Department of Higher Education
U.P. Government, Lucknow

National Education Policy-2020

Common Minimum Syllabus for all U.P. State Universities and Colleges
For First Three Years of Higher Education

(Revised syllabus of Chemistry for the undergraduate program)

[Effective from July, 2024]

PROPOSED STRUCTURE OF UG CHEMISTRY SYLLABUS

National Education Policy-2020
Common Minimum Syllabus for all U.P. State Universities/ Colleges
SUBJECT: CHEMISTRY

Name	Designation	Affiliation
Steering Committee		
Mrs. Monika S. Garg, (I.A.S.) Chairperson Steering Committee	Additional Chief Secretary	Dept. of Higher Education U.P., Lucknow
Prof. Poonam Tandan	Professor, Dept. of Physics	Lucknow University, U.P.
Prof. Hare Krishna	Professor, Dept. of Statistics	CCS University Meerut, U.P.
Dr. Dinesh C. Sharma	Associate Professor, Dept. of Zoology	K.M. Govt. Girls P.G. College Badalpur, G.B. Nagar, U.P.
Supervisory Committee-Science Faculty		
Dr. Vijay Kumar Singh	Associate Professor, Dept. of Zoology	Agra College, Agra
Dr. Santosh Singh	Dean, Dept. of Agriculture	Mahatma Gandhi Kashi Vidhyapeeth, Varanasi
Dr. Baby Tabussam	Associate Professor, Dept. of Zoology	Govt. Raza P.G. College Rampur, U.P.
Dr. Sanjay Jain	Associate Professor, Dept. of Statistics	St. John's College, Agra

Syllabus Developed by:

S.No.	Name	Designation	Department	College/University
1.	Dr. Susan Verghese P	Associate Professor and Head	Chemistry	St. John's College, Agra
2.	Dr. Mohd Kamil Hussain	Assistant Professor	Chemistry	Govt. Raza P.G. College Rampur, U.P.
3.	Mrs. Neha Tripathee	Assistant Professor	Chemistry	Km. Mayawati Govt. Girls P.G. College, Badalpur, G.B. Nagar

Semester-wise Titles of the Papers in B.Sc. Chemistry

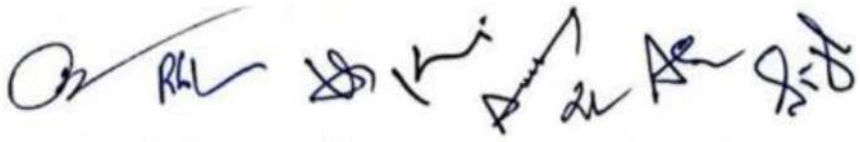
Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Bioorganic and Medicinal Chemistry					
1	I	B020101T	Fundamentals of Chemistry	Theory	4
		B020102P	Quantitative Analysis	Practical	2
	II	B020201T	Bioorganic and Medicinal Chemistry	Theory	4
		B020202P	Biochemical Analysis	Practical	2
Diploma in Chemical Dynamics and Analytical Techniques					
2	III	B020301T	Chemical Dynamics & Coordination Chemistry	Theory	4
		B020302P	Physical Analysis	Practical	2
	IV	B020401T	Quantum Mechanics and AnalyticalTechniques	Theory	4
		B020402P	Instrumental Analysis	Practical	2
Degree in Bachelor of Science					
3	V	B020501T	Organic Synthesis-A	Theory	4
		B020502T	Chemistry of Group Elements	Theory	4
		B020503P	Qualitative Analysis	Practical	2
		B020504R	Research Project	Project	3
	VI	B020601T	Organic Synthesis-B	Theory	4
		B020602T	Chemical Energetics and Radiochemistry	Theory	4
		B020603P	Analytical Methods	Practical	2
		B020604R	Research Project	Project	3

Purpose of the Program

The purpose of the undergraduate chemistry program at the university and college level is to provide the key knowledge base and laboratory resources to prepare students for careers as professionals in various industries and research institutions.

Program's Outcomes

1. Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in analytical, Inorganic, Organic and Physical Chemistries.
2. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
3. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
5. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
6. Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
7. Students will be able to function as a member of an interdisciplinary problem solving team.



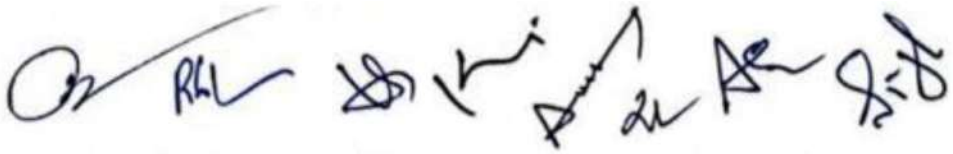
PROGRAM SPECIFIC OUTCOMES (PSOS)	
CERTIFICATE IN BIOORGANIC AND MEDICINAL CHEMISTRY	
First Year	Certificate in Bioorganic and Medicinal Chemistry will give the student a basic knowledge of all the fundamental principles of chemistry like molecular polarity , bonding theories of molecules, Periodic properties of more than 118 elements, mechanism of organic reactions, stereochemistry, basic mathematical concepts and elementary computer knowledge, chemistry of carbohydrates, proteins and nucleic acids: medicinal chemistry and chemistry of aliphatic hydrocarbons. Student will be able to do qualitative quantitative and bio chemical analysis of the compounds in the laboratory. This certificate course is definitely going to prepare the students for various fields of chemistry and will give an insight into all the branches of chemistryand enable our students to join the knowledge and available opportunities related to chemistry in the government and private sector services particularly in the field of food safety, health inspector, pharmacist etc. Have a broad foundation in chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective.
Second Year	**DIPLOMA IN CHEMICAL DYNAMICS AND ANALYTICAL TECHNIQUES**
	Diploma in Chemical Dynamics and Analytical Techniques will provide the theoretical as well as practical knowledge of handling chemicals, apparatus, equipment and instruments. The knowledge about feasibility and velocity of chemical reactions through quantum mechanics, chemical kinetics, chemical equilibrium, phase equilibrium, kinetic theories of gases, coordination chemistry, metal carbonyls photochemistry, separation techniques and bioinorganic will enable the students to work as chemists in pharmaceutical industries. The knowledge about atomic structure, various spectroscopic tools and separation technique will make the students skilled to work in industries: Achieved the skills required to succeed in the chemical industry like cement industries, agro product, paint industries, rubber industries, petrochemical industries, food processing industries, fertilizer industries, pollution monitoring and control agencies etc. Got exposures of a breadth of experimental techniques using modern instrumentation Learn the laboratory skills and safely measurements to transfer and interpret knowledge entirely in the working environment. monitoring of environment issues: monitoring of environmental pollution problems of atmospheric sciences, water chemistry and soil chemistry and design processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
Third Year	**DEGREE IN BACHELOR OF SCIENCE**
	Degree in Bachelor of Science programme aims to introduce very important aspects of modern day course curriculum, namely, aromatic hydrocarbons, alcohols, carbonyl compounds, carboxylic acids, phenols, amines, synthetic polymers, synthetic dyes, heterocyclic compounds, natural products, dyes, photochemistry, main group elements, qualitative analysis, separation techniques and analytical techniques. It will enable the students to understand the importance of the elements in the periodic table including their physical and chemical nature and role in the daily life and also to understand the concept of chemistry to inter relate and interact to the other subject like mathematics, physics,biological science etc. • Upon completion of a degree, chemistry students are able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program • Various research institutions and industry people in the pharmaceuticals, polymers, and food industry sectors will surely value this course.

Subject: Chemistry							Total Credits of the subject
Year	Sem.	Theory Paper	Units	Practical Paper	Units	Research Project	
1	I	Fundamentals of Chemistry	1. Molecular polarity and Weak Chemical Forces 2. Simple Bonding theories of Molecules 3. Periodic properties of Atoms 4. Basic Concepts of Organic Chemistry 5. Mechanism of Organic Reactions 6. Stereochemistry 7. Basic Computer system (in brief) 8. Mathematical Concepts for Chemistry	Quantitative Analysis	1. Water Quality analysis 2. Estimation of Metals ions 3. Estimation of acids and alkali contents 4. Estimation of inorganic salts and hydrated water	Nil	4+2 = 6
	II	Bioorganic and Medicinal Chemistry	1. Chemistry of Carbohydrates 2. Chemistry of Proteins 3. Chemistry of Nucleic Acids 4. Introductory Medicinal Chemistry 5. Chemistry of Alkanes 6. Chemistry of Cycloalkanes 7. Chemistry of Alkenes 8. Chemistry of alkynes	Biochemical Analysis	1. Qualitative and quantitative analysis of carbohydrates 2. Qualitative and quantitative analysis of Proteins, amino acids and Fats 3. Analysis of organic compounds 4. Synthesis of simple drug molecules.	Nil	4+2 = 6
2	III	Chemical Dynamics & Coordination Chemistry	1. Chemical kinetics 2. Chemical Equilibrium 3. Phase Equilibrium 4. Kinetic theories of Gases 5. Coordination Chemistry 6. Theories of Coordination Chemistry 7. Thermodynamic and kinetic aspects of Metal complexes 8. Inorganic Spectroscopy and Magnetism	Physical Analysis	1. Strengths of solution 2. Surface tension and viscosity of pure liquids 3. Melting Point, Boiling point and Transition temperature 4. Phase Equilibrium	Nil	4+2 = 6
	IV	Quantum Mechanics and Analytical Techniques	1. Elementary Quantum Mechanics 2. Atomic Structure 3. Molecular Spectroscopy 4. UV-Visible Spectroscopy 5. Infrared Spectroscopy 6. ^{1}H-NMR Spectroscopy 7. Photochemistry 8. Separation techniques	Instrumental Analysis	1. Molecular Weight Determination 2. Spectrophotometry 3. Spectroscopy 4. Chromatographic Separations	Nil	4+2 = 6
3	V	Organic Synthesis-A	1. Arenes and Aromaticity 2. Alcohols 3. Phenols 4. Ethers and Epoxides 5. Chemistry of Organic Halides	Qualitative Analysis	1. Inorganic Qualitative Analysis 2. Systematic Analysis of Organic Compounds 3. Separation of organic Mixture 4. Preparation of Simple Polymers	Research Project	4+4+2 +3 =13

			6. Introduction to Polymers 7. Rearrangements 8. Synthetic Dyes				
		Chemistry of Group Elements	1. Solid State 2. Catalysis 3. Chemistry of the Main Group Elements 4. Chemistry of Transition Elements 5. Chemistry of Lanthanides 6. Chemistry of Actinides 7. Metal Carbonyls 8. Bioinorganic Chemistry				
	VI	Organic Synthesis-B	1. Reagents in Organic synthesis 2. Organometallic Compounds 3. Aldehydes and Ketones 4. Carboxylic acids and their FunctionalDerivatives 5. Organic Synthesis *via* Enolates 6. Organic Compounds of Nitrogen 7. Heterocyclic Compounds 8. Natural Products	Analytical Methods	1. Gravimetric Analysis 2. Paper Chromatography 3. Thin Layer Chromatography 4. Thermochemistry	Research Project	4+4+2 +3 =13
		Chemical Energetics and Radiochemistry	1. Thermodynamics-I 2. Thermodynamics-II 3. Thermochemistry 4. Electrochemistry 5. Ionic Equilibrium 6. Colligative Properties of Solutions 7. Surface Chemistry 8. Radiochemistry				

COURSE		SUBJECT: CHEMISTRY					Total Credits of the subject
Year	Sem.	Paper Title		Prerequisite for paper	Elective For Major Subject	Hours per Semester	
Certificate in Bioorganic and Medicinal Chemistry	I	Theory-1	Fundamentals of Chemistry	Chemistry in 12th	Yes Open to all	**60**	4
		Practical-1	Quantitative Analysis	Chemistry in 12th	Yes Open to all	**60**	2
	II	Theoty-1	Bioorganic and Medicinal Chemistry	Passed Sem-I, Theory paper-1	**Yes** Zoo/Bot./Physics/Math/Comp Sci	**60**	4
		Pracical-2	Biochemical Analysis	Opted Sem-II, Theory Ppaer-1	Yes Zoo/Bot./Physics/Math/Comp Sci.	**60**	2
Diploma in Chemical Dynamics and Analytical Techniques	III	Theoty-1	Chemical Dynamics & Coordination Chemistry	Chemistry in 12th Physics in 12th	Yes Zoo/Bot./Physics/Math/Comp Sci.	**60**	4
		Pracical-2	Physical Analysis	Opted Sem-III, Theory Ppaer-1	Yes Zoo/Bot./Physics/Math/Comp Sci.	**60**	2
	IV	Theoty-1	Quantum Mechanics and Analytical Techniques	Chemistry in 12th	Yes Zoo/Bot./Physics/Math/Comp Sci.	**60**	4
		Practical-2	Instrumental Analysis	Chemistry in 12th	Yes Zoo/Bot./Physics/Math/Comp Sci.	**60**	2
Degree in Bachelor of Science	V	Theory-1	Organic Synthesis-A	Passed Sem-I, Theory paper-	Yes Zoo/Bot./Physics/Math/Comp Sci.	**60**	4
		Theory-1	Chemistry of Group Elements	Passed Sem-I, Theory paper-	Yes Zoo/Bot./Physics/Math/Comp Sci.	**60**	4
		Practical-3	Qualitative analysis	Opted Sem-V Theory Ppaer-1 &2	Yes Zoo/Bot./Physics/Math.	**60**	2

		Research Project	……	……..	……	45	3
	VI	Theory-1	Organic Synthesis-B	Passed Sem-V Theory paper-1	Yes Zoo/Bot./Physics/Math	60	4
		Theory-1	Chemical Energetics and Radiochemistry	Chemistry in 12^{th} Physics in 12^{th}	Yes Zoo/Bot./Physics/Math/Comp Sci.	60	4
		Practical-3	Analytical Methods	Chemistry in 12^{th}	Yes Zoo/Bot./Physics/Math/Comp Sci.	60	2
		Research Project	……	……	……	45	3



Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Bioorganic and Medicinal Chemistry					
1	I	B020101T	Fundamentals of Chemistry	Theory	4
		B020102P	Quantitative Analysis	Practical	2
1	II	B020201T	Bioorganic and Medicinal Chemistry	Theory	4
		B020202P	Biochemical Analysis	Practical	2

Semester-1,
Paper-1 (Theory)
Course Title: Fundamentals of Chemistry

Programme/Class: Certificate inBioorganic and Medicinal Chemistry	Year: First	Semester: First
Paper-1 Theory		Subject: **Chemistry**
Course Code:B020101T	**Course Title: Fundamentals of Chemistry**	

Course outcomes:

There is nothing more fundamental to chemistry than the chemical bond. Chemical bonding is the language of logic for chemists. Chemical bonding enables scientists to take the 100-plus elements of the periodic table and combine them in myriad ways to form chemical compounds and materials. Periodic trends, arising from the arrangement of the periodic table, provide chemists with an invaluable tool to quickly predict an element's properties. These trends exist because of the similar atomic structure of the elements within their respective group families or periods, and because of the periodic nature of the elements. Reaction mechanism gives the fundamental knowledge of carrying out an organic reaction in a step-by-step manner. This course will provide a broad foundation in chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective. Students will gain an understanding of:

- Molecular geometries, physical and chemical properties of the molecules.
- Current bonding models for simple inorganic and organic molecules in order to predict structures and important bonding parameters.
- The chapter basic concepts of organic chemistry give the most primary and utmost important knowledge and concepts of organic chemistry.
- This course gives a broader theoretical picture in multiple stages in an overall chemical reaction. It describes reactive intermediates, transition states and states of all the bonds broken and formed .It enables to understand the reactants, catalyst, stereochemistry and major and minor products of any organic reaction.
- It describes the types of reactions and the kinetic and thermodynamic aspects one should know for carrying out any reaction and the ways how the reaction mechanism can be determined.
- The chapters Stereochemistry gives the clear picture of two-dimensional and three-dimensional structure of themolecules, and their role in reaction mechanism.

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

Total No. of Lectures = 60

Unit	Topics	No. of Lectures
I	*Introduction to Indian ancient Chemistry and contribution of Indian Chemists, in context to the holistic development of modern science and technology, should be included under Continues Evaluation (CIE)*	10

	Molecular polarity and Weak Chemical Forces : Resonance and resonance energy, formal charge, dipole moment and molecular Structure (Diatomic and polyatomic molecules), Percentage ionic character from dipole moment, polarizing power and polarizability, Fajan's rules, Hydrogen bonding, Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction.	
II	**Simple Bonding theories of Molecules** Atomic orbitals, Aufbau principle, multiple bonding (σ and π bond approach) and bond lengths, the valence bond theory (VBT), Concept of hybridization, hybrid orbitals and molecular geometry, Bent's rule, Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_5, SF_6, SF_4, ClF_3, I_3 , and H_3O^+. Molecular orbital theory (MOT). Molecular orbital diagrams bond orders of homonuclear and heteronuclear diatomic molecules and ions (N_2, O_2, F_2, CO, NO).	10
III	**Periodic properties of Atoms (with reference to s & p-block)**: Brief discussion, factors affecting and variation trends of following properties in groups and periods. Effective nuclear charge, shielding or screening effect, Slater rules, Atomic and ionic radii, Electronegativity, Pauling's/ Allred Rochow's scales, Ionization enthalpy, Electron gain enthalpy.	05
IV	**Basic Concepts of Organic Chemistry:** Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, charge transfer complexes, hyperconjugation, Electronic Displacements: Inductive, electromeric, resonance, mesomeric effects and their significances.	05
V	**Mechanism of Organic Reactions:** Curved arrow notation, drawing electron movements with allows, half-headed and double-headed arrows, homolytic and heterolytic bond fission, Types of reagents – electrophiles and nucleophiles, Types of organic reactions, Energy considerations. Reactive intermediates – Carbocations, carbanions, free radicals, carbenes.	10
VI	**Stereochemistry-**Concept of isomerism, Types of isomerism; Optical isomerism – elements of symmetry, molecular chirality, enantiomers, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, disasteromers, threo and erythro diastereomers, meso compounds, resolution of enantiomer, inversion, retention and recemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometric isomerism –Cis-Trans, E-Z & Syn-Anti system, Conformational isomerism – conformational analysis of ethane and n-butane.	10

VII	**Basic Computer system (in brief)-**Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit; Software Products (ChemOffice, chemsketch, scilab, matlab, hyperchem, etc.), internet applications.	05
VIII	**Mathematical Concepts for Chemistry** Logarithmic relations, curve sketching, linear graphs and calculation of slopes, differentiation of functions like Kx, e^x, X^n , sin x, log x; maxima and minima, partial differentiation and reciprocity relations, Integration of some useful/relevant functions; permutations and combinations, Factorials, Probability	05

Suggested Readings:

1. Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010
2. Huheey, J.E., Keiter, E.A., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006.
3. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
4. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.
5. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.
6. Singh J.,Yadav L.D.S.,Advanced Organic Chemistry,Pragati Edition
7. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education, 2012.
9. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press, 2008.
10. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry,* 2nd edition, Oxford University Press, 2012.
11. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons, Inc.
12. Sykes, P. *A guidebook to Mechanism in Organic Chemistry,* Pearson Education, 2003
13. Francis**, P. G.** Mathematics for Chemists, Springer, 1984

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggested online links:

http://heecontent.upsdc.gov.in/Home.aspx
https://nptel.ac.in/courses/104/106/104106096/
http://heecontent.upsdc.gov.in/Home.aspx
https://nptel.ac.in/courses/104/106/104106096/
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
https://nptel.ac.in/courses/104/103/104103071/#

This course is compulsory for the students of following subjects: Chemistry in 12th Class

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, among others .
Or

Assessment and presentation of Assignment	(10 marks)
04 tests (Objective): Max marks of each test = 10 (average of all 04 tests)	(10 marks)
Overall performance throughout the semester, Discipline, participation in different activities)	**(**05 marks)

Course prerequisites: To study this course, a student must have had the chemistry in class 12th

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Semester-I, Paper-2 (Practical)
Course Title: Quantitative Analysis

Programme: Certificate in Bioorganic and Medicinal Chemistry	Year: First	Semester: I
Practical paper-2		Subject: Chemistry
Course Code: B020102P	**Course Title: Quantitative Analysis**	

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to: understand the laboratory methods and tests related to estimation of metals ions and estimation of acids and alkali contents in commercial products.

- Potability tests of water samples.
- Estimation of metal ions in samples
- Estimation of alkali and acid contents in samples
- Estimation of inorganic salts and hydrated water in samples

Credits: 2	Elective
Max. Marks: 25+75 = 100	Min. Passing Marks:
Practical	**60 h**

Unit	Topics	No of Lectures
I	**Water Quality analysis** 1. Estimation of hardness of water by EDTA. 2. Determination of chemical oxygen demand (COD). 3. Determination of Biological oxygen demand (BOD).	**16**
II	**Estimation of Metals Ions** 1. Estimation of ferrous and ferric by dichromate method. 2. Estimation of copper using thiosulphate.	**14**
II	**Estimation of Acids and Alkali Contents** 1. Determination of acetic acid in commercial vinegar using NaOH. 2. Determination of alkali content – antacid tablet using HCl. 3. Estimation of oxalic acid by titrating it with $KMnO_4$.	**14**
IV	**Estimation of inorganic salts and hydrated water** 1. Basic operational procedures of chemical balance. 2. Estimation of calcium content in chalk as calcium oxalate by permanganometry. 3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.	**16**

Suggested Readings:

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

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggestive digital platforms web links

6. https://www.labster.com/chemistry-virtual-labs/
7. https://www.vlab.co.in/broad-area-chemical-sciences
8. **http://chemcollective.org/vlabs**

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

Suggested Continuous Evaluation Methods:	
Viva voce	(10 marks)
Mock test	(10 marks)
Overall performance	(05marks)

Course prerequisites: To study this course, a student must have had the chemistry in 12th Class

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Semester-II Paper-1

Course Title: Bioorganic and Medicinal Chemistry

Programme: Certificate in Bioorganic and Medicinal Chemistry	Year: 1	Semester: II
Paper-1	Elective	Subject: Chemistry
Course Code: B020201T	**Course Title: Bioorganic and Medicinal Chemistry**	

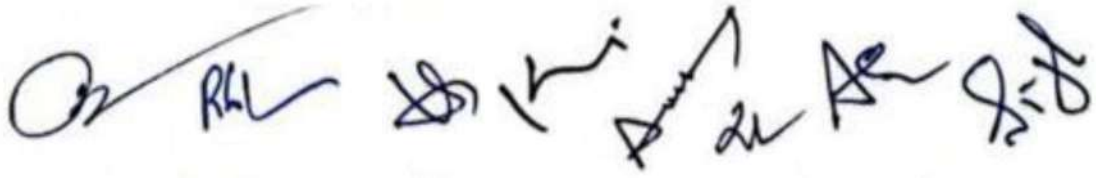
Course outcomes: Biomolecules are important for the functioning of living organisms. These molecules perform or trigger important biochemical reactions in living organisms. When studying biomolecules, one can understand the physiological function that regulates the proper growth and development of a human body. This course aims to introduce the students with basic experimental understanding of carbohydrates, amino acids, proteins, nucleic acids and medicinal chemistry as well as aliphatic hydrocarbos. Upon completion of this course students may get job opportunities in food, beverage and pharmaceutical industries.

Credits: 4	Elective
Max. Marks: 25+75	Min. Passing Marks:……

Total No. of Lectures = 60

Unit	Topics	No. of Lectures
I	**Chemistry of Carbohydrates**: Classification of carbohydrates, reducing and non-reducing sugars, General properties of Glucose, open chain structure, Epimers, mutarotation and anomers. Mechanism of mutarotation, Cyclic structure of glucose. Haworth projections. Inter conversions of sugars (ascending and descending of sugar series, conversion of aldoses to ketoses).	**10**
II	**Chemistry of Proteins:** Classification *of amino acids,* zwitter ion structure and Isoelectric point. Essential and non-essential amino acids, Overview of primary, secondary, tertiary and quaternary structure of proteins. Synthesis of simple peptides (upto dipeptides) Merrifield solid phase synthesis. Protein denaturation/ renaturation,	**08**
III	**Chemistry of Nucleic Acids:** Constituents of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), Nucleosides and nucleotides **(nomenclature**), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (**types of RNA**), Biological roles of DNA and RNA:	**06**

IV	**Introductory Medicinal Chemistry:** Drug discovery, design and development; Drug action-receptor theory. Basic introduction and uses of followings drugs: antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), HIV-AIDS related drugs (AZT- Zidovudine)	**10**
V	**Chemistry of Alkanes**: Classification of carbon atom in alkanes, General methods of preparation, properties of alkanes: Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity	**05**
VI	**Chemistry of Cycloalkanes**: Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations, Axial and Equitorial groups, Chair, Boat and Twist boat forms of cyclohexane with energy diagrams ring strain in small rings, theory of strain less rings.	**05**
VII	**Chemistry of Alkenes** Methods of formation of alkenes, Addition to **C=C:** mechanism (with evidence wherever applicable),reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenation, hydrohalogenation, hydration, hydroboration-oxidation, epoxidation, *syn* and *anti*-hydroxylation, ozonolysis,; addition to diene (conjugated dienes and allene).	**08**
VIII	**Chemistry of Alkynes** Methods of formation of alkynes, Addition to C≡C, mechanism, reactivity, regioselectivity and stereoselectivity; reactions: hydrogenation, hydration, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch); inter conversion of terminal and non-terminal alkynes.	**08**



Suggested Readings:

1. Davis, B. G., Fairbanks, A. J., *Carbohydrate Chemistry*, Oxford Chemistry Primer, Oxford University Press.
2. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.,* W. H. Freeman.
4. Berg, J. M., Tymoczko, J. L. & Stryer, L. *Biochemistry 7th Ed.,* W. H. Freeman.
5. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Patrick, G. L. Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
7. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.
8. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
9. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
10. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
11. R.B. Seymour & C.E. Carraher: *Polymer Chemistry: An Introduction,* Marcel Dekker, Inc. New York, 1981.
12. G. Odian: *Principles of Polymerization*, 4th Ed. Wiley, 2004.
13. F.W. Billmeyer: *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
14. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education, 1991

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggested online links:

http://heecontent.upsdc.gov.in/Home.aspx
https://nptel.ac.in/courses/104/105/104105124/
https://nptel.ac.in/courses/103/106/105106204/
https://nptel.ac.in/courses/104/105/104105034/
https://nptel.ac.in/courses/104/103/104103121/
https://nptel.ac.in/courses/104/102/104102016/
https://nptel.ac.in/courses/104/106/104106106/
https://nptel.ac.in/courses/104/105/104105120/

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

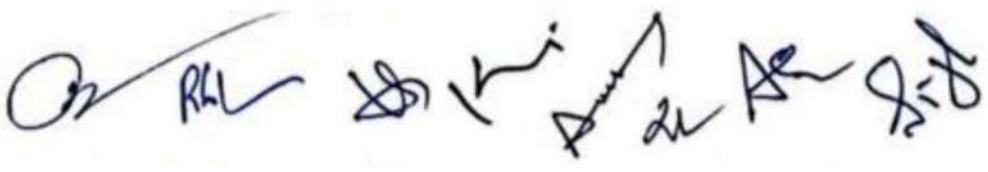
Suggested Continuous Evaluation Methods:

Assessment and presentation of Assignment	(10 marks)
04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
Overall performance throughout the semester (Discipline, participation in different activities)	**(**05 marks)

Course prerequisites: To study this course, a student must have Passed Sem-I, Theory paper-1

Suggested equivalent online courses:
……..

Further Suggestions:
……..



Semester-II , Paper-2 (Practical)
Course Title: Biochemical Analysis

Programme: Certificate in Bioorganic and Medicinal Chemistry	Year: 1	Semester: II
Subject: Chemistry		
Course Code: B020202P	Course Title: Biochemical Analysis	

Course outcomes:
This course will provide basic qualitative and quantitative experimental knowledge of biomolecules such as carbohydrates, proteins, amino acids, nucleic acids drug molecules. Upon successful completion of this course students may get job opportunities in food, beverage and pharmaceutical industries.

Credits: 2	Elective
Max. Marks: 25+75 = 100	Min. Passing Marks:

Practical **60-h**

Unit	Topics	No of Lectures
I	**Qualitative and quantitative analysis of Carbohydrates:** 1. Separation of a mixture of two sugars by ascending paper chromatography 2. Differentiate between a reducing/non-reducing sugar 3. Molisch test of carbohydrates.	**15**
II	**Qualitative and quantitative analysis of Proteins, amino acids and Fats** 1. Isolation of protein. 2. Determination of protein by the Biuret reaction. 3. TLC separation of a mixture containing 2/3 amino acids 4. Paper chromatographic separation of a mixture containing 2/3 amino acids	**15**
III	**Analysis of organic compounds** 1. Analysis of functional groups in organic compounds, determination of melting and boiling points.	**15**
IV	**Synthesis of Simple drug molecules** 1. To synthesize aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC. 2. Preparation of Paracetamol. 3. Preparation of malonyl urea.	**15**

Suggested Readings:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education.
3. *Vogel's Qualitative Inorganic Analysis*, Revised by G. Svehla.
4. Vogel, A.I. *A Textbook of Quantitative Analysi*s, ELBS. 1986
5. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. *Vogel's Textbook of Practical Organic Chemistry*, ELBS.
6. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,*Universities Pres
7. Cooper, T.G. Tool of Biochemistry. Wiley-Blackwell (1977).
8. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).
9. Varley, H., Gowenlock, A.H & Bell, M.: Practical Clinical Biochemistry, Heinemann,

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. **http://chemcollective.org/vlabs**

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

Suggested Continuous Evaluation Methods:

Viva voce	(10 marks)
Mock test	(10 marks)
Overall performance	(05marks)

Course prerequisites: To study this course, a student must have Opted Sem-II, Theory Ppaer-1**.**

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Diploma in Chemical Dynamics and Analytical Techniques					
2	III	B020301T	Chemical Dynamics & Coordination Chemistry	Theory	4
		B020302P	Physical Analysis	Practical	2
	IV	B020401T	Quantum Mechanics and Analytical Techniques	Theory	4
		B020402P	Instrumental Analysis	Practical	2

Semester III, Paper-1 (Theory)

Course Title: Chemical Dynamics & Coordination Chemistry

Programme: Diploma in Chemical Dynamics and Analytical Techniques	**Year: Two**	**Semester: III**
Paper-1 Theory		Subject: **Chemistry**
Course Code:B020301T	**Course Title: Chemical Dynamics & Coordination Chemistry**	

Course outcomes: Upon successful completion of this course students should be able to describe the characteristic of the three states of matter and describe the different physical properties of each state of matter, kinetic theory of gases, laws of crystallography, liquid state and liquid crystals, conductometric, potentiometric, optical methods, polarimetry and spectrophotometer technique to study Chemical kinetics and chemical equilibrium. After the completion of the course, Students will be able to understand .metal- ligand bonding in transition metal complexes, thermodynamic and kinetic aspects of metal complexes.

Credits: 4	**Elective**
Max. Marks: 25+75	Min. Passing Marks:……

Total No. of Lectures = 60

Unit	Topics	No. of Lectures
I	**Chemical Kinetics:** Rate of a reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristic of simple chemical reactions – zero order, first order, second order, half-life and mean life. Determination of the order of reaction – differential method, method of integration, half-life method and isolation method. **Theories of chemical kinetics:** Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory, Expression for the rate constant based on equilibrium constant.	10
II	Chem**ical Equilibrium:** Equilibrium constant and free energy, thermodynamic derivation of law of mass action, Le-Chatelier's principle. reaction isotherm and reaction isochore – Clapeyron-Clausius equation and its applications.	05
III	**Phase Equilibrium** : Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system– water, and CO_2 systems. Phase equilibria of two component systems – Solid - liquid equilibria, simple eutectic –Pb-Ag systems.	05

IV	**Kinetic theories of gases** **Gaseous State:** Postulates of kinetic theory of gases, deviation from ideal behavior, Van der Waals equation of state. **Critical phenomena**: PV isotherms of real gases, continuity of states, critical constants, relationship between critical constants and Van der Waals constants, the law of corresponding states, reduced equation of state. **Molecular Velocities**: Qualitative discussion of the Maxwell's distribution of molecular velocities; collision number, mean free path and collision diameter.	**10**
V	**Coordination Chemistry** Werner's theory of coordination complexes, classification of ligands, ambidentate ligands, chelates, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, geometrical and optical isomerism in square planar and octahedral complexes.	**05**
VI	**Theories of Coordination Chemistry:** Metal- ligand bonding in transition metal complexes, limitations of valance bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planner complexes, John teller effect, factors affecting the crystal-field parameters.	**05**
VII	**Thermodynamic and kinetic aspects of metal complexes:** Thermodynamic and kinetic aspects of metal complexes: A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, stability constants of complexes and their determination, substitution reactions of square planar complexes	**05**
VIII	**Inorganic Spectroscopy and Magnetism** Electronic spectra of Transition Metal Complexes, Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion, Magnetic properties of transition metal complexes, types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_s and $\mu_{eff.}$ values,	**15**

Suggested Readings:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley 1995
5. Lee,J.D, Concise Inorganic Chemistry 4th Edition ELBS,1977
6. Douglas,B, McDaniel ,D and Alexander,J ,Concepts of Models of Inorganic Chemistry, John Wiley & Sons; 3rd edition , 1994
7. Shriver,D.E Atkins,P.W and Langford,C .H , Inorganic Chemistry ,Oxford University Press, 1994.
8. Porterfield ,W.W, Inorganic Chemistry ,Addison Wesley 1984.
9. Sharpe,A .G, Inorganic Chemistry, ELBS,3RD edition ,1993
10. Miessler,G.L,Tarr,D.A, Inorganic Chemistry, 2nd edition , Prentice Hall,2001

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggestive digital platforms web links-

Suggestive digital platforms web links:

11. https://swayam.gov.in/
12. https://www.coursera.org/learn/physical-chemistry
13. https://www.mooc-list.com/tags/physical-chemistry
14. https://www.openlearning.com/courses/introduction-to-physical-chemistry/
15. https://www.my-mooc.com/en/categorie/chemistry
16. https://onlinecourses.swayam2.ac.in/nce19_sc15/preview
17. https://swayam.gov.in/
18. **https://www.coursera.org/browse/physical-science-and-engineering/chemistry**

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

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, among others .

Or

Assessment and presentation of Assignment	(10 marks)
04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
Overall performance throughout the semester (Discipline, participation in different activities)	**(**05 marks)

Course prerequisites: To study this course, a student must have had the chemistry in class 12th , Physics in Class 12th

Suggested equivalent online courses:

……..

Further Suggestions:

……..

Semester III, Paper-2 (Practical):
Course Title: Physical Analysis

Programme: Diploma in Chemical Dynamics and Analytical Techniques	Year: Two	Semester: III
Practical paper-2		Subject: Chemistry
Course Code: B020302P	**Course Title: Physical Analysis**	

Course Outcomes: Upon successful completion of this course students should be able to calibrate apparatus and prepare solutions of various concentrations, estimation of components through volumetric analysis; to perform dilatometric experiments: one and two component phase equilibrium experiments.

Credits: 4	Elective
Max. Marks: 25 +75	Min. Passing Marks:
Practical	**60 H**

Unit	Topics	No of Lectures
I	**Strengths of Solute & Solution** Calibration of fractional weights, pipettes, burettes and types of chemical substances; Preparation of standard solutions of oxalic acid, sodium hydroxide and hydrochloric acid; Dilution of solution from 0.1 M to 0.001 M. Mole Concept and Concentration Units: Mole Concept, molecular weight, formula weight, and equivalent weight. Concentration units: Molarity, Formality, Normality, Molality, Mole fraction, Percent by weight, Percent by volume, parts per thousand, Parts per million, Parts per billion, pH, pOH, milli equivalents, Milli moles.	**20**
II	**Surface Tension and Viscosity** 1. Determination of percentage composition by surface tension method. 2. Determination of percentage composition by viscosity method.	**06**
III	**Melting and Boiling point and Transition Temperature** 1. Melting & boiling points of common organic compounds: Oxalic acid, Urea, Benzoic Acid, benzamide, acetylacetone, isobutyl methyl ketone, isobutyl alcohol, acetonitrile, benzaldehyde and acetophenone. [Melting & Boiling points of the chosen organic compounds should preferably be within 180^0C]. 2. Transition Temperature, Determination of the transition temperature of the given substance by thermometric/dialometric method (e.g. $MnCl_2.4H_2O/CaCl_2.2H_2O$)	**14**

IV	**Phase Equilibrium** 1. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration ofthat solute in the given phenol-water system. 2. To construct the phase diagram of two component (e.g. diphenylamine – benzophenone) system by cooling curve method.	**20**

Suggested Readings:

1. Skoog .D.A., West.D.M and Holler .F.J., "Analytical Chemistry: An Introduction", 7th edition, Saunders college publishing, Philadelphia,(2010).
2. Larry Hargis.G" Analytical Chemistry: Principles and Techniques" Pearson©(1988)

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. **http://chemcollective.org/vlabs**

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

Suggested Continuous Evaluation Methods:	
Viva voce	(10 marks)
Mock test	(10 marks)
Overall performance	(05marks)

Course prerequisites: To study this course, a student must have Opted Sem-III, Theory Ppaer-1

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Semester IV Paper-1 (Theory)
Course Title: Quantum Mechanics and Analytical Techniques

Programme: Diploma in Chemical Dynamics and Analytical Techniques	Year: **Two**	Semester: **IV**
Paper-1	Elective	Subject: **Chemistry**
Course Code: BO20401T	**Course Title:** Atomic Structure and Analytical Techniques	

Course Outcomes:: Upon successful completion of this course students should be able to describe atomic structure, elementary quantum mechanics, atomic structure, wave function and its significance; Schrodinger wave equation and its applications; Molecular orbital theory, basic ideas – Criteria for forming molecular orbital from atomic orbitals , Molecular Spectroscopy, Rotational Spectrum ,vibrational, electronic Spectrum: photo chemistry and kinetics of photo chemicalreaction. Analytical chemistry plays an enormous role in our society, such as in drug manufacturing, process control in industry,environmental monitoring, medical diagnostics, food production, and forensic surveys. It is also of great importance in different research areas. Analytical chemistry is a science that is directed towards creating new knowledge so that chemical analysis can be improved to respond to increasing or new demands.

- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to function as a member of an interdisciplinary problem solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems
- Students will gain an understanding of how to determine the structure of organic molecules using IR and NMR spectroscopic techniques.
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography.

Credits: 4	Elective
Max. Marks: 25+75	Min. Passing Marks:……
Total No. of Lectures- = 60	

Unit	Topics	No. of Lectures
I	**Elementary Quantum Mechanics:** Black body radiation, Plank's radiation law, photoelectron effect, Bohr's model of hydrogen atom (No derivation) and its effect, Compton effect, de-Broglie's hypothesis, Hiesenberg's uncertainity principle, Schrodinger wave equation and its importance, physical interpretation of wave function, quantum number and its importance, Molecular orbital theory, Basic ideas, Criteria for forming MO and AO, Construction of MO by LCAO method for homonulear and heteronuclear diatomic molecule.	**06**

II	**Atomic Structure:** Idea of de-Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrödinger wave equation, significance of Ψ and Ψ^2, quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d, orbitals. Aufbau and Pauli exclusion principles, Hund's multiplicity rule.	**06**
III	**Molecular Spectroscopy**: Introduction: Electromagnetic radiation, regions of the spectrum, statement of the Born-Oppenheimer approximation, degrees of freedom **Rotational Spectrum**: Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, determination of bond length, qualitative description of non-rigid rotor. **Vibrational Spectrum:** Infrared spectrum : Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, idea of vibrational frequencies of different functional groups. **Raman spectrum:** Concept of polarizability , pure rotational and pure vibrational, Raman spectra of diatomic molecules, selection rules. Electronic Spectrum: Concept of potential energy curves for bonding and antibonding molecular orbitals.	**14**
IV	**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, Intensity of absorption; application of Woodward Fieser Rules for calculation of λ_{max} for the conjugated dienes: alicyclic, homoannular and heteroannular;	**06**
V	**Infrared Spectroscopy:** **IR Spectroscopy**: Fundamental and non-fundamental molecular vibrations; Hooke's law selection rule, IR absorption positions of various functional groups (C=O, OH, NH, COOH and nitile) , Effect of H-bonding, conjugation, resonance and ring size of cyclic ketones and lactones on IR absorptions; Fingerprint region and its significance; application in functional group analysis and and interpretation of I.R. spectra of simple organic compounds.	**06**
VI	**^{1}H-NMR Spectroscopy (PMR)** NMR Spectroscopy: introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; equivalent and non-equivalent protons; chemical shift and factors influencing it; up-/downfield, shielded and deshielded protons; spin coupling and coupling constant; relative intensities of first-order multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR; NMR peak area, interpretation of NMR spectra of simple compounds. Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules such as Ethyl bromide, Ethyl acetate, acetone, acetaldehyde, dimethylformamide, Cis and trans 1,2-dimethyl cycloprpanone, propene, vinyl chloride, acetophenone, ethyl benzene.	**10**

VII	**Photo Chemistry:** Interaction of radiation with matter, difference between thermal and photochemical processes, Jablonski diagram, depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield.	**04**
VIII	**Separation Techniques:** Solvent extraction: Classification, principle and 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, extraction of organic species from the aqueous and non-aqueous media. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.	**08**

Suggested Readings:

1. Alberty, R A, Physical Chemistry,4th edition Wiley Eastern Ltd ,2001.
2. Atkins, P W, the elements of physical chemistry,Oxford ,1991
3. Barrow, G .M, International student Edition .McGraw Hill, McGraw-Hill,1973.
4. Cotton, F.A, Wilkinson, G and Gaus,P. L, Basic Inorganic Chemistry,3rd Edition ,Wiley 1995
5. Lee,J.D, Concise Inorganic Chemistry 4th Edition ELBS,1977
6. Clayden, J., Greeves, N., Warren, S., *Organic Chemistry,* Second edition, Oxford University Press 2012.
7. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds*, John Wiley and Sons, INC, Fifth edition.
8. Pavia, D. L. *et al. Introduction to Spectroscopy,* 5th Ed. Cengage Learning India Ed.
9. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
10. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
11. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
12. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.

Suggestive digital platforms web links

1. https://www.coursera.org/courses?query=chemistry&languages=en
2. https://www.mooc-list.com/tags/physical-chemistry
3. https://www.coursera.org/learn/physical-chemistry
4. https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2017/
5. http://heecontent.upsdc.gov.in/Home.aspx
6. https://nptel.ac.in/courses/104/108/104108078/
7. https://nptel.ac.in/courses/104/108/104108124/
8. https://nptel.ac.in/courses/104/106/104106122/

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

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, among others .

Or

Assessment and presentation of Assignment	(10 marks)
04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
Overall performance throughout the semester (Discipline, participation in different activities)	(05 marks)

Course prerequisites: To study this course, a student must have had the chemistry in class 12th

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Semester IV, Paper-2 (Practical)
Course Title: Instrumental Analysis

Programme: Diploma in Chemical Dynamics and Analytical Techniques	Year: Two	Semester: V
Practical paper-3		Subject: Chemistry
Course Code: B020402P	**Course Title: Instrumental Analysis**	

Course outcomes: Upon completion of this course, chemistry majors are able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program.

- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to function as a member of an interdisciplinary problem solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems
- Students will gain an understanding of how to determine the structure of organic molecules using IR and NMR spectroscopic techniques
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography

Credits: 2	Elective
Max. Marks: 25 + 75	Min. Passing Marks:
Practical	**60 h**

Unit	Topics	No of Lectures
I	**Molecular Weight Determination** 1. Determination of molecular weight of a non-volatile solute by Rast method/ Beckmann freezing point method. 2. Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) in aqueous solution at different concentrations by ebullioscopy.	**10**
II	**Spectrophotometry** 1. To verify Beer – Lambert Law for $KMnO_4/K_2Cr_2O_7$ and determining the concentration of the given solution of the substance from absorption measurement 2. Determination of pKa values of indicator using spectrophotometry. 3. Simple qualitative analysis of inorganic salts.	**10**

III	**Spectroscopy** 1. Assignment of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C≡C, C≡N stretching frequencies; characteristic bending vibrations are included. Spectra to be provided). 2. Assignment of labelled peaks in the ^{1}H-NMR spectra of the known organic compoundsexplaining the relative δ-values and splitting pattern. 3. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).	**20**
IV	**Chromatographic Separations** 1. Paper chromatographic separation of following metal ions: i. Ni (II) and Co (II) ii. Cu(II) and Cd(II) 2. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer Chromatography (TLC) 3. Separation and identification of the amino acids present in the given mixture by paper chromatography. Reporting the Rf values 4. TLC separation of a mixture of dyes (fluorescein and methylene blue)	**20**

Suggested Readings:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.*Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & AlliedMethods*, Elles Harwood Ltd. London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, New York, 1974.

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. **http://chemcollective.org/vlabs**

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

Suggested Continuous Evaluation Methods:

Viva voce	(10 marks)
Mock test	(10 marks)
Overall performance	(05marks)

Course prerequisites: To study this course, a student must have had the chemistry in class
Suggested equivalent online courses: ……..
Further Suggestions: ……..

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Degree in Bachelor of Science					
3	V	B020501T	Organic Synthesis-A	Theory	4
		B020502T	Chemistry of Group Elements	Theory	4
		B020503P	Qualitative Analysis	Practical	2
		B020504R	Research Project	Project	3
	VI	B020601T	Organic Synthesis-B	Theory	4
		B020602T	Chemical Energetics and Radio Chemistry	Theory	4
		B020603P	Analytical Methods	Practical	2
		B020604R	Research Project	Project	3

Semester V, Paper-1
(Theory) Course Title:
Organic Synthesis A

Programme: Degree in Bachelor of Science	Year: Three	Semester: **V**
Paper-2 Theory	**Compulsory**	**Subject: Chemistry**
Course Code: B020501T	**Course Title: Organic Synthesis A**	

Course outcomes: Hydrocarbons are the principal constituents of petroleum and natural gas. They serve as fuels and lubricants as well as raw materials for the production of plastics, fibers, rubbers, solvents and industrial chemicals. This course will provide a broad foundation in for the synthesis of hydrocarbons, Hydroxy and carbonyl compounds are industrially important compounds The industries of plastics, fibers, petroleum and rubbers will specially recognize this course. Students will gain an understanding of which are used as solvents and raw material for synthesis of drug and other pharmaceutically important compounds.

- Synthesis and chemical properties of aliphatic and aromatic hydrocarbons
- Synthesis and chemical properties of alcohols, halides carbonyl compounds, carboxylic acids and esters
- How to design and synthesize aliphatic and aromatic hydrocarbons.
- How to convert aliphatic and aromatic hydrocarbons to other industrially important compounds
- Functional group interconversion.

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

Total No. of Lectures- = 60

Unit	Topics	No. of Lectures
I	**Aromaticity and Chemistry of Arenes** Nomenclature of benzene derivatives, MO picture of benzene, Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions, Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their Mechanism. Directing effects of the groups. Birch reduction.	**08**
II	**Chemistry of Alcohols** Classification and nomenclature, Monohydric alcohols – nomenclature, methods of formation by reduction of Aldehydes, Ketones, Carboxylic acids and Esters, Hydrogen bonding, Acidic nature, Reactions of alcohols. Dihydric alcohols nomenclature, methods of formation, oxidative cleavage [$Pb(OAc)_4$ and HIO_4]. Trihydric alcohols - methods of formation, chemical reactions of glycerol.	**08**
III	**Chemistry of Phenols** : Nomenclature, structure and bonding, preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols – electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman syntheis, Hauben Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction	**08**

IV	**Chemistry of Ethers and Epoxides**: Nomenclature of ethers and methods of their formation, Chemical reactions – cleavage and autoxidation, Ziesel's method. Synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides.	**04**
V	**Chemistry of Organic Halides** Nomenclature and classes of alkyl halides, methods of formation, chemical reactions, Mechanisms of nucleophilic substitution reactions of alkyl halides, SN^2 and SN^1 reactions with energy profile diagrams; Methods of formation of aryl halides, nuclear and side chain reactions; The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions; Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides.	**10**
VI	**Introduction to Polymer** Monomers, Oligomers, Polymers and their characteristics, Classification of polymers: Natural synthetic, linear, cross linked and network; Mechanism, Addition or chain- growth polymerization, Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler- Natta polymerization and vinyl polymers, Condensation or step growth-polymerization, Polyesters, polyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes.	**07**
VII	**Rearrangements** A detailed study of the following rearrangements: Pinacol-pinacolone, Demjanov, Benzil-Benzilic acid, Favorskii, Hofman, Curtius, Schmidt, Baeyer-Villiger and Fries rearrangement	**08**
VIII	**Synthetic Dyes:** Colour and constitution (electronic Concept), Classification of dyes, Chemistry and synthesis of Methyl orange, Congo red, Malachite green, crystal violet, phenolphthalein, fluorescein, Alizarin and Indigo.	**07**

Suggested Readings:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry,* Pearson Education, 2003.
3. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education, 2012.
4. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press, 2008.
5. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry,* 2nd edition, Oxford University Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons, Inc.
7. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
8. March, J. *Advanced Organic Chemistry*, Fourth edition, Wiley. \
9. Bariyar and Goyal , Organic Chemistry-II, Krishna Prakashan Media, Meerut , Third Eddition, 2019

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggested online links:

http://heecontent.upsdc.gov.in/Home.aspx
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
https://nptel.ac.in/courses/104/103/104103071/#
https://nptel.ac.in/courses/104/106/104106096/

This course is compulsory for the students of following subjects: Chemistry in 12th Class

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, among others .

Or

Assessment and presentation of Assignment	(10 marks)
04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
Overall performance throughout the semester (Discipline, participation in different activities)	**(**05 marks)

Course prerequisites: To study this course, a student must have Passed Sem-I, Theory paper

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Semester-V Paper-2
Course Title: Chemistry of Group Elements

Programme: Degree in Bachelor of Science	Year: Three	Semester: V
Paper-2 Theory	**Elective**	Subject: Chemistry
Course Code: B020502T	**Course Title: Chemistry of Group Elements**	

Course outcomes: This paper provides detailed knowledge of basic concepts about solid state and catalysts as well as study of main elements of periodic table, their trend wise properties. Besides these it covers metal carbonyls and basic concepts of bioinorganic chemistry.

- It relates and gives an analytical aptitude for synthesizing various industrially important compounds.
- This paper also provides a detailed knowledge on the elements present in our surroundings, their occurrence in nature. Their position in periodic table, their physical and chemical properties as well as their extraction. This paper also gives detailed understanding of the s, p, d and f block elements and their characteristics.

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

Total No. of Lectures- = 60

Unit	Topics	No. of Lectures
I	**Solid State** Definition of space lattice, unit cell. Laws of crystallography – (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices and iii) Symmetry elements in crystals andlaw of symmetry .X-ray diffraction by crystals. Derivation of Bragg equation. Determinationof crystal structure of NaCl, KCl and CsCl (powder method).	**07**
II	**Catalysis** General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications. Deactivation or regeneration of catalysts. Phase transfer catalysts, Enzyme catalysis; Michaelis-Menten equation, turn-over number.	**07**

III	**Chemistry of Main Group Elements** **s-Block Elements:** Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their function in biosystems, an introduction to alkyls and aryls. **p-Block Elements**: Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of group 13-16, hydrides of boron-diborane and higher boranes, borazine, hydrazine, fullerenes, silicates, silicones (structural principle), phosphazines, basic properties of halogens, interhalogens.. **Chemistry of Noble Gasses**: Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.	**14**
IV	**Chemistry of Transition Elements** **Chemistry of Elements of First Transition Series** -Characteristic properties of d-block elements. Binary compounds (hydrides, carbides and oxides) of the elements of the first transition series and complexes with respect to relative stability of their oxidation states, coordination number and geometry. **Chemistry of Elements of Second and Third Transition Series-** General characteristics, comparative treatment of Zr/Hf, Nb/Ta, Mo/W in respect of ionic radii, oxidation states, magnetic behavior, spectral properties and stereochemistry.	**08**
V	**Chemistry of Lanthanides** Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analytical uses.	**06**
VI	**Chemistry of Actinides** Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.	**05**
VII	**Metal Carbonyls** Metal carbonyls: 18-electron rule, preparation, structure and nature of bonding in the mononuclear and dinuclea carbonyls.	**05**
VIII	**Bioinorganic Chemistry** Essential and trace elements in biological processes, metallo-porphyrins with special reference to heamoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with specialreference to Ca^{2+}. Nitrogen fixation.	**08**

Suggested Readings:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry,* Pearson Education, 2003.
3. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education, 2012.
4. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press, 2008.
5. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry,* 2nd edition, Oxford University Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons, Inc.

7. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
8. March, J. *Advanced Organic Chemistry*, Fourth edition, Wiley.
9. Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010
10. Huheey, J.E., Keiter, E.A., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006
11. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
12. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.
13. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.
14. Francis**, P. G.** Mathematics for Chemists, Springer, 1984
15. Prakash Satya,Tuli G.D.,Basu S.K.Madan R.D.,Advanced inorganic Chemistry,S.Chand publishing.
16. Bariyar and Goyal , Inorganic Chemistry-II, Krishna Prakashan Media, Meerut , Third Eddition, 2019

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggested online links:
http://heecontent.upsdc.gov.in/Home.aspx
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
https://nptel.ac.in/courses/104/103/104103071/#
https://swayam.gov.in/

This course can be opted as an elective by the students of following subjects: Chemistry in 12 th Class

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, among others .
Or

Assessment and presentation of Assignment	(10 marks)
04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
Overall performance throughout the semester (Discipline, participation in different activities)	**(**05 marks)

Course prerequisites: To study this course, a student must have Passed Sem-I, Theory paper

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Semester V, Paper-3 (Practical)
Course Title: Qualitative Analysis

Programme: Degree in Bachelor of Science	Year: Three	Semester: V
Practical paper-3		Subject: Chemistry
Course Code: B020503P	**Course Title: Qualitative Analysis**	

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 mixtures and organic compounds.

- Identification of acidic and basic radicals in inorganic mixtures
- Separation of organic compounds from mixture
- Elemental analysis in organic compounds
- Identification of functional group in organic compounds
- Identification of organic compound

Credits: 2	Elective
Max. Marks: 25+75	Min. Passing Marks:

Practical **60 h**

Unit	Topics	No of lectures
I	**Inorganic Qualitative Analysis** Semi micro Analysis – cation analysis, separation and identification of ions from groups I, II, III, IV, V and VI, Anion analysis. Mixture containing 6 radicals-2 +4 or 4+2 or 3+3	**16**
II	**Systematic analysis Organic Compounds** Systematic analysis and identification of organic compounds.by chemical methods.	**14**
III	**Separation of Organic Mixture** Separation of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives.	**18**
IV	**Preparation of Simple Polymers** Preparation of Bakelite. Preparation of rayon fibres from filter paper.	**12**

Suggested Readings:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
5. Harris, D.C.*Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
6. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggestive digital platforms web links

4. https://www.labster.com/chemistry-virtual-labs/
5. https://www.vlab.co.in/broad-area-chemical-sciences
1. **http://chemcollective.org/vlabs**

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

Suggested Continuous Evaluation Methods:

Viva voce	(10 marks)
Mock test	(10 marks)
Overall performance	(05marks)

Course prerequisites: To study this course, a student must have Opted Sem-V Theory Ppaer-1 &2

Suggested equivalent online courses:
……..

Further Suggestions:
……..

Semester-VI Paper-1
Course Title: Organic Synthesis B

Programme: Degree in Bachelor of Science	Year: Three	Semester: VI
Paper-1 Theory	**Compulsory**	Subject: Chemistry
Course Code:B020601T	**Course Title: Organic Synthesis B**	

Course outcomes: This paper provides detailed knowledge of various reagents used in synthesis of various class of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which providesjobs in production & QC departments related to chemicals, drugs, medicines, FMCG etc. industries. The study of natural products and heterocyclic compounds offers an excellent strategy toward identifying novel biological probes for a number of diseases. Historically, natural products have played an important role in the development of pharmaceutical drugs for a number of diseases including cancer and infection.

- It relates and gives an analytical aptitude for synthesizing various industrially important compounds.
- Learn the different types of alkaloids, & terpenes etc and their chemistry and medicinal importance.
- Explain the importance of natural compounds as lead molecules for new drug discovery.

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

Total No. of Lectures- = 60

Unit	Topics	No. of Lectures
I	**Reagents in Organic Synthesis** A detailed study of the following reagents in organic transformations: Oxidation with DDQ, SeO_2, mCPBA, Jones Oxidation, PCC, PDC, Collin's reagent	**05**
II	**Organometallic Compounds-** Organo magnesium compounds: the Grignard reagents, formation,structure and chemical reactions.. Organolithium compounds: formation and chemical reactions.	**05**
III	**Chemistry of Aldehydes and ketones:** Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones, synthesis of aldehydes and ketones, synthesis of aldehydes & ketones from nitriles carboxylic acids, Mechanism of nucleophillic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction, Cannizzaro reaction, , Clemmensen, Wolff-Kishner. $NaBH_4$ & $LiAlH_4$ Reductions.	**10**

IV	**Carboxylic acids and their Functional Derivatives** Nomenclature and classification of aliphatic and aromatic carboxylic acids. Preparation and reactions. Acidity (effect of substituents on acidity) and salt formation, Reactions, Preparation and properties of dicarboxylic acids such as oxalic, malonic, action of heat on hydroxy acids. Preparation of acid chlorides, acid anhydrides, amides and esters, acid and alkaline hydrolysis of esters(AAC^2 & BAC^2)	07
V	**Organic Synthesis via Enolates** Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate, Synthesis of ethyl acetoacetate: Claisen condensation, Keto-enol tautomerism of ethyl acetoacetate. Alkylation of: 1, 3-dithianes, diethyl malonate and ethyl acetoacetate, Synthetic importances of AAE & Malonic ester.	08
VI	**Organic Compounds of Nitrogen-** Preparation of nitroarenes, Chemical reactions of nitroarenes. their reductions in acidic, neutral and alkaline media, Picric acid. Structure and nomenclature of amines, Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts, Preparation of alkyl and aryl amines (reduction of nitro & nitriles), Gabriel-phthalimide reaction, Reactions of amines, electrophilic aromatic substituton in aryl amines, Synthetic transformations of aryl diazonium salts, azo coupling.	10
VII	**Heterocyclic Chemistry** Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with mechanism of electrophilic substitution, Mechanism of nucleophilic substitution, Comparison of basicity of pyridine, piperidine and pyrrole. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Nepieralski synthesis, Mechanism of electrophilc substitution reactions of indole, quinoline and isoquinoline	08
VIII	**Natural Products** **Alkaloids & Terpenes:** Natural occurrence, General structural features, their physiological action, Hoffmann's exhaustive methylation, Emde's modification; Structure and medicinal importance ofNicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. Natural Occurrence and classification of terpenes, isoprene rule.	07

Suggested Readings:

17. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
18. Sykes, P. *A guidebook to Mechanism in Organic Chemistry,* Pearson Education, 2003.
19. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education, 2012.
20. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press, 2008.
21. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry,* 2nd edition, Oxford University Press, 2012.
22. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons, Inc.
23. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
24. March, J. *Advanced Organic Chemistry*, Fourth edition, Wiley.
25. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly& Sons (1976).
26. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
27. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural
28. Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
29. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Prakashan (2010).
30. Organic Chemistry III, Krishna Prakashan Media, Meerut , Third Eddition, 2019

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggested online links:

http://heecontent.upsdc.gov.in/Home.aspx
https://nptel.ac.in/courses/104/103/104103111/
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
https://nptel.ac.in/courses/104/103/104103071/#
https://swayam.gov.in/

This course compulsory for the students of following subjects: Chemistry in 12th Class

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, among others .

Or	
Assessment and presentation of Assignment	(10 marks)
04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
Overall performance throughout the semester (Discipline, participation in different activities)	(05 marks)
Course prerequisites: To study this course, a student must have Passed Sem-V Theory paper-1	
Suggested equivalent online courses: ……..	
Further Suggestions: ……..	

Semester-VI Paper-2

Course Title: Chemical Energetics and Radiochemistry

Programme: Degree in Bachelor of Science	Year: Three	Semester: VI
Paper-2 Theory	**Elective**	Subject: Chemistry
Course Code: B020602T	**Course Title: Chemical Energetics and Radiochemistry**	

Course outcomes: Upon successful completion of this course students should be able to describe laws of thermodynamics, thermochemistry and its applications, phase equilibria of one and two component system, electro chemistry ,ionic equilibrium applications of conductivity and potentiometric measurements as well as basic concepts of radiochemistry.

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

Total No. of Lectures- = 60

Unit	Topics	No. of Lectures
I	**Thermodynamics-1 :** **First Law of Thermodynamics**: Statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law – Joule-Thomson coefficient and inversion temperature . Calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.	06
II	**Thermodynamics II** Second Law of thermodynamics, Carnot cycle and its efficiency. Carnot theorem. Concept of Entropy, Entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium. Gibbs function (G) and Helmhotz function (A) as thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, Variation of G and A with P, V and T.	10

III	**Thermochemistry:** Standard state, standard enthalpy of formation – Hess's law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization ; Bond dissociation energy and its calculation from thermo-chemical data , temperature dependence of enthalpy. Kirchhoff's equation.	**06**
IV	**Electrochemistry**: Electrical transport:- Conduction in metals and in electrolyte solutions, specific conductance molar and equivalent conductance, Migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations. Weak and strong electrolytes. Ostwald's dilution law, its uses and limitations. Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only), Transport number, definition and determination by Hittorf method and moving boundary method.	**08**
V	**Ionic Equilibrium**: Electrode reactions, Nernst equation, derivation of cell EMF and single electrode potential, standard hydrogen electrode-reference electrodes and their applications, standard electrode potential, sign conventions, Electrolytic and Galvanic cells–Reversible and irreversible cells, conventional representation of electrochemical cells. EMF of a cell and its measurement. Definition of pH and pKa, Mechanism of buffer action, Henderson-Hazel equation, application of buffer solution. Hydrolysis of salts	**08**
VI	**Colligative Properties-**Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination, Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure, Elevation of boiling point and depression of freezing, Vant-Hoff factor, Colligative properties of degree of dissociation and association of solutes.	**08**
VII	**Surface Chemistry** **Adsorption**: Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption; Heterogenous catalysis (single reactant). **Colloids**: Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential (qualitative idea), Tyndall effect, Electrokinetic phenomena (qualitative idea only); Micelle formation.	**08**
VIII	**Radiochemistry** Natural and induced radioactivity; radioactive decays: α-decay, β-decay, γ-decay; n^0 (neutron)-emission, β^+(positron)-emission, electron capture; unit of radioactivity (Curie); half life period; Geiger-Nuttal rule, radioactive series. Measurement of radioactivity: ionization chamber, Geiger counters, scintillation counters. Applications of radiochemistry.	**06**

Suggested Readings:

1. Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th ed., B..I. Waverly Pvt. Ltd. New Delhi.
2. Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
3. Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).
4. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
5. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
6. Castellan, G. W. Physical Chemistry 4th Edn. Narosa (2004).
7. Allen Bard ,J Larry . Faulkner R ,Fundamentals of Electrochemical methods –fundamentals and applications ,new York John ,Wiley &sons , 2001
8. H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4th ed., New Age International, New Delhi, 1995.
9. Bariyar,and Goyal, Physical Chemistry-II, Krishna Prakashan Media, Meerut , Third Eddition, 2019

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Suggested online links:

http://heecontent.upsdc.gov.in/Home.aspx

https://swayam.gov.in/

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

https://www.mooc-list.com/tags/physical-chemistry

https://www.openlearning.com/courses/introduction-to-physical-chemistry/

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class	
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, among others . **Or**	
Assessment and presentation of Assignment	(10 marks)
04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
Overall performance throughout the semester (Discipline, participation in different activities)	**(**05 marks)
Course prerequisites: To study this course, a student must have had the chemistry in class 12th, Physics in 12th	
Suggested equivalent online courses: ……..	
Further Suggestions: ……..	

Semester VI, Paper-3 (Practical)
Course Title: Analytical Methods

Programme: Degree in Bachelor of Science	Year: Three	Semester: IV
Practical paper-3		Subject: Chemistry
Course Code: B020603P	**Course Title: Analytical Methods**	

Course Outcomes: Upon successful completion of this course students should be able to quantify the product obtained through gravimetric method; determination of R_f values and identification of organic compounds through paper and thin layer chromatography laboratory techniques: perform thermo chemical reactions

Credits: 2	Elective
Max. Marks: 25+75	Min. Passing Marks:
Practical	**60 h**

Unit	Topics	No of Lectures
I	**Gravimetric Analysis** 1. Analysis of Cu as CuSCN, 2. Analysis of Ni as Ni (dimethylgloxime) 3. Analysis of Ba as $BaSO_4$.	20
II	**Paper Chromatography** Ascending and Circular. Determination of R*f* values and identification of organic compounds: Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid Leucine and glutamic acid. Spray reagent – ninhydrin. Separation of a mixture of D, L – alanine, glycine, and L-leucine using n-butanol:acetic acid: water (4:1:5). Spray reagent – ninhydrin. Separation of monosaccharaides – a mixture of D- galactose and D -fructose using n- butanol: acetone: water (4:5:1). Spray reagent – aniline hydrogen phthalate	12

III	**Thin Layer Chromatography** Determination of R*f* values and identification of organic compounds: Separation of green leaf pigments (spinach leaves may be used), Separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2, and 3-one using toluene and light petroleum (40:60), Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5)	14
IV	**Thermochemistry** 1. To determine the solubility of benzoic acid at different temperatures and to determine ΔH of the dissolution process 2. To determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionization of the weak acid/weak base 3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born-Haber cycle	14

Suggested Readings:

1. Skoog .D.A., West.D.M and Holler .F.J., "Analytical Chemistry: An Introduction", 7th edition, Saunders college publishing, Philadelphia,(2010).
2. Larry Hargis.G" Analytical Chemistry: Principles and Techniques" Pearson©(1988)

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggestive digital platforms web links

4. https://www.labster.com/chemistry-virtual-labs/
5. https://www.vlab.co.in/broad-area-chemical-sciences
6. **http://chemcollective.org/vlabs**

This course can be opted as an elective by the students of following subjects: Chemistry in 12th Class

Suggested Continuous Evaluation Methods:

Viva voce	(10 marks)
Mock test	(10 marks)
Overall performance	(05marks)

Course prerequisites: To study this course, a student must have had the chemistry in 12th class

Suggested equivalent online courses:

……..

Further Suggestions:

……..