

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/ nonreducing sugar 3. Synthesis of Osazones.	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 5. Action of salivary amylase on starch 6. To determine the concentration of glycine solution by formylation method. 7. To determine the saponification value of an oil/fat. 8. To determine the iodine value of an oil/fat	20
III	Determination and identification of Nucleic Acids 1. Determination of nucleic acids 2. Extraction of DNA from onion/cauliflower	12
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. Synthesis of barbituric acid 3. Synthesis of propranolol	13

	values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes.	
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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:

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Further Suggestions:

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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 Solution Calibration of fractional weights, pipettes and burettes. Preparation of standards solutions. Dilution – 0.1 M to 0.001 M solutions. 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 surface tension of pure liquid or solution 2. Determination of viscosity of liquid pure liquid or solution	06
III	Boiling point and Transition Temperature 1. Boiling point of common organic liquid compounds ANY FIVE] <i>n</i> butylalcohol, cyclohexanol, ethyl methyl ketone, cyclohexanone, acetylacetone, isobutyl methyl ketone, isobutyl alcohol, acetonitrile, benzaldehyde and acetophenone. [Boiling points of the chosen organic compounds should preferably be within 180 ⁰ C]. 2. Transition Temperature, Determination of the transition temperature of the given substance by thermometric /dialometric method (e.g. MnCl ₂ .4H ₂ O/SrBr ₂ .2H ₂ O)	14
IV	Phase Equilibrium	20

	<ol style="list-style-type: none"> 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 of that 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. 	
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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:

<i>Viva voce</i>	(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:

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Further Suggestions:

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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: Quantum Mechanics and Analytical Techniques	
<p>Course Outcomes:: Upon successful completion of this course students should be able to describe atomic structure, elementary quantum mechanics, 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 chemical reaction</p> <p>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.</p> <ul style="list-style-type: none"> • 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	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.	5
II	Elementary Quantum Mechanics : Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. de-Broglie hypothesis. Heisenberg uncertainty principle. Hamiltonian Operator.	10

	<p>Schrödinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box. Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions. Molecular orbital theory, basic ideas – Criteria for forming MO from AO, construction of MO by LCAO – H₂ + ion, calculation of energy levels from wave functions, physical picture of bonding and anti-bonding wave functions, concept of σ, σ^*, π, π^* orbitals and their characteristics.</p>	
III	<p>Molecular Spectroscopy: Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom</p> <p>Rotational Spectrum: Diatomic molecules . Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect .</p> <p>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, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.</p> <p>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, qualitative description of selection rules.</p>	10
IV	<p>UV-Visible Spectroscopy :</p> <p>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 Rules for calculation of λ_{max} for the conjugated dienes: alicyclic, homoannular and heteroannular; extended conjugated systems distinction between cis and trans isomers (Cis and trans stilbene) .</p>	5
V	<p>Infrared Spectroscopy:</p> <p>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 nitrile) , 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 interpretation of I.R. spectra of simple organic compounds.</p>	5

VI	<p>¹H-NMR Spectroscopy (PMR)</p> <p>NMR Spectroscopy: introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; choice of solvent and internal standard; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of first-order multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR ; anisotropic effects in alkene, alkyne, aldehydes and aromatics; NMR peak area, integration; relative peak positions with coupling patterns of common organic compounds; interpretation of NMR spectra of simple compounds. Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules such as Ethanol, Ethyl acetate, acetone, acetaldehyde, dimethylformamide, Cis and trans 1,2-dimethyl cyclopropanone, propene, vinyl chloride, acetophenone, benzaldehyde, phenol, Toluene and ethyl benzene.</p>	10
VII	<p>Introduction to Mass Spectrometry: Principle of mass spectrometry, the mass spectrum, mass spectrometry diagram, molecular ion, metastable ion, fragmentation process, McLafferty rearrangement.</p>	3
VIII	<p>Separation Techniques: 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, extraction of organic species from the aqueous and non-aqueous media.</p> <p>Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.</p>	07

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:

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Further Suggestions:

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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	
<p>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.</p> <ul style="list-style-type: none"> • 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	<p>Molecular Weight Determination</p> <ol style="list-style-type: none"> 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	<p>Spectrophotometry</p> <ol style="list-style-type: none"> 1. To verify Beer – Lambert Law for $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ and determining the concentration of the given solution of the substance from absorption measurement 2. Determination of pKa values of indicator using spectrophotometry. 3. Determination of chemical oxygen demand (COD). 	20

	4. Determination of Biological oxygen demand (BOD).	
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 compounds explaining the relative δ-values and splitting pattern. 3. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).	10
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 R _f 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 & Allied Methods*, Elles Harwood Ltd. London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation*. Van Nostrand, New York, 1974.

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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:

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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	Rearrangements and 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

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	
<p>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.</p> <ul style="list-style-type: none"> • 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	<p>Chemistry of Alkanes and Cycloalkanes</p> <p>A) Alkanes :Classification of carbon atom in alkanes, General methods of preparation, physical and chemical properties of alkanes: Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity</p> <p>B) Cycloalkanes: Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Chair, Boat and Twist boat forms of cyclohexane with energy diagrams ring strain in small rings, theory of strain less rings. The case of cyclopropane ring, banana bonds.</p>	8
II	<p>Chemistry of Alkenes</p> <p>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, oxymercuration demercuration, hydroboration-oxidation, epoxidation, <i>syn</i> and <i>anti</i>-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; Simmons-Smith cyclopropanation reaction; electrophilic</p>	12

	addition to diene (conjugated dienes and allene); radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; interconversion of <i>E</i> - and <i>Z</i> - alkenes.	
III	Chemistry of Alkynes Methods of formation of alkynes, Addition to C≡C, mechanism, reactivity, regioselectivity and stereoselectivity; reactions: hydrogenation, halogenations, hydrohalogenation, hydration, oxymercuration demercuration, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch); reactions of terminal alkynes by exploring its acidity; inter conversion of terminal and non-terminal alkynes.	06
IV	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, Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl, naphthalene and anthracene.	10
V	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, chemical reactions of vicinal glycols, oxidative cleavage [Pb(OAc) ₄ and HIO ₄] and pinacol pinacolone rearrangement. Trihydric alcohols - nomenclature, methods of formation, chemical reactions of glycerol.	8
VI	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 synthesis, Hauben Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction	06
VII	Chemistry of Ethers and Epoxides : Nomenclature of ethers and methods of their formation, physical properties, Chemical reactions – cleavage and autoxidation, Ziesel's method. Synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.	05
VIII	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	05

diagrams; Polyhalogen compounds : Chloroform, carbon tetrachloride; 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, Synthesis and uses of DDT and BHC.

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., Giuliano, 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 Edition, 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:

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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: Rearrangements and 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: Rearrangements and Chemistry of Group Elements	
<p>Course outcomes: This paper provides detailed knowledge of synthesis of various class of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which provides jobs in production & QC departments related to chemicals, drugs, medicines, FMCG etc. industries.</p> <ul style="list-style-type: none"> • 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	<p>Rearrangements</p> <p>A detailed study of the following rearrangements: Pinacol-pinacolone, Demjanov, BenzilBensilic acid, Favorskii, Hofman, Curtius, Schmidt, Baeyer-Villiger and Fries rearrangement</p>	6
II	<p>Catalysis</p> <p>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, application of zeolites as catalysts. Enzyme catalysis; Michaelis-Menten equation, turn-over number.</p>	8
III	<p>Chemistry of Main Group Elements</p>	10

	<p>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> <p>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, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetra nitride, basic properties of halogens, interhalogens and polyhalides.</p> <p>Chemistry of Noble Gasses: Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.</p>	
IV	<p>Chemistry of Transition Elements</p> <p>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.</p> <p>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.</p>	06
V	<p>Chemistry of Lanthanides</p> <p>Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analytical uses.</p>	4
VI	<p>Chemistry of Actinides</p> <p>Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.</p>	4
VII	<p>Metal Carbonyls</p> <p>Metal carbonyls: 18-electron rule, preparation, structure and nature of bonding in the mononuclear and dinuclear carbonyls.</p>	6
VIII	<p>Bioinorganic Chemistry</p> <p>Essential and trace elements in biological processes, metalloporphyrins with special reference to hemoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+}. Nitrogen fixation.</p>	6
<p>Suggested Readings:</p> <ol style="list-style-type: none"> 1. Morrison, R. N. & Boyd, R. N. <i>Organic Chemistry</i>, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2. Sykes, P. <i>A guidebook to Mechanism in Organic Chemistry</i>, Pearson Education, 2003. 3. Carey, F. A., Giuliano, R. M. <i>Organic Chemistry</i>, Eighth edition, McGraw Hill Education, 2012. 4. Loudon, G. M. <i>Organic Chemistry</i>, Fourth edition, Oxford University Press, 2008. 5. Clayden, J., Greeves, N. & Warren, S. <i>Organic Chemistry</i>, 2nd edition, Oxford University Press, 2012. 6. Graham Solomons, T.W., Fryhle, C. B. <i>Organic Chemistry</i>, 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 Edition, 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 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:

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Further Suggestions:

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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	
<p>Course outcomes:</p> <p>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.</p> <ul style="list-style-type: none"> • 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+ or 3+3	16
II	Elemental analysis and identification of functional groups Detection of extra elements (N, S and halogens) and functional groups (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and anilide) in simple organic compounds.	14
III	Separation of Organic Mixture Analysis of an organic mixture containing two solid components using water, NaHCO ₃ , NaOH for separation and preparation of suitable derivatives	18
IV	Identification of organic compounds Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.	12

Suggested Readings:		
<ol style="list-style-type: none"> 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. <i>Exploring Chemical Analysis</i>, 9th Ed. New York, W.H. Freeman, 2016. 6. Khopkar, S.M. <i>Basic Concepts of Analytical Chemistry</i>. 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		
<ol style="list-style-type: none"> 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:		
<i>Viva voce</i>		(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	
<p>Course outcomes: This paper provides detailed knowledge of synthesis of various class of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which provides jobs in production & QC departments related to chemicals, drugs, medicines, FMCG etc. industries.</p> <p>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.</p> <ul style="list-style-type: none"> • 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	<p>Reagents in Organic Synthesis</p> <p>A detailed study of the following reagents in organic transformations</p> <p>Oxidation with DDQ, CAN and SeO₂, mCPBA, Jones Oxidation, PCC, PDC, PFC, Collin's reagent and ruthenium tetroxide. Reduction with NaBH₄, LiAlH₄, Meerwein-Ponndorf-Verley (MPV) reduction, Wilkinson's catalyst, Birch reduction, DIBAL-H</p>	6

II	Organometallic Compounds -Organomagnesium compounds: the Grignard reagents, formation, structure and chemical reactions. Organozinc compounds: formation and chemical reactions. Organolithium compounds: formation and chemical reactions.	4
III	Chemistry of Aldehydes and ketones: Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones uses 1, 3-dithianes, synthesis of ketones from nitrites and from carboxylic acids, Physical properties. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction. Oxidation of aldehydes, Cannizzaro reaction, MPV, Clemmensen, Wolff-Kishner, LiAlH_4 and NaBH_4 reductions. Halogenation of enolizable ketones An introduction to α , β unsaturated aldehydes and Ketones.	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: Mechanism of reduction, substitution in alkyl or aryl group. Preparation and properties of dicarboxylic acids such as oxalic, malonic, succinic, glutaric, adipic and phthalic acids and unsaturated carboxylic acids such as acrylic, crotonic and cinnamic acids, Reactions: Action of heat on hydroxy and amino acids, and saturated dicarboxylic acids, stereospecific addition to maleic and fumaric acids. Preparation and reactions of acid chlorides, acid anhydrides, amides and esters, acid and alkaline hydrolysis of esters, trans-esterification.	8
V	Organic Synthesis via Enolates Acidity of α -hydrogens, alkylation of diethyl malonate and ethyl acetoacetate, Synthesis of ethyl acetoacetate: the Claisen condensation, Keto-enol tautomerism of ethyl acetoacetate. Alkylation of 1, 3-dithianes, Alkylation and acylation of enamines.	5
VI	Organic Compounds of Nitrogen- Preparation of nitroalkanes and nitroarenes, Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media, Picric acid. Halonitroarenes: reactivity, Structure and nomenclature of amines, physical properties, Stereochemistry 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 compounds, nitrites), reductive amination of aldehydic and ketonic compounds, Gabriel-phthalimide reaction, Hofmann bromamide reaction. Reactions of amines, electrophilic aromatic	10

	substituted in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling	
VII	<p>Heterocyclic Chemistry</p> <p>Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, Mechanism of nucleophilic substitution reaction in pyridine derivatives, Comparison of basicity of pyridine, piperidine and pyrrole. Introduction to condensed five and six membered heterocycles, Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Nepieralski synthesis, Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline</p>	10
VIII	<p>Natural Products</p> <p>Alkaloids & Terpenes: Natural occurrence, General structural features, their physiological action, Hoffmann's exhaustive methylation, Emde's modification;. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. Natural Occurrence and classification of terpenes, isoprene rule.</p>	7

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., Giuliano, 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 Wiley & 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 Edition, 2019

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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 Radio Chemistry

Programme: Degree in Bachelor of Science	Year: Three	Semester: VI
Paper-2 Theory	Elective	Subject: Chemistry
Course Code: B020602T	Course Title: Chemical Energetics and Radio Chemistry	
Course outcomes: Upon successful completion of this course students should be able to describe laws of thermodynamics and its applications, phase equilibria of one and two component system, electro chemistry ,ionic equilibrium applications of conductivity and potentiometric measurements		
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. 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.	8
II	Thermodynamics II	10

	<p>Second Law of Thermodynamics, Need for the law, different statements of the law, Carnot cycle and its efficiency. Carnot theorem. Thermodynamic scale of temperature.</p> <p>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. Entropy change in ideal gases and mixing of gases. Gibbs and Helmholtz Functions</p> <p>Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, Variation of G and A with P, V and T.</p> <p>Third Law of Thermodynamics; Nernst heat theorem, statement and concept of residual entropy. Nernst distribution law – Thermodynamic derivation, applications.</p>	
III	<p>Electrochemistry: Electrical transport:- Conduction in metals and in electrolyte solutions, specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation of molar, equivalent and specific conductances with dilution. 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.</p>	8
IV	<p>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, determination of pH using hydrogen, quinhydrone and glass electrodes by potentiometric methods. Buffers – Mechanism of buffer action, Henderson-Hasselbalch equation, application of buffer solution. Hydrolysis of salts</p>	10
V	<p>Photo Chemistry: Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothuss- Drapper law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples), kinetics of photochemical reaction.</p>	04

VI	<p>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, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, Van't Hoff factor, Colligative properties of degree of dissociation and association of solutes.</p>	6
VI I	<p>Surface Chemistry</p> <p>Adsorption: Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess; Heterogenous catalysis (single reactant);</p> <p>Colloids: Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena (qualitative idea only); Stability of colloids and zeta potential; Micelle formation</p>	07
VI II	<p>Radiochemistry</p> <p>Natural and induced radioactivity; radioactive decay-α-decay, β-decay, γ-decay; neutron emission, positron emission, electron capture; unit of radioactivity (Curie); half life period; Geiger-Nuttal rule, radioactive displacement law, radioactive series. Measurement of radioactivity: ionization chamber, Geiger counters, scintillation counters. Applications: energy tapping, dating of objects, neutron activation analysis, isotopic labelling studies, nuclear medicine-^{99m}Tc radiopharmaceuticals</p>	07

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. Arnika, *Essentials of Nuclear Chemistry*, 4th ed., New Age International, New Delhi, 1995.
9. Bariyar, and Goyal, Physical Chemistry-II, Krishna Prakashan Media, Meerut, Third Edition, 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:

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Further Suggestions:

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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	
<p>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</p>		
Credits: 2	Elective	
Max. Marks: 25+75	Min. Passing Marks:	
Practical		60 h
Unit	Topics	No of Lectures
I	<p>Gravimetric Analysis</p> <ol style="list-style-type: none"> 1. Analysis of Cu as CuSCN, 2. Analysis of Ni as Ni (dimethylgloxime) 3. Analysis of Ba as BaSO₄. 	30
II	<p>Paper Chromatography</p> <p>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</p>	8

	– 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	
III	<p>Thin Layer Chromatography</p> <p>Determination of R_f values and identification of organic compounds: Separation of green leaf pigments (spinach leaves may be used) Preparation of separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2, and 3-one using toluene and light petroleum (40:60)</p> <p>Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5)</p>	8
IV	<p>Thermochemistry</p> <p>1. To determine the solubility of benzoic acid at different temperatures and to determine ΔH of the dissolution process</p> <p>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</p> <p>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</p>	14
<p>Suggested Readings:</p> <ol style="list-style-type: none"> 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) <p>Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University</p> <p>Suggestive digital platforms web links</p> <ol style="list-style-type: none"> 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:		
<i>Viva voce</i>		(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:		