush Frank. Blighs.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

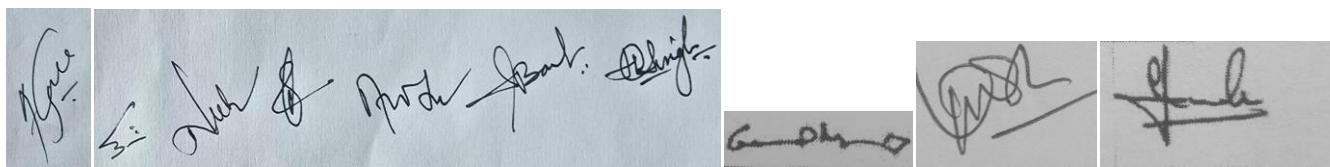
- Understand of advanced quantum mechanics will help them to explain the related terms. Acquire the knowledge about concept of molecular orbital and valence bond theories will help them to understand the bonding concept.
- a detailed idea about the de Broglie is concept different types of operators Schrodinger wave equation, and application of Schrodinger's Wave Equation to some models, that is particle in 1D 3D box and hydrogen atom

Credits:4	General Elective
Max. Marks: As per University rules	Min. Passing Marks: As per University rules

Unit	Topic	No. of Hours
Unit I	Quantum Chemistry-I: de-Broglie concept and de-Broglie equation, physical interpretation and properties of wave functions, Linear, Laplacian, Linear-momentum and Hamiltonian operators, postulates of quantum mechanics, eigen values, eigen functions, normalization and orthogonalization, derivation of the Schrodinger's wave equation, concept of cartesian and spherical coordinates.	10
Unit II	Quantum Chemistry-II: Schrodinger's wave equation general and detailed discussion on the applications of Schrodinger's wave equation to some model systems viz. particles in a 1D-, 3D- box, harmonic oscillator, rigid rotator and hydrogen atom.	15
Unit III	Advanced Quantum Mechanics: Applications of basic concepts of quantum chemistry, Angular momentum including spin coupling of angular momentum and spin-orbit coupling. Ordinary angular momentum, generalized angular momentum, eigen functions for angular momentum, eigen values of angular momentum, operator using ladder operators.	10
Unit IV	Concepts in Molecular Orbital (MO) Theory and Concepts in Valence Bond (VB) Theory: MO theory of H_2 molecule, Introduction to Hückel Molecular Orbital (MO) method as means to explain modern theoretical methods, advanced techniques in PMO and FMO theory, Ab initio method, semi empirical methods. Quantitative MO theory – Hückel Molecular Orbital (HMO) methods, MO energy levels, orbital symmetry, orbital interaction diagrams, MO of simple organic systems. Valence Bond (VB) configuration mixing diagrams, reaction profiles, potential energy diagrams.	15
Unit V	PROBLEMS RELATED TO THE ABOVE	15

Recommended Readings

- G.W. Castellan, Physical Chemistry, 4th Ed. Narosa.
- R.G. Mortimer, Physical Chemistry, 3rd Ed. Elsevier: NOIDA, UP.



- F.A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Parts A & B, Plenum: U.S.
- W. M. Horspool, Aspects of Organic Photochemistry, Academic Press.
- T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry Addison-Wesley Educational Publishers, Inc.
- J. March, Advanced Organic Chemistry, John Wiley & Sons.
- L. Stryer, Biochemistry, W. H. Freeman & Co.
- P. A. Sykes, Guidebook to Mechanism in Organic Chemistry, Prentice-Hall.
- James H. Clark and Duncan J. Macquarrie, Handbook of Green Chemistry and Technology, Wiley-Blackwell.
- Paul T. Anastas and Tracy C. Williamson Green Chemistry: Frontiers in Benign Chemical syntheses and Processes, Oxford University Press.
- Geoffrey Alan Ozin, A. C. Arsenault and L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online courses:

- <https://www.ias.ac.in/article/fulltext/reso/023/03/0277-0290>
- <https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>
- <https://www.ias.ac.in/article/fulltext/reso/023/03/0277-0290>

Semester-X

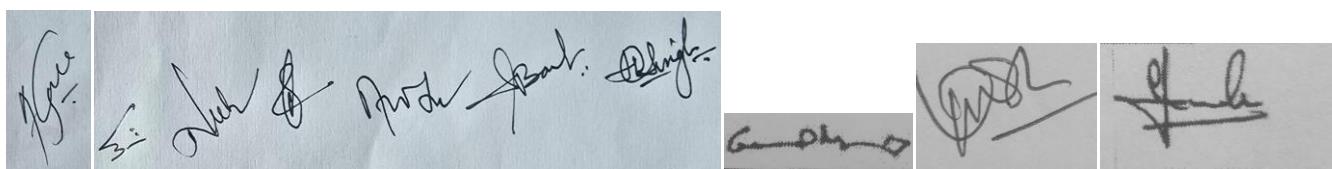
Master's in chemistry

DISCIPLINE-SPECIFIC ELECTIVE (DSE 10 I) Radio and Electroanalytical Techniques

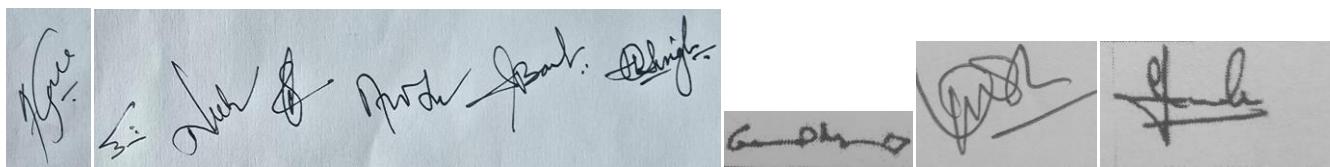
No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE 10 I: Radio and Electroanalytical Techniques	4	4	-	-	Chemistry in Bachelor of Science	-



MASTER'S IN CHEMISTRY				
Programme: Master's in Chemistry	Year: V	Semester: X Paper: DSE 10 I		
Subject: Chemistry				
Course: DSE 10 I	Course Title: Radio and Electroanalytical Techniques			
Course Outcomes:				
Upon successful completion of this course, the students will be able to:				
<ul style="list-style-type: none"> • Understand the theory of voltammetry, amperometry and radioanalytical techniques. • Explain the principle of polarography, CV and radioanalytical techniques. • Apply the concepts of polarography, voltammetry, amperometry and radioanalytical techniques. • Appreciate the importance and applications of polarography, voltammetry, amperometry and radioanalytical techniques. • Solve the problems based on the concepts of polarography, voltammetry, amperometry and radioanalytical techniques.. 				
Credits:4	Discipline Specific Elective			
Max. Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours		
Unit I	Advanced Electroanalytical Techniques: Voltammetry Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry. Stripping Voltammetry- anodic, cathodic, and adsorption Chemically and electrolytically modified electrodes and ultra-microelectrodes in voltammetry	15		
Unit II	Advanced Electroanalytical Techniques: Amperometry, potentiometry and Polarography Potential Step method- Chronoamperometry Controlled potential technique- Chronopotentiometry Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography	10		
Unit III	Radio Analytical Techniques: Radiotracer Techniques Choice of Radiotracers Factors Affecting Choice of Radiotracers Isotope Dilution Analysis (IDA) Principle and Equation Instrumentation Applications Advantages and Limitations Substoichiometric Isotope Dilution Analysis (SIDA)	10		



	Activation Analysis (AA) Principle of NAA Neutron Sources Interferences Sensitivity and Detection Limits Classification Instrumentation Applications Advantages and Limitations	
Unit IV	Radiometric Titrations (RT): Procedure Advantages and Limitations, Radiochromatography, Radioimmunoassay Principle Methodology Procedure Applications	10
Unit V	PROBLEMS RELATED TO THE ABOVE	15

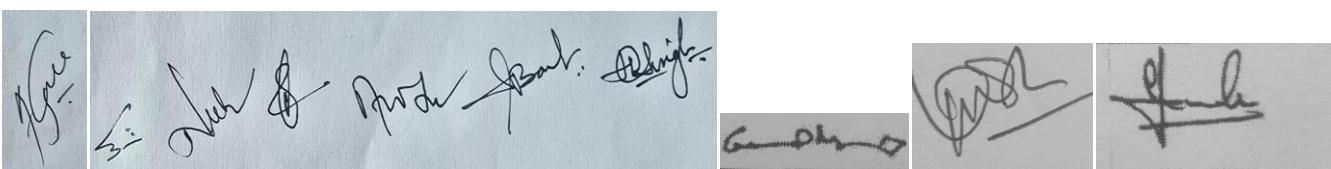
Recommended Readings

- Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987)
- Electrochemical Methods, A. J. Bard and L.R. Faulkner, John Wiley, New York, (1980)
- Electroanalytical Chemistry, J.J . Lingane, 2 nd Ed Interscience, New York (1958)
- Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker, New York, 1980. 10. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (A series of volumes) 11. Techniques and mechanism of electrochemistry, P. A. Christian and A. Hamnett, Blachie Academic and Professional (1994)
- Radiochemistry and Nuclear Methods of Analysis by W. D. Ehmann and D. E. Vance, John Wiley & Sons, New Delhi (1994).
- Principles of Activation Analysis by P. Kruger, Wiley-Interscience, New York (1971). 3. Neutron Activation Analysis by D. De Soete, R. Gijbels and J. Hoste, Wiley Interscience, New York (1972).
- 7.Radioanalytical Chemistry by J. Tolgyessy and M. Kyrs, Vol 1 and 2, Ellis Horwood Ltd, Chichester (1989).
- Modern Methods for Trace Element Determination by C. Vandecasteele and C. B. Block, John Wiley & Sons, Chichester (1993).
- Activation Analysis, Ed. Z. B. Alfassi, Vol 1 and 2, CRC Press, Boca Raton, USA (1991).
- Instrumental Methods of Analysis, 7th Edn by H. H. Willard, L. L. Merritt, J. A. Dean and F. Settle, CBS Publishers and Distributors, New Delhi (2000).
- Instrumental Analysis, Editors, Eds. H. H. Bauer, G. D. Christian and J. E. O'Reilly, 2nd Edn, Allyn and Bacon, Inc., Boston (1991).
- Principles of Instrumental Analysis, 5th Edn, by D. A. Skoog, F. J. Holler and T. A. Nieman. Thomson, Brooks/Cole (2003).

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Suggested equivalent online courses:

- https://gtu.ge/AgroLib/Vogels_TEXTBOOK_OF_QUANTITATIVE_CHEMICAL_ANALYSIS_5th_ed.pdf
- https://media.iupac.org/publications/analytical_compendium/Cha16all.pdf
- <https://egyankosh.ac.in/bitstream/123456789/43341/1/Unit-13.pdf>
- <https://pubs.acs.org/doi/10.1021/acs.jchemed.7b00361>
- <https://ebooks.inflibnet.ac.in/esp02/chapter/cyclic-voltammetry/>



Semester – X

MASTER'S IN CHEMISTRY

GENERIC ELECTIVE (GE 10 A)

Corrosion, Energy and Polymers

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: 10A Corrosion, Energy and Polymers	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY				
Programme: Master's in Chemistry	Year: V	Semester: X		
Paper: GE 10A				
Subject: Chemistry				
Course: GE 10A	Course Title: Corrosion, Energy, and Polymers			
Course Outcomes:				
Upon completion of this course, students will:				
<ul style="list-style-type: none"> Understand corrosion causes, types, and prevention. Analyze battery components, operation, and advantages. Gain insight into fuel properties and polymer characteristics. 				
Credits:4	Generic Electives 1			
Max. Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours		
Unit I	Corrosion: Introduction, cause of corrosion, types and mechanism of corrosion, passivity, factors influencing corrosion, protective measure against corrosion.	15		
Unit II	Batteries: Primary and secondary batteries, battery component and their role, Characteristics of the battery, Working of the following batteries: Pb storage battery, Li battery, Fuel cell, advantage of fuel cell, Dry cell, Mercury Cell, Solar cell and polymer cell.	15		
Unit III	Fuels: Introduction, definition and classification of fuels, Characteristics of a good fuel, calorific value, determination of calorific value, Use of coal and its composition, Coal gas, producer gas, and water gas- composition and uses.	15		
Unit IV	Polymers			

Yours
W. H. Brewster
BOSTON MASS.

	Fibers: Polyamides, Polyethylene terephthalate (PET), Cellulose acetate, Polyvinyls, Acronitriles Rubbers/ Elastomers: Natural rubbers, styrene rubber, nitrile rubber Plastics: Polyethylene, polyvinyl Chloride, Polyvinyl acetate, Teflon	15
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Recommended Readings:

- Alexander V. Dimitrov, Introduction to Energy Technologies for Efficient Power Generation, CRC Press
- Charles E. Carraher Jr., Introduction to Polymer Chemistry, CRC Press
- H.A. Kiehne and F. Lampert, Battery Technology Handbook, CRC Press
- Isidor Buchmann, Batteries in a Portable World: A Handbook on Rechargeable Batteries for Non-Engineers, Cadex Electronics Inc.
- Malcolm P. Stevens, Polymer Chemistry: An Introduction - Oxford University Press
- Manas Chanda and Salil K. Roy, Introduction to Polymer Science and Chemistry: A Problem-Solving Approach - CRC Press
- Pierre Roberge, Corrosion Engineering: Principles and Practice - McGraw Hill Education
- R. Winston Revie and Herbert H. Uhlig, Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering – Wiley
- Robert J. Young and Peter A. Lovell, Introduction to Polymers, CRC Press
- Sivakumar Pasupathi, Fuel Cells: Principles, Design, and Analysis, Elsevier

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

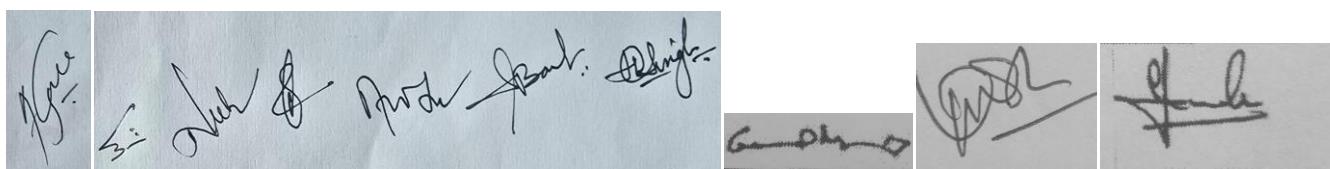
Semester – X

MASTER'S IN CHEMISTRY

GENERIC ELECTIVE (GE 10 B) Metallurgy and Inorganic Materials

No. of Hours- 60 CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

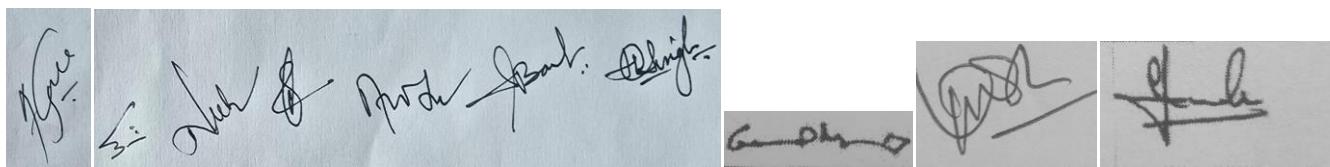
Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: 10 B Metallurgy and Inorganic Materials	4	4	-	-	Chemistry in Bachelor of Science	-



MASTER'S IN CHEMISTRY				
Programme: Master's in Chemistry	Year: V	Semester: X Paper: GE 10B		
Subject: Chemistry				
Course: GE 10 B	Course Title: Metallurgy and Inorganic Materials			
Course Outcomes:				
By the end of this course, students will:				
<ul style="list-style-type: none"> Understand metallurgical processes, from ore extraction to metal refining. Analyze and synthesize a variety of inorganic materials, including cement, glass, ceramics, steel, and silicones. 				
Credits:4	Generic Electives			
Max. Marks: As per University rules	Min. Passing Marks: As per University rules			
Unit	Topic	No. of Hours		
Unit I	Metallurgy: Minerals & ore, Crushing of the ore, Concentration of the ore: Gravity separation, Froth Floatation, Leaching, Extraction of Crude metal: Calcinations, Roasting, flux, Smelting.	20		
Unit II	Cement, Glass and Ceramics: Cement (Portland Cement): Composition of cement, manufacture, Setting of cement Glass: different type, manufactures, raw material, manufacture of ordinary glass. Ceramics: Types, Manufacturing Techniques, and Applications	15		
Unit III	Steel and Paint Steel: Classification of steel, Manufacture of steel, heat treatment of steel Paints: Requisites of a good paint, constituents of pigments, white pigments, blue pigment, red pigment, green pigment, black pigment, yellow pigment.	15		
Unit IV	Silicones: Preparation, classification of silicones, properties and uses of different type of silicones	10		

Recommended Readings:

- R. K. Rajput, Material Science and Metallurgy, S. Chand Publishing
- B. V. Raghavaiah, Engineering Materials and Metallurgy, Pearson India Education Services
- V. D. Kodgire, Material Science and Metallurgy, Everest Publishing House
- O. P. Khanna, Material Science and Metallurgy, Dhanpat Rai Publications
- S. L. Kakani, Material Science and Metallurgy, Khanna Publishers
- R. K. Singal, Engineering Materials: Material Science and Metallurgy, Khanna Publishers
- R. Balasubramaniam, Material Science and Metallurgy, Oxford University Press India
- R. Santha Kumar, Materials Science and Metallurgy, Pearson Education India



- N. R. Aravindan, Metallurgical Engineering Materials Science and Metallurgy, McGraw Hill Education India
- V. D. Kodgire, Material Science and Metallurgy, Nirali Prakashan

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Semester-X

MASTER'S IN CHEMISTRY

GENERIC ELECTIVES (GE 10C)
Environmental Chemistry

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: 10C Environmental Chemistry	4	4	-	-	Chemistry in Bachelor of Science	-

MASTER'S IN CHEMISTRY

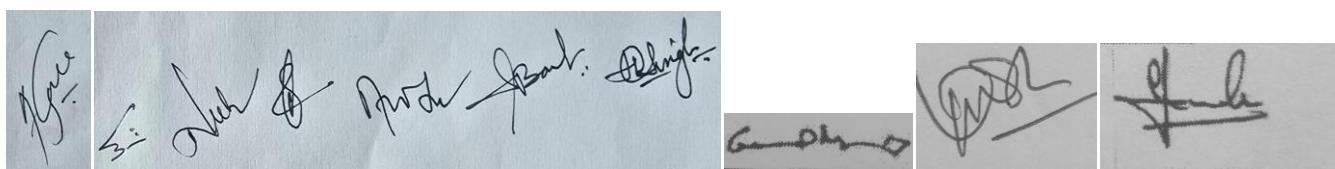
Programme: Master's in Chemistry	Year: V	Semester: X
Subject: Chemistry	Paper: GE	

Course: GE 10C	Course Title: Environmental Chemistry
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Course Outcomes:

- Upon successful completion of this course, the students will be able to:
- Understand information regarding the chemical processes taking place in atmosphere, lithosphere, hydrosphere along with the chemistry of toxic chemical and pollutants.
- State Atmosphere, Lithosphere, Hydrosphere, Biosphere, Acid Rain and ozone layer
- Define Composition of soil, types of soil, Soil Classification Based on Particle Size.
- Understand Control of Soil Erosion and Conservation. Concept of pH and pH measurement.
- Explain Structure and Physiochemical Properties of Water, sources of water.
- Explain different types of water purification methods and determination of pH of water.

Credits:4	Generic Elective 3
Max. Marks: As per University rules	Min. Passing Marks: As per University rules



Unit	Topic	No. of Hours
Unit I	Introduction to Environmental Chemistry: Concept and scope of environmental chemistry. Environmental terminology and nomenclatures. Environmental segments. The natural cycles of environment (Hydrological, Oxygen, Nitrogen).	12
Unit II	Atmosphere and Air Pollution: Regions of the atmosphere, reactions in atmospheric chemistry, Earth's radiation balance, particles, ion and radicals in the atmosphere. Chemistry of ozone layer. Particulates, aerosols, SO _x , NO _x , CO _x and hydrocarbon. Photochemical smog, air-quality standards.	12
Unit III	Hydrosphere and Water Pollution: Complexation in natural water and waste-water. Micro-organism in aquatic chemical reactions. Eutrophication. Microbiology mediated redox reactions Water-quality parameters and standards: physical and chemical parameters (colour, odour, taste and turbidity). Dissolved oxygen: BOD, COD. Total organic carbon, nitrogen, sulfur, phosphorus and chlorine. Chemical speciation (Pb, As, Hg). Lithosphere: Inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and NPK in soil.	25
Unit IV	Chemical Toxicology : Toxic chemicals in the environments. Impact of toxic chemicals on enzymes. Biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, nitrogen oxides and sulphur oxides.	11

Recommended Readings:

- Environmental Chemistry A global perspective; Fourth Edition, Gary W. vanLoon and Stephen J. Duffy
- Environmental Chemistry A.K. Day, New Age.

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Suggested equivalent online content:

- <https://nptel.ac.in/courses/122/106/122106030/>
- <https://nptel.ac.in/courses/104/103/104103020/>
- <https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ce57/>
- https://onlinecourses.nptel.ac.in/noc21_ce63/preview
- https://www.vssut.ac.in/lecture_notes/lecture1530778260.pdf
- <https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ>

