

# **School of Basic Sciences and Research**

**Department of Chemistry and Biochemistry**

**Program Structure: Three Year UP  
Higher Education for Chemistry  
Discipline**

**AY: 2021-22 Onwards**

## **1.1 Vision, Mission and Core Values of the University**

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### **Vision of the University**

**To serve the society by being a global University of higher learning in pursuit of academic excellence, innovation and nurturing entrepreneurship.**

### **Mission of the University**

- 1. Transformative educational experience**
- 2. Enrichment by educational initiatives that encourage global outlook**
- 3. Develop research, support disruptive innovations and accelerate entrepreneurship**

### **Core Values**

- Integrity**
- Leadership**
- Diversity**
- Community**

## **1.2 Vision and Mission of the School**

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### **Vision of the School**

**Achieving excellence in the realm of basic and applied sciences to address the global challenges of evolving society**

### **Mission of the School**

- 1. To equip the students with knowledge and skills in basic and applied sciences**
- 2. Capacity building through advanced training and academic flexibility.**
- 3. To establish centre of excellence for ecologically and socially innovative research.**
- 4. To strengthen interinstitutional and industrial collaboration for skill development and global employability.**

## **1.3 Vision and Mission of Department of chemistry and Biochemistry**

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### **Vision of Department of chemistry and Biochemistry**

**Strive to achieve excellence in teaching and research in the field of Chemistry and Biochemistry and to build human resource for solving contemporary problems.**

### **Mission of Department of chemistry and Biochemistry**

- **Providing distinctive and relevant education in Chemistry and Biochemistry to students.**
- **Motivating young minds through innovative teaching methods, to acquire theoretical knowledge and practical skills in different disciplines of chemistry and empowering them with problem solving skills.**
- **Nurturing innovation by carrying out world class research and scholarly work**
- **Promoting interdisciplinary research in collaboration with national/international laboratories/Institutions.**

## 1.4 Programme Educational Objectives (PEO)

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PEO 1: Providing distinctive and relevant education in chemistry to students.

PEO 2: Motivating young minds to acquire theoretical knowledge and practical skills in different disciplines of chemistry and empowering them with problem solving skills through innovative teaching methods.

PEO 3: Encouraging interdisciplinary research in collaboration with National/ International laboratories.

PEO 4: Promoting scholarly research work and innovation among students.

PEO5: Providing ethical understanding of safe handling of chemicals and various issues related with chemical compounds

PEO6: Promoting chemistry as an integral aspect for addressing social economic and environmental issues.

PEO7: Providing education to bridge the research gap between various search tools

### 1.4.3 Program Outcomes (PO's)

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PO1: Ability to gain the knowledge of chemical principles with a thorough understanding in chemistry and its sub-discipline such as bio-organic, bio-inorganic, medicinal, analytical, organic, inorganic and physical.

PO2: Capacity to identify and design the problems and formulate the strategy to find the solution by applying analytical and rational thinking.

PO3: Capability to combine the knowledge in Chemistry with mathematics, physics and biology to solve problems of interdisciplinary nature.

PO4: Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PO5: Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour 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.

PO6: Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.

PO7: Competency in using modern library search tools to locate and retrieve scientific information.

## ***B. Program Structure***

**1. TITLE:** Three Year UP Higher Education Program Structure for Chemistry  
Discipline

**2. DURATION OF THE COURSE:** 3 Years

**3. YEAR OF IMPLIMENTATION**

This syllabus will be implemented for the session academic year 2021-22 onwards.

**4. PREAMBLE**

Total Credits- 150

Minimum credit required for multiple entry and exit:

Total credit of the 03 year UG Program for year wise multiple entry and exit	01 <sup>st</sup> Year	46
	02 <sup>nd</sup> Year	96
	03 <sup>rd</sup> Year	146

Total Number of Semesters – 06 (Two semesters per year)

Total Number of Theory Papers – 28

Total Number of Practical courses – 20

Total Number of Minor Projects/Dissertations- 02

Number of papers (theory) per semester – 04-05

Number of Laboratory courses per semester – 02-04

Community Connect: 01

Internship: 01

## Semester wise subjects

No.	Subject Code	Course Name	Subject	Theory/ Practical	Credit		(Min.-Max. Total Credits) After completion {Minimum Credits} [Max Duration in years]	
					Total	Min.-Max. of the semester/year		
<b>Year 01: Certificate in Bioorganic and Medicinal Chemistry</b>								
<b>Semester 1</b>								
1.	B020101T	Fundamentals of Chemistry	Major I	Theory	04	23	(46-50) {46} [4] Certificate in Bioorganic and Medicinal Chemistry	
2.	B020102P	Quantitative Analysis	Major I	Practical	02			
3.	B020103T	Principles of physical chemistry	Major II	Theory	04			
4.	B020104P	Physical chemistry lab	Major II	Practical	02			
5.	B010102T/ T/	General properties of matter / Mathematics/ Biomolecules	Major III	Theory	04			
6.	B010106P P	Physics Lab-II / Mathematics lab-I / Biological Science lab-I	Major III	Practical	02			
7.	I020101P	Modern trends in chemical analysis: Step forward from laboratory to industry-I	Vocational	Practical	03			
8.	H000101T	Food and Nutrition	Co-curricular	Theory	02			
<b>Total credit</b>					<b>23</b>			
<b>Semester 2</b>								
1.	B020201T	Bioorganic and Medicinal Chemistry	Major I	Theory	04	23-27		
2.	B020202P	Biochemical Analysis	Major I	Practical	02			
3.	B020203T	Basics of Pharmaceuticals	Major II	Theory	04			
4.	B020204P	Pharmaceutical chemistry lab	Major II	Practical	02			
5.	B010202T/ T/	Renewable energy resources / Mathematics course/ Cell biology	Major III	Theory	04			
6.	B010206P/ P/	Physics Lab-IV/ Mathematics lab-II / Biological Science lab-II	Major III	Practical	02			
7.		Foundation Course in Mathematics/ Calculus I/ Biostatistics/ Fundamentals of Life Sciences	Minor/ Elective	Theory	04			
8.	I020201P	Modern trends in chemical analysis: Step forward from laboratory to industry-II	Vocational	Practical	03			
9.	H000201T	Health and Hygiene	Co-curricular	Theory	02			



<b>Total credit</b>					<b>27</b>		
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**Year 02: Diploma in Chemical Dynamics and Analytical Techniques**

**Semester 3**

1.	B020301T	Chemical Dynamics & Coordination Chemistry	Major I	Theory	04	23-27	
2.	B020302P	Physical Analysis	Major I	Practical	02		
3.	B020303T	Industrial chemicals and engineering materials	Major II	Theory	04		
4.	B020304P	Inorganic materials chemistry lab	Major II	Practical	02		
5.	B010302T	Oscillation and waves/ Molecular Biology-I	Major III	Theory	04		
6.	B010307P	Physics lab VI/ Biological Science lab III	Major III	Practical	02		
7.		Foundation Course in Mathematics/ Calculus I/ Biostatistics/ Fundamentals of Life Sciences	Minor/ Elective	Theory	04		
8.	I020301P	Modern trends in chemical analysis: Step forward from laboratory to industry-III	Vocational	Practical	03		
9.	H000301T	Physical Education	Co-curricular	Theory	02		
<b>Total credit</b>					<b>27</b>		

**Semester 4**

1.	B020401T	Quantum Mechanics and Analytical Techniques	Major I	Theory	04	23	
2.	B020402P	Instrumental Analysis	Major I	Practical	02		
3.	B020403T	Chemistry in action	Major II	Theory	04		
4.	B020404P	Chemistry in action lab	Major II	Practical	02		
5.	B010402T/	Laser and its application/ Bioinformatics	Major III	Theory	04		
6.	B010407P/	Physics lab VIII/ Bioinformatics lab IV	Major III	Practical	02		
7.	I020401P	Modern trends in chemical analysis: Step forward from laboratory to industry-IV	Vocational	Practical	03		
8.	H000401T	Human values and Environment Studies	Co-curricular	Theory	02		
<b>Total credit</b>					<b>23</b>		

96-100  
{96}  
[7]  
Diploma in  
Chemical  
Dynamics and  
Analytical  
Techniques

**Year 03: Degree in Bachelor of Science**

**Semester 5**

1.	B020501T	Organic Synthesis-A	Major I	Theory	04	25	
2.	B020502T	Rearrangements and Chemistry of Group Elements	Major I	Theory	04		
3.	B020503P	Qualitative Analysis	Major I	Practical	02		
4.	B020504R	Research Project (will be undertaken as a part of internship after semester 4)	Industrial Training/ Survey/ Project	Project	01		
5.	B020505T	Analytical chemistry I	Major II	Theory	04		
6.	B020506T	Advanced topics in chemistry	Major II	Theory	04		
7.	B020507P	Analytical chemistry lab-I	Major II	Practical	02		
8.	H000501T	Analytic Ability and Digital Awareness	Co-curricular	Theory	02		
9.	H020509R	Community connect	Industrial Training/ Survey/ Project	Project	02		
Total credit					25		
<b>Semester 6</b>							
	B020601T	Organic Synthesis-B	Major I	Theory	04	25	(146-150) { 146} [10] Degree in Bachelor of Science
	B020602T	Chemical Energetics and Radiochemistry	Major I	Theory	04		
	B020603P	Analytical Methods lab	Major I	Practical	02		
	B020604R	Research Project	Industrial Training/ Survey/ Project	Project	03		
	B020605T	Biological chemistry	Major II	Theory	04		
	B020606T	Analytical chemistry II	Major II	Theory	04		
	B020607P	Analytical chemistry lab-II	Major II	Practical	02		
	H000601T	Communication Skills and Personality Development	Co-curricular	Theory	02		
Total credit					25		
<b>Total credit of the 03 year UG Program: 150</b>			01 <sup>st</sup> Year		46-50	<b>Minimum credit required: 146</b>	
			02 <sup>nd</sup> Year		96-100		
			03 <sup>rd</sup> Year		146-150		

### Three years UG programme structure of Chemistry as per UP Higher Education

Year	Sem.	Subject I	Subject II	Subject III	Subject IV	Vocational I	Co-Curricular	Industrial Training/Survey/Project	Credits	(Min.-Max. Total Credits) After completion [Minimum Credits] [Max Duration in years]
		Major (Chemistry)	Major (Chemistry)	Major (Maths/Physics/Biochemistry)	Minor/Elective	Minor	Minor	Major		
		Credits 4 + 2	Credits 4 + 2	Credits 4 + 2	Credits 4	Credits 3	Credits 2	Credits 03/06/08		
		Own Faculty	Own Faculty	Any Faculty	Other Department/Faculty	Vocational Faculty	Co-Curricular Course	Inter/Intra Faculty related to main Subjects		
1	I	Fundamentals of Chemistry (L)	Principles of physical chemistry	General properties of matter / Mathematics/ Biomolecules		Modern trends in chemical analysis: Step forward from laboratory to industry-I	Food and Nutrition		23	(50) {46} [4] Certificate in Bioorganic and Medicinal Chemistry
		Qualitative analysis (P)	Physical chemistry lab	Physics Lab-II / Mathematics lab-I / Biological Science lab-I						
	II	Bioorganic and Medicinal Chemistry (L)	Basics of Pharmaceuticals	Renewable energy resources / Mathematics course/ Cell biology	Foundation Course in Mathematics/ Calculus I/ Biostatistics /	Modern trends in chemical analysis: Step forward from laboratory to industry-II	Health and Hygiene		27	
		Biochemical Analysis (P)	Pharmaceutical chemistry lab	Physics Lab-IV/ Mathematics lab-II / Biological Science lab-II	Fundamentals of Life Sciences					

2	III	Chemical Dynamics & Coordination Chemistry (L)	Industrial chemicals and engineering materials	Oscillation and waves/ Molecular Biology-I	Foundation Course in Mathematics/ Calculus I/ Biostatistics / Fundamentals of Life Sciences	Modern trends in chemical analysis: Step forward from laboratory to industry-III	Physical Education	27	(100) {96} [7] Diploma in Chemical Dynamics and Analytical Techniques	
		Physical Analysis (P)	Inorganic materials chemistry lab	Physics lab III/ Biological Science lab III (P)						
	IV	Quantum Mechanics and Analytical Techniques (L)	Chemistry in action	Laser and its application / Bioinformatics	Modern trends in chemical analysis: Step forward from laboratory to industry-IV	Human values and Environment Studies	23			
		Instrumental Analysis	Chemistry in action lab	Physics lab VIII/ Bioinformatics lab IV						
3	V	Organic Synthesis-A (L)	Analytical chemistry I				Analytic Ability and Digital Awareness	Community connect (2) + Summer internship of term IV (1)	25	
		Rearrangements and Chemistry of Group Elements (L)	Advanced topics in chemistry							
		Qualitative Analysis	Analytical chemistry lab-I							
		Research Project								
	VI	Organic Synthesis-B	Biological chemistry				Communication Skills and Personality Development	1(3)	25	(150) {146} [10] Degree in Bachelor of Science
		Chemical Energetics and Radiochemistry	Analytical chemistry II							
		Analytical Methods lab	Analytical chemistry lab-II							
		Research Project								

**Semestr-1**  
**Paper-1 (Theory)**  
**Course Title: Fundamentals of Chemistry**

Programme/Class: Certificate in Bioorganic and Medicinal Chemistry	Year: First	Semester: First
Paper-1 Theory	Subject: <b>Chemistry</b>	
Course Code: B020101T	<b>Course Title: Fundamentals of Chemistry</b>	

**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 Recapitulation of basics of organic chemistry gives 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 the molecules, and their role in reaction mechanism.

<b>Credits: 4</b>		<b>Compulsory</b>
Max. Marks: 25+75		Min. Passing Marks:.....
Total No. of Lectures = 60		
<b>Unit</b>	<b>Topics</b>	<b>No. of Lectures</b>
<b>I</b>	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 Continuous Evaluation (CIE)	10
	<b>Molecular polarity and Weak Chemical Forces :</b> Resonance and resonance energy, formal charge, Van der Waals forces, ion-dipole forces, dipole- dipole interactions, induced dipole interaction, dipole moment and molecular Structure (Diatomic and polyatomic molecules), Percentage ionic character from dipole moment, polarizing power and polarizability. Fajan's rules and consequences of polarization. Hydrogen bonding, van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Effects of weak chemical forces, melting and boiling points, solubility, energetics of dissolution process. Lattice energy and Born-Haber cycle, solvation energy, and solubility of ionic solids.	
<b>II</b>	<b>Simple Bonding theories of Molecules</b> Atomic orbitals, Aufbau principle, multiple bonding ( $\sigma$ and $\pi$ 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 <sub>2</sub> O, NH <sub>3</sub> , PCl <sub>5</sub> , SF <sub>6</sub> , SF <sub>4</sub> , -        -        2-        + ClF <sub>3</sub> , I <sub>3</sub> , ClF <sub>2</sub> and SO <sub>4</sub> and H <sub>3</sub> O . Molecular orbital theory (MOT). Molecular orbital diagrams bond orders of homonuclear and heteronuclear diatomic molecules and ions (N <sub>2</sub> , O <sub>2</sub> , C <sub>2</sub> , B <sub>2</sub> , F <sub>2</sub> , CO, NO, and their ions)	10
<b>III</b>	<b>Periodic properties of Atoms (with reference to s &amp; p-block):</b> 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	<p><b>Recapitulation of basics of Organic Chemistry:</b> Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, Van der Waals interactions, inclusion compounds, Clathrates, Charge transfer complexes, hyperconjugation, Dipole moment; Electronic Displacements: Inductive, electromeric, resonance mesomeric effects and their applications</p>	05
V	<p><b>Mechanism of Organic Reactions:</b> 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, arynes and nitrenes (with examples). Assigning formal charges on intermediates and other ionic species. Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).</p>	10
VI	<p><b>Stereochemistry-</b>Concept of isomerism, Types of isomerism; Optical isomerism – elements of symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomer, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D &amp; L and R &amp; S systems of nomenclature. Geometric isomerism – determination of configuration of geometric isomers, E &amp; Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds. Conformational isomerism – conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives, Newman projection and Sawhorse formulae, Fischer and flying wedge formulae, Difference between configuration and conformation.</p>	10
VII	<p><b>Basic Computer system (in brief)-</b>Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS, WINDOWS, and Linux); Software languages: Low level and High Level languages (Machine language, Assembly language; QBASIC, FORTRAN and C++); Software Products (Office, chemsketch, scilab, matlab, hyperchem, etc.), internet application.</p>	05

<b>VIII</b>	<b>Mathematical Concepts for Chemistry</b> 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
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**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., Giuliano, 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*, 2<sup>nd</sup> 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/VirtTxt.Jml/intro1.htm>  
<https://nptel.ac.in/courses/104/103/104103071/#>

**This course is compulsory for the students of following subjects: Chemistry in 12<sup>th</sup> 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/ Research Orientation assignment	(10 marks)
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04 tests (Objective): Max marks of each test = 10 (average of all 04 tests)	(10 marks)
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Overall performance throughout the semester, Discipline, participation in different activities)	(05 marks)
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**Course prerequisites: To study this course, a student must have had the chemistry in class 12<sup>th</sup>**

**Suggested equivalent online courses:**

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**Further Suggestions:**

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

<b>Programme: Certificate in Bioorganic and Medicinal Chemistry</b>	Year: First	Semester: I
<b>Practical paper-2</b>		Subject: Chemistry
Course Code: B020102P	<b>Course Title: Quantitative Analysis</b>	
<b>Course outcomes:</b>		
<p>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.</p> <ul style="list-style-type: none"> <li>• Potability tests of water samples.</li> <li>• Estimation of metal ions in samples</li> <li>• Estimation of alkali and acid contents in samples</li> <li>• Estimation of inorganic salts and hydrated water in samples</li> </ul>		
Credits: 2		Elective
Max. Marks: 25+75 = 100		Min. Passing Marks:
<b>Practical</b>		<b>60 h</b>
<b>Unit</b>	<b>Topics</b>	<b>No of Lectures</b>
<b>I</b>	<b>Water Quality analysis</b> 1. Estimation of hardness of water by EDTA. 2. Determination of chemical oxygen demand (COD). 3. Determination of Biological oxygen demand (BOD).	<b>16</b>
<b>II</b>	<b>Estimation of Metals ions</b> 1. Estimation of ferrous and ferric by dichromate method. 2. Estimation of copper using thiosulphate.	<b>14</b>
<b>II</b>	<b>Estimation of acids and alkali contents</b> 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 <sub>4</sub> .	<b>14</b>

<b>IV</b>	<b>Estimation of inorganic salts and hydrated water</b> 1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. 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 $\text{KMnO}_4$ .	<b>16</b>
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<b>Suggested Readings:</b> 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. Skooog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition  <b>Note:</b> For the promotion of Hindi language, course books published in Hindi may be prescribed by the University  Suggestive digital platforms web links  5. <a href="https://www.labster.com/chemistry-virtual-labs/">https://www.labster.com/chemistry-virtual-labs/</a> 6. <a href="https://www.vlab.co.in/broad-area-chemical-sciences">https://www.vlab.co.in/broad-area-chemical-sciences</a> 7. <a href="http://chemcollective.org/vlabs">http://chemcollective.org/vlabs</a>	
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**This course can be opted as an elective by the students of following subjects: Chemistry in 12<sup>th</sup> 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 12<sup>th</sup> Class**

Suggested equivalent online courses:

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Further Suggestions:

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## Semester-I, Paper-3

(Theory)

**Course Title:** Fundamentals of Physical Chemistry

<b>Programme/Class:</b> Certificate in Bioorganic and Medicinal Chemistry	<b>Year: First</b>	<b>Semester:</b> <b>First</b>
Paper-1 Theory	Subject: <b>Chemistry</b>	
<b>Course Code :</b> B020103T	<b>Course Title: Fundamentals of Physical Chemistry</b>	
<p>There is nothing more fundamental to chemistry than the quantitative analysis using Physical chemistry tools. Physical Chemistry is the language of chemists to provide more concrete details quantitatively. Fundamentals of Physical Chemistry course is designed in a way so as Students will gain an understanding of the:</p> <ol style="list-style-type: none"><li>1. Ionic product of water, solubility products, pH of solution</li><li>2. Quantitative analysis using suitable titrations</li><li>3. Physical chemistry aspect of catalytic role in biological process</li><li>4. Water quality parameters</li><li>5. Purification techniques and significance of non-aqueous solvents.</li></ol> <p><b>Course outcomes:</b> Upon successful completion of this course students should be able to:</p> <p><b>CO 1:</b> Calculate ionic product of water to calculate hydrogen ion and hydroxide ion concentrations in aqueous solution, Identify the components of a buffer and their function and realize the different types of salts solution and their pH</p> <p><b>CO 2:</b> Prepare solutions with desired molar or percent concentrations and carry out dilutions of these solutions and different types of titrations</p> <p><b>CO 3:</b> How catalysis increase the rate of reaction and its types</p> <p><b>CO 4:</b> Realize the importance of clean and healthy water by giving knowledge about water quality parameters and cleaning measures.</p> <p><b>CO 5:</b> Physical and chemical properties of non-aqueous solvents in biological applications.</p> <p><b>CO 6:</b> Broader theoretical and practical applications of physical chemistry concepts in biomedical applications.</p>		
<b>Credits: 4</b>	<b>Compulsory</b>	
Max. Marks: 25 + 75	Min. Passing Mark:	
Total No. of Lectures = 60		
<b>Unit</b>	<b>Topics</b>	<b>No. of Lectures</b>
<b>I</b>	<b>Ionic Equilibria</b> Strong, weak electrolytes, Arrhenius theory, degree of ionization, factors affecting degree of ionization, ionization constant, concept of $pK_a$ and $pK_b$ , common ion effect; dissociation constants of mono-(acetic acid), di-(carbonic acid) and triprotic (phosphoric acid) acids.	15

	<p>Ionic product of water. pH scale Buffer solutions, its types and mechanism of buffer action, Henderson-Hasselbalch equation for calculation of pH, buffer capacity,</p> <p>Hydrolysis of salts; degree of hydrolysis and pH of salt solutions.</p> <p>Solubility and solubility product of sparingly soluble salts, applications of solubility product principle.</p> <p>Complexometric titration, Redox titration (Iodometric and Iodometric), Precipitation titration, Acid-base titration and types, Titration curves and equivalence point, acid–base indicators; selection of indicators and their limitations.</p>	
II	<p><b>Solutions</b></p> <p>Concentration units: Molarity, Molality, Normality, mole fraction, volume percentage, mass percentage, gm/lit, parts per million</p> <p>Ideal/ non-ideal solution, Solutions of gases in gases, Henry’s law; Solutions of liquids in liquids, Solubility of completely miscible liquids, Solubility of partially miscible liquids, Phenol–water system, Trimethylamine–water system, Nicotine–water system, Vapour pressures of liquid-liquid solutions Azeotropes, Theory of fractional distillation, Steam distillation, Solutions of solids in liquids, Solubility–equilibrium Concept, Determination of solubility, Solubility of solids in solids</p>	15
III	<p><b>Catalysis</b></p> <p>What is catalysis, Types of catalysis, Homogeneous catalysis, Heterogeneous catalysis</p> <p>Characteristics of catalytic Reactions, Promoters, Catalytic poisoning, Autocatalysis, Negative catalysis, Activation energy and Catalysis, Theories of catalysis, The intermediate compound Formation theory, The adsorption theory</p> <p>Hydrogenation of ethene in presence of nickel Acid–base catalysis, Mechanism of acid catalysis</p> <p>Enzyme catalysis, Mechanism of enzyme catalysis, Michelis-Menton equation, Characteristics of enzyme Catalysis, Metal ion catalysis for drug synthesis</p>	12
IV	<p><b>Solid State</b></p> <p>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 and law of symmetry. X-ray diffraction by crystals. Derivation of Bragg equation.</p> <p>Determination of crystal structure of NaCl, KCl and CsCl (Laue's method and powder method). Hexagonal close-packed structure, Cubic close-packed</p>	12

	structure, Body-centred cubic structure, Crystal defects, Vacancy defect, Interstitial defect, Impurity defect	
V	<p><b>Non-aqueous Solvents</b></p> <p>Physical properties of solvents (Melting and Boiling Point, Heat of Fusion and Heat of Vaporization, Trouton Constant, Dielectric constant, Dipole Moment, Viscosity), Liquid ammonia (Comparison with water), Liq SO<sub>2</sub>, Liq HF, Self Ionisation, Reactions of Liquid ammonia – Protolysis and Ammonolysis, Solution of alkali metal in liquid ammonia.</p>	06

**Suggested Readings:**

1. Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010
2. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.
3. Puri, B.R., Sharma, L.R., and Pathania, M.S., “Principles of Physical Chemistry”, Vishal publishing company.
4. Bahl Arun, Bahl B.S. and J.D Tuli, “Essentials of Physical Chemistry”, S.Chand & Co.
5. University chemistry, by B. H. Mahan
6. Chemistry: Principles and Applications, by M. J. Sienko and R. A.Plane

**Suggested online links:**

<http://heecontent.upsdc.gov.in/Home.aspx>  
<https://nptel.ac.in/courses/104/103/104103071/>  
<https://nptel.ac.in/courses/104/101/104101084/>

**This course is compulsory for the students of following subjects: Chemistry in 12<sup>th</sup> Class**

**Continuous Evaluation Methods:** Students will 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 .

Assessment and presentation of Assignment/ Research Orientation assignment	(10 marks)
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04 tests (Objective): Max marks of each test = 10 (average of all 04 tests)	(10 marks)
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Overall performance throughout the semester, Discipline, participation in different activities)	(05 marks)
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**Course prerequisites: To study this course, a student must have had the chemistry in class 12<sup>th</sup>**

**Suggested equivalent online courses:**

<http://heecontent.upsdc.gov.in/Home.aspx>  
<https://nptel.ac.in/courses/104/103/104103071/>  
<https://nptel.ac.in/courses/104/101/104101084/>

**Semester-I, Paper-4  
(Practical)**

**Course Title: Fundamentals of Physical Chemistry Lab**

<b>Programme:</b> Certificate in Bioorganic and Medicinal Chemistry		Year: First	Semester: I
<b>Practical paper-1</b>	Subject: Chemistry		
Course Code: B020104P	<b>Course Title:</b> Fundamentals of Physical Chemistry Lab		
<b>Course outcomes:</b> Upon completion of this course the students will have the knowledge and skills to understand the various laboratory methods related to physical chemistry. They will understand various chemical analysis and estimation of physical parameters of compounds.			
<ul style="list-style-type: none"> <li>• Volumetric analysis.</li> <li>• pH-metric analysis</li> <li>• Estimation of physical parameters</li> <li>• Purification methods</li> </ul>			
<b>Credits:2</b>	Electives		
<b>Max. Marks:</b> 25+75=100	<b>Min. Passing Marks:</b>		
<b>Practical</b>	<b>60 h</b>		
<b>Unit</b>	<b>Topics</b>	<b>No. of Lectures</b>	
<b>I</b>	<b>Volumetric analysis</b> 1. To prepare N/10 normality solution of sodium carbonate and use it to standardize the given hydrochloric acid solution. 2. To prepare N/10 normality solution of sodium carbonate and use it to standardize the given hydrochloric acid solution. 3. To determine the amount and constituents of alkalinity of given water sample. 4. To prepare N/30 normality solution of potassium dichromate and use it to standardize the given hypo solution. 5. To determine the hardness of water by EDTA method.	20	
<b>II</b>	<b>pH- metric analysis</b> 6. Preparation of buffer solutions: (a) Sodium acetate-acetic acid, Measurement of the pH of buffer solutions and comparison of the values with theoretical values. Study the effect on pH of addition of HCl/NaOH to buffer solutions. (b) Ammonium chloride-ammonium hydroxide, Measurement of the pH of buffer solutions and comparison of the values with theoretical Values. Study the effect on pH of addition of HCl/NaOH to buffer solutions.	12	

	7. To determine the strength of given HCl solution by titrating with standard NaOH solution by (a) Indicator method (b) pH metrically 8. Determination of dissociation constant of a weak acid via pH meter.	
<b>III</b>	<b>Estimation of physical parameters</b> 9. Study the variation of viscosity of sucrose solution with the concentration of solute using Ostwald viscometer. 10. Determination of the critical solution temperature and composition of the phenol-water system and study of the effect of impurities on it. 11. To determine the solubility of an organic acid (oxalic acid) in water at room temperature.	12
<b>IV</b>	<b>Purification methods</b> 12. Purification of organic compounds (Water + acetone) by simple distillation.	4

**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

**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 12<sup>th</sup> Class**

Continuous Evaluation Methods:

Viva Voce	10 marks
Mock test	10 marks
Overall performance	15 marks

**Course prerequisites: To study this course, a student must have had the chemistry in 12<sup>th</sup> Class**

Suggested equivalent online courses:

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Further Suggestions:

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**Semester-I, Paper-5**  
**(Practical)**

**Course Title:** Modern trends in chemical analysis: Step forward from laboratory to industry-I

<b>Programme:</b> Certificate in Bioorganic and Medicinal Chemistry		Year: First	Semester: I
<b>Practical paper-1</b>	Subject: Chemistry		
Course Code: I020101P	<b>Course Title:</b> Modern trends in chemical analysis: Step forward from laboratory to industry-I		
<b>Course outcomes:</b> Upon completion of this course the students will have the knowledge and skills to understand the various laboratory methods related to common laboratory practices. They will understand procedure of how to use the various laboratory techniques, safe handling of chemicals and glass wares, and prepare and purify certain chemical of industrial importance.			
<ul style="list-style-type: none"> <li>• Chemical safety and ethical handling of chemicals</li> <li>• Procedure for Cleaning Glass Apparatus in Analytical Laboratories</li> <li>• Determination of melting and boiling point and preparation of inorganic reagents of laboratory importance</li> <li>• Recrystallisation, filtration and drying</li> </ul>			
<b>Credits:3</b>	Electives		
<b>Max. Marks:</b> <b>25+75=100</b>	<b>Min. Passing Marks:</b>		
<b>Practical</b>	<b>60 h</b>		
<b>Unit</b>	<b>Topics</b>	<b>No. of Lectures</b>	
<b>I</b>	<p><b>Chemical safety and ethical handling of chemicals</b></p> <p>Safe working procedure and protective environment, Protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemical, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric- safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.</p>	15	

<b>II</b>	<p><b>Procedure for Cleaning Glass Apparatus in Analytical Laboratories</b> Common laboratory apparatus; Hands on for preparing laboratory cleaning agents and its use; use of ultrasonic bath for cleaning; hands-on training on cutting and bending of glass tubing; making and using heating bath; making and using cooling bath; magnetic stirrer and mechanical agitation device and its use; gas absorption trap and its practical utilities, calibration of thermometers; water pump; electric heating mantles and its construction construction/ rectification in lab</p>	15
<b>III</b>	<p><b>Determination of melting and boiling point and preparation of inorganic reagents of laboratory importance</b> Experimental determination of the boiling point; Experimental determination of the melting point; typical assemblies of apparatus for distillation and refluxing and its laboratory use, simple, fractional, steam and vacuum distillation. Preparation of laboratory grade inorganic solid, liquid and gaseous reagents</p>	15
<b>IV</b>	<p><b>Recrystallisation, filtration and drying</b> Purification of solid compounds by crystallization; preparation of fluted filter paper; removal of traces of colouring matter and resinous products; difficulties in recrystallization; drying of the recrystallised material; Recrystallisation acetanilide, naphthalene, sulphanilic acid; recrystallisation in an atmosphere of inert gas; preparation and purification of double salt of Ni; filtration with suction; drying of solid compounds; drying of organic solvents</p>	15

**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. A text-book of practical organic chemistry including qualitative organic analysis by Vogel, 3<sup>rd</sup> Edition.

**Suggestive digital platforms web links**

6. [https://www.researchgate.net/publication/268049349\\_Development\\_of\\_a\\_Standardized\\_Procedure\\_for\\_Cleaning\\_Glass\\_Apparatus\\_in\\_Analytical\\_Laboratories](https://www.researchgate.net/publication/268049349_Development_of_a_Standardized_Procedure_for_Cleaning_Glass_Apparatus_in_Analytical_Laboratories)
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 12<sup>th</sup> Class**

Continuous Evaluation Methods:

Viva Voce	10 marks
Mock test	10 marks
Overall performance	15 marks

**Course prerequisites: To study this course, a student must have had the chemistry in 12<sup>th</sup> Class**

Suggested equivalent online courses:

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Further Suggestions:

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**Semester-II Paper-1**  
**(Theory)**

**Course Title: Bioorganic and Materials Chemistry**

Programme: Certificate in Bioorganic and Medicinal Chemistry	Year: 1	Semester: II
Paper-1	Elective	Subject: Chemistry
Course Code: B020201T	<b>Course Title: Bioorganic and Medicinal Chemistry</b>	
<p><b>Course outcomes:</b> 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. Upon completion of this course students may get job opportunities in food, beverage and pharmaceutical industries.</p>		
Credits: 4	Elective	
Max. Marks: 25+75	Min. Passing Marks:.....	
Total No. of Lectures = 60		
Unit	Topics	No. of Lectures
I	<p><b>Chemistry of Carbohydrates</b> : Classification of carbohydrates, reducing and non-reducing sugars, General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Mechanism of mutarotation Determination of configuration of Glucose (Fischer's proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Inter conversions of sugars (ascending and descending of sugar series, conversion of aldoses to ketoses). Lobry de Bruyn-van Ekenstein rearrangement; stepping-up (Kiliani- Fischer method) and stepping-down (Ruff's &amp; Wohl's methods) of aldoses; end-group-interchange of aldoses Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation</p>	10

II	<p><b>Chemistry of Proteins:</b> Classification of <i>amino acids</i>, zwitter ion structure and Isoelectric point. Overview of primary, secondary, tertiary and quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection &amp; C-activating groups and Merrifield solid phase synthesis. Protein denaturation/ renaturation Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action(Including stereospecificity),</p>	10
	Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non-competitive inhibition including allosteric inhibition).	
III	<p><b>Chemistry of Nucleic Acids:</b> Constituents of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), Nucleosides and nucleotides (<b>nomenclature</b>), Synthesis of nucleic acids, Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (<b>types of RNA</b>), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation</p>	05
IV	<p><b>Introductory Medicinal Chemistry :</b> Drug discovery, design and development; Basic Retrosynthetic approach. Drug action-receptor theory. Structure –activity relationships of drug molecules, binding role of –OH group, -NH<sub>2</sub> group, double bond and aromatic ring. Synthesis of the representative drugs of the following classes: analgesics agents, 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</p>	10
V	<p><b>Introduction to Polymer</b> Monomers, Oligomers, Polymers and their characteristics, Classification of polymers : Natural synthetic, linear, cross linked and network; plastics, elastomers, fibres, Homopolymers and Co-polymers, Bonding in polymers : Primary and secondary bond forces in polymers ; cohesive energy, and decomposition of polymers. Determination of Molecular mass of polymers: Number Average molecular mass (M<sub>n</sub>) and Weight average molecular mass(M<sub>w</sub>) of polymers and determination by (i) Viscosity (ii) Light scattering method (iii) Gel permeation chromatography (iv) Osmometry and Ultracentrifuging. <b>Silicones and Phosphazenes</b> –Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.</p>	15

<b>VI</b>	<p><b>Kinetics and Mechanism of Polymerization</b>  Polymerization techniques, Mechanism and kinetics of copolymerization, 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, Natural and synthetic rubbers, Elementary idea of organic conducting polymers.</p>	05
<b>VII</b>	<p><b>Synthetic Dyes:</b> 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.</p>	05

**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 Biochemistry 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*, 4<sup>th</sup> Ed. Wiley, 2004.
  13. F.W. Billmeyer: *Textbook of Polymer Science*, 2<sup>nd</sup> 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 12<sup>th</sup> Class**

**Suggested Continuous Evaluation Methods:**

**Viva voce: 10 Marks**

**Mock test: 10 Marks**

**Overall performance: 05 Marks**

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

**Suggested equivalent online courses:**

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**Further Suggestions:**

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**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	
<b>Course outcomes:</b> 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:
<b>Practical</b>		<b>60-h</b>
<b>Unit</b>	<b>Topics</b>	<b>No of Lectures</b>
<b>I</b>	<b>Qualitative and quantitative analysis of Carbohydrates: .</b> 1. Separation of a mixture of two sugars by ascending paper chromatography 2. Differentiate between a reducing/ nonreducing sugar 3. Synthesis of Osazones.	<b>15</b>
<b>II</b>	<b>Qualitative and quantitative analysis of Proteins, amino acids and Fats</b> 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	<b>20</b>
<b>III</b>	<b>Determination and identification of Nucleic Acids</b> 1. Determination of nucleic acids 2. Extraction of DNA from onion/cauliflower	<b>12</b>
<b>IV</b>	<b>Synthesis of Simple drug molecules</b> 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	<b>13</b>

**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 Analysis*, 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 Press
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 12<sup>th</sup> 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:

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Further Suggestions:

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**Semester-2, Paper-3**  
(Theory)  
**Course Title: Basics of Pharmaceuticals**

<b>Programme/Class: Certificate in Bioorganic and Medicinal Chemistry</b>		<b>Year: First</b>	<b>Semester: Second</b>
<b>Paper-2 Theory</b>		<b>Subject: Chemistry</b>	
<b>Course Code: B020203T</b>		<b>Course Title: Basics of Pharmaceuticals</b>	
<b>Course Description</b> To highlight the importance of Medicinal Chemistry in our lives and the fascination of working in a field that overlaps the disciplines of Chemistry, Biology, Biochemistry, Pharmacology etc.			
<b>Course Objective</b>			
1. To learn about drug-receptor interactions, lead discovery, drug design and molecular mechanism by which drug acts in the body.			
2. To understand various drug targets in the body and drug development strategies with mechanism of action of antibacterial agents and concept of drug resistance.			
3. To compare and contrast the specific pharmacology of the major classes of drugs, important distinctions among members of each class, the risks and benefits, in relation to the organ systems they affect, and the diseases for which they are used therapeutically.			
4. To apply the pharmacodynamic and pharmacokinetic principles that describe drug actions in humans. 5. To identify the role of molecular genetics and pharmacoeconomics principles in pharmacotherapeutics and drug development.			
<b>Course Outcomes</b>			
The student will be able to -			
<b>CO1:</b> Understand the basic sources of different drugs and effect of physicochemical properties on drug action.			
<b>CO2:</b> Identify the fundamental principles of pharmacokinetics and pharmacodynamics.			
<b>CO3:</b> Have a sound knowledge of basic terminology of medicinal chemistry and concept of Pharmacoeconomics and rational prescribing of drugs with their legal aspects.			
<b>CO4:</b> Explain the biochemistry involved behind the drug action, mechanism of action of antibacterial, antiseptic agents and concept of drug resistance.			
<b>CO5:</b> Understand drug-receptor interactions, lead discovery, drug design, drug development and its evaluation.			
<b>CO6:</b> Have a thorough grounding in Pharmaceutical Chemistry and basic knowledge in drug designing.			
<b>Credits:4</b>		<b>Elective</b>	
<b>Max. Marks : 25+75</b>		<b>Min. Passing Marks</b>	
<b>Total No. of Lectures : 60</b>			
<b>Units</b>	<b>Topics</b>	<b>No. of Lectures</b>	
<b>I</b>	<b>Physicochemical principles of drug action</b> Introduction to the different systems of medicines, Sources of drugs: Microbial, Plant, Marine, synthetic, A historical perspective. classification of drugs. Physicochemical principles of drug action: Partition coefficient, drug dissolution, acid-base properties, surface activity, bioavailability, stereochemical aspects of drug action Hammett equation and electronic parameters (sigma), lipophilicity effects and parameters (log P, $\pi$ -substituent constant), steric effects (Taft steric and molar refractivity), and determining relationship between chemical and biological data (Hansch approach) Biological parameters.	<b>12</b>	

<b>II</b>	<p><b>Pharmacology - 1</b>  Pharmacokinetics: various modes of administration of drug, distribution, metabolism (biotransformation) and drug excretion, apparent volume of distribution (aVd), half-life (<math>t_{1/2}</math>), and clearance (CL) that are used to decide the doses and rational dosing during the drug treatment.  Pharmacodynamics: site and mechanism of drug action, Basic idea about drug targets: Proteins as drug targets &amp; nucleic acids as drug target, drug receptors and receptor regulation  Concepts of agonists, antagonists, partial agonist and inverse agonist drugs.</p>	<b>10</b>
<b>III</b>	<p><b>Pharmacology-2</b>  Definition of the following medicinal terms: soft drug, drug analogue, prodrug, drug efficacy and potency, LD50, ED50, drug toxicity, drug addiction, spurious drugs, misbranded drugs, adulterated drugs, pharmacopoeia. Quantitative aspect of drug action: analysis of dose response curve and therapeutic index (safety index) Factors affecting drug action and doses, how to prolong or shorten the drug action and effects. Concept of evidence-based medicine, essential medicines, Pharmacoeconomics and rational prescribing. Drug regulation acts and other legal aspects.</p>	<b>10</b>
<b>IV</b>	<p><b>Medicinal Biochemistry</b>  Introduction to development of antimicrobial agents, historical development of antimicrobials, chemotherapy, use of synthetic compounds and antibiotic revolution. Mechanism of action at molecular level of selected antibiotics: inhibitors of cell wall: introduction to bacterial cell wall, peptidoglycan structure synthesis, mechanism of antibiotics inhibiting cell wall synthesis. Plasma membrane antiseptics, mechanism of antiseptics, disinfectants, cationic antibiotics, polypeptide antibiotics ionophoric and polyene antibiotics.</p>	<b>18</b>
<b>V</b>	<p><b>Drug development</b>  Discovery and Development of Drugs- History of drug discovery, Strategies in drug discovery, lead discovery, lead development, pharmacophore identification  Bioassays, screening of compounds. Development of new drugs: pre-clinical and clinical phases of drug evaluation. Scope and relevance of Clinical Pharmacology. Introduction to computer aided drug design (CADD).</p>	<b>10</b>

**Suggested Readings:**

1. A Text Book of Medicinal Chemistry, Vol-I and Vol-II, Surendra N. Pandeya, SG Publishers.
2. An Introduction to Drug Design, S.S. Pandeya and J. R. Dimmock, New Age International Publishers.
3. Medicinal Chemistry, Ashutosh Kar, New Age International Publishers.
4. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
5. Introduction to Medicinal Chemistry, A. Gringauge, Wiley-VCH.
6. Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, Edited by J.N. Delgado and W. A. Remers, J.B. Lipincott Company.
7. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
8. Burger's Medicinal Chemistry and Drug Discovery, Vol. I-V, Edited by M.E. Wolff, John Wiley & Sons Ltd
9. Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley & Sons Ltd.

**Suggested online links:**

<https://nptel.ac.in/courses/104/106/104106106/>

<https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cy16/>

<https://www.edx.org/course/medicinal-chemistry-the-molecular-basis-of-drug-di>

**Subject: Pharmaceutical Science - e-PG Pathshala**

<https://epgp.inflibnet.ac.in> > Home > ViewSubject

**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/ Research Orientation assignment	(10 marks)
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04 tests (Objective): Max marks of each test = 10 (average of all 04 tests)	(10 marks)
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Overall performance throughout the semester, Discipline, participation in different activities)	(05 marks)
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**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-2: Paper-4**  
**(Practical)**  
**Course Title: Pharmaceutical Chemistry lab**

<b>Programme/Class:</b> Certificate in Bio-organic and Medicinal Chemistry		<b>Year:</b> First	<b>Semester:</b> II
<b>Paper-2 Practical</b>		<b>Subject:</b> Chemistry	
<b>Course Code:</b> B020204P		<b>Course Title:</b> Pharmaceutical Chemistry lab	
<b>Course description:</b> This course gives the idea about physico-chemical properties, synthetic processes, purification methods and analysis of drugs.			
<b>Course Objectives:</b>			
To explain the analysis of physico-chemical properties of drugs			
To demonstrate the extraction and analysis method of bioactive compounds			
To understand the elementary steps in synthesis of organic compounds and drugs			
To execute the elementary steps involved in purification of organic compounds/drugs like precipitation and recrystallization			
To perform Qualitative and quantitative analysis of drugs			
To understand and execute few basic concepts involved in pharmaceutical lab			
<b>Course outcomes:</b>			
Upon completion of this course the students will have the knowledge and skills to:			
CO1: Understand the laboratory methods and tests related to analysis of various physico-chemical properties of drugs			
CO2: Learn to extract bioactive molecules from natural sources,			
CO3: Perform basic steps involved in synthesis of drugs			
CO4: Perform the purification of organic compounds/drugs			
CO5: Execute elementary quantitative analysis of chemicals in drugs			
CO6: Utilize the basic concepts learn during this lab to deal with complex problems of pharmaceutical chemistry			
<b>Credits:2</b>		<b>Compulsory</b>	
<b>Max. Marks : 25+75</b>		<b>Min. Passing Marks</b>	
<b>Practical</b>			<b>60h</b>
<b>Units</b>	<b>Topics</b>	<b>No. of Lectures</b>	
<b>I</b>	<b>Analysis of Physicochemical properties</b> Exp1. Determination of Oil-Water Partition Coefficient of Mandelic Acid Exp2. Influence of pH and $pK_a$ on Ionization and Solubility of Drugs (i) Paracetamol (ii) Aspirin (iii) p-aminophenol Exp3. To Synthesize potassium Salt of Benzoic acid and evaluation of its physico-chemical properties Exp4. To Synthesize sodium Salt of Benzoic Acid and evaluation of its physico-chemical properties.	<b>16</b>	
<b>II</b>	<b>Separation and analysis of bioactive compounds</b> Exp5. Separation and analysis of ascorbic acid from Vitamin C tablet. Exp6. Free Radical Scavenger Activity: Determination of the Antioxidant Profile of Ascorbic acid and its comparison with bioactive Substances (aloevera, lemon juice, green tea, pomegranate juice).	<b>8</b>	

<b>III</b>	<b>Synthesis and Purification</b> Exp7. Synthesis of Bis- $\beta$ -naphthol & its purification using precipitation or crystallization method. Exp8. Synthesis of oil of wintergreen from salicylic acid Exp9. To Synthesize and purify 2, 3-diphenyl Quinoxaline from o-phenylenediamine and Benzil by Condensation Reaction	<b>12</b>
<b>IV</b>	<b>Chemical analysis of drugs</b> Exp10. Analysis of commercial antacid tablet by titration method. Exp11. Determination of the Free Salicylic Acid Concentration in Aspirin by forming Fe <sup>+3</sup> Complexes Exp12. Analyze the concentration of drugs paracetamol and aspirin by using UV-Vis spectrophotometer.	<b>12</b>

**Suggested Readings:**

A Practical book of Medicinal Chemistry, January 2019, ISBN: 978-93-24457-15-7 PT-1948  
Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.  
Advanced Practical Medicinal Chemistry Paperback – 1 January 2015 by Ashutosh Kar  
Practical Medicinal Chemistry by Dr. K. Yogananda Reddy, Dr. K.N. Jayaveera & Dr. S. Subramanyam

**Suggested online links:**

[https://old.iupac.org/publications/cd/medicinal\\_chemistry/index.html](https://old.iupac.org/publications/cd/medicinal_chemistry/index.html)  
<http://greenparkschool.co.in/greenpark/index.php/blog/chemistry/COMPARITIVE%20STUDY%20OF%20COMMERCIAL%20ANTACIDS%20-%201.pdf>

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

Suggested continuous Evaluation Methods

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

**Course prerequisites: To study this course, a student must have had the chemistry in class 12<sup>th</sup>**

**Suggested equivalent online courses:** .....

**Further Suggestions:** .....

**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: <b>Chemistry</b>	
Course Code: B020301T	<b>Course Title: Chemical Dynamics &amp; Coordination Chemistry</b>	

**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.

<b>Credits: 4</b>	<b>Elective</b>
Max. Marks: 25+75	Min. Passing Marks:.....

Total No. of Lectures = 60

Unit	Topics	No. of Lectures
	<p><b>Chemical Kinetics:</b> 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, pseudo order, half-life and mean life. Determination of the order of reaction – differential method, method of integration, half-life method and isolation method. Brief outline of experimental of studying chemical kinetics: potentiometric, optical methods      Conductometric, methods, polarimetry and spectrophotometer</p> <p><b>Theories of chemical kinetics:</b> Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects (no derivation).</p>	
II	Chemical 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.	5
III	<b>Phase Equilibrium :</b> Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system– water, CO <sub>2</sub> and systems. Phase equilibria of two component systems – Solid - liquid equilibria, simple eutectic – Bi- Cd, Pb- Ag systems.	05

IV	<p><b>Kinetic theories of gases</b>  <b>Gaseous State:</b> Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waals equation of state.  <b>Critical phenomena:</b> PV isotherms of real gases, continuity of states, the isotherms of Van der Waals equation, relationship between critical constants and Van der Waals constants, the law of corresponding states, reduced equation of state.  <b>Molecular Velocities:</b> Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. Liquefaction of gases (based on Joule-Thomson effect).</p>	10
V	<p><b>Liquid State</b>  <b>Liquid State:</b> Intermolecular forces, structure of liquids (a qualitative description). Structural differences between solids, liquids and gases. Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and cholesterol phases. Thermography and seven segment cell.  <b>Liquids in solids (gels):</b> Classification, preparation and properties, inhibition, general application</p>	5
VI	<p>Coordination Chemistry  Coordinate bonding: double and complex salts. 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. VI</p>	5
VII	<p>Theories of Coordination Chemistry  I Metal- ligand bonding in transition metal complexes, limitations of valence bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters.  II. 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</p>	10

Inorganic Spectroscopy and Magnetism I) 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 d1 and d9 states, discussion of the electronic spectrum of  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  complex ion.

II) Magnetic properties of transition metal complexes, types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of  $\mu_s$  and  $\mu_{\text{eff}}$  values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes. Physical properties and molecular structure : Optical activity, polarization – (Clausius - Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties paramagnetism, diamagnetism and ferromagnetism, magnetic susceptibility, its measurements and its importance.

VIII

10

### 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, 3<sup>rd</sup> Edition ,Wiley 1995
5. Lee, J.D, Concise Inorganic Chemistry 4<sup>th</sup> 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, 3<sup>RD</sup> edition ,1993
10. Miessler, G.L, Tarr, D.A, Inorganic Chemistry, 2<sup>nd</sup> 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](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 12<sup>th</sup> 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.

Assessment and presentation of Assignment/ Research Orientation 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 12 <sup>th</sup> .....
Suggested equivalent online courses:.....
Further Suggestions: .....

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

<b>Programme:</b> Diploma in Chemical Dynamics and Analytical Techniques	Year: Two	Semester: III
<b>Practical paper-2</b>		Subject: Chemistry
Course Code: B020302P	<b>Course Title: Physical Analysis</b>	
<b>Course Outcomes:</b> 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:	
<b>Practical</b>		<b>60 h</b>
Unit	Topics	No of Lectures
<b>I</b>	<p><b>Strengths of Solution</b> Calibration of fractional weights, pipettes and burettes. Preparation of standards solutions. Dilution – 0.1 M to 0.001 M solutions.</p> <p>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</p>	20
<b>II</b>	<p><b>Surface Tension and Viscosity</b></p> <ol style="list-style-type: none"> <li>Determination of surface tension of pure liquid or solution</li> <li>Determination of viscosity of liquid pure liquid or solution</li> </ol>	06
<b>III</b>	<p><b>Boiling point and Transition Temperature</b></p> <ol style="list-style-type: none"> <li>Boiling point of common organic liquid compounds <b>ANY FIVE</b> <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°C].</li> <li>Transition Temperature, Determination of the transition temperature of the given substance by thermometric /dilatometric method (e.g. <math>MnCl_2 \cdot 4H_2O/SrBr_2 \cdot 2H_2O</math> )</li> </ol>	14
<b>IV</b>	<b>Phase Equilibrium</b>	20

- |  |  |  |
|--|--|--|
|  | <ol style="list-style-type: none"> <li>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</li> <li>To construct the phase diagram of two component (e.g. diphenylamine – benzophenone) system by cooling curve method.</li> </ol> |  |
|--|--|--|

**Suggested Readings:**

- Skoog .D.A., West.D.M and Holler .F.J., “Analytical Chemistry: An Introduction”, 7th edition, Saunders college publishing, Philadelphia,(2010).
- 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**

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

**This course can be opted as an elective by the students of following subjects: Chemistry in 12<sup>th</sup> 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:**

**Further Suggestions:**

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

<b>Programme:</b> Diploma in Chemical Dynamics and Analytical Techniques	Year: <b>Two</b>	Semester: <b>IV</b>
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Paper-1	Elective	Subject: <b>Chemistry</b>
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Course Code: BO20401T	<b>Course Title:</b> Quantum Mechanics and Analytical Techniques
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**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

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

Unit	Topics	No. of Lectures
<b>I</b>	<b>Atomic Structure:</b> Idea of de-Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrödinger wave equation, significance of $\Psi$ and $\Psi^2$ , 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
<b>II</b>	<b>Elementary Quantum Mechanics :</b> 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

	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 – H <sub>2</sub> + ion, calculation of energy levels from wave functions, physical picture of bonding and anti-bonding wave functions, concept of $\sigma$ , $\sigma^*$ , $\pi$ , $\pi^*$ orbitals and their characteristics.	
III	<p><b>Molecular Spectroscopy:</b> Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.</p> <p><b>Rotational Spectrum:</b> 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><b>Vibrational Spectrum:</b> 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><b>Raman spectrum:</b> 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 and Franck-Condon principle.</p>	10
IV	<p><b>UV-Visible Spectroscopy :</b></p> <p>Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules. Types of electronic transitions, <math>\lambda_{max}</math>, chromophores and auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; application of Woodward Rules for calculation of <math>\lambda_{max}</math> for the conjugated dienes: alicyclic, homoannular and heteroannular; extended conjugated systems distinction between cis and trans isomers.</p>	5
V	<p><b>Infrared Spectroscopy:</b></p> <p><b>IR Spectroscopy:</b> Fundamental and non-fundamental molecular vibrations; Hooke's law selection rule, IR absorption positions of various functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance;</p>	5

	application in functional group analysis and interpretation of I.R. spectra of simple organic compounds.	
VI	<p><b><sup>1</sup>H-NMR Spectroscopy (PMR)</b></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.</p>	10
VII	<p><b>Introduction to Mass Spectrometry:</b> Principle of mass spectrometry, the mass spectrum, mass spectrometry diagram, molecular ion, metastable ion, fragmentation process, McLafferty rearrangement.</p>	3
VIII	<p><b>Separation Techniques: Solvent extraction:</b> 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><b>Chromatography:</b> Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition &amp; 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, 3<sup>rd</sup> Edition , Wiley 1995
5. Lee, J.D, Concise Inorganic Chemistry 4<sup>th</sup> 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 12<sup>th</sup> 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 online tests, home assignments, group discussions or oral presentations, among others .

**Or**

Assessment and presentation of Assignment/ Research Orientation 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 12<sup>th</sup>**

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
<b>Practical paper-3</b>		Subject: Chemistry
Course Code: B020402P	<b>Course Title: Instrumental Analysis</b>	
<p><b>Course outcomes:</b> 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"> <li>• Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.</li> <li>• Students will be able to function as a member of an interdisciplinary problem solving team.</li> <li>• Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems</li> <li>• Students will gain an understanding of how to determine the structure of organic molecules using IR and NMR spectroscopic techniques</li> <li>• To develop basic skills required for purification, solvent extraction, TLC and column chromatography</li> </ul>		
Credits: 2		Elective
Max. Marks: 25 + 75		Min. Passing Marks:
<b>Practical</b>		<b>60 h</b>
Unit	Topics	No of Lectures
<b>I</b>	<p><b>Molecular Weight Determination</b></p> <ol style="list-style-type: none"> <li>1. Determination of molecular weight of a non-volatile solute by Rast method/ Beckmann freezing point method.</li> <li>2. Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) in aqueous solution at different concentrations by ebullioscopy</li> </ol>	<b>10</b>
<b>II</b>	<p><b>Spectrophotometry</b></p> <ol style="list-style-type: none"> <li>1. To verify Beer – Lambert Law for <math>\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7</math> and determining the concentration of the given solution of the substance from absorption measurement</li> <li>2. Determination of pKa values of indicator using spectrophotometry.</li> <li>3. Determination of chemical oxygen demand (COD).</li> </ol>	<b>20</b>



	4. Determination of Biological oxygen demand (BOD).	
III	<p><b>Spectroscopy</b></p> <ol style="list-style-type: none"> <li>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).</li> <li>2. Assignment of labelled peaks in the <sup>1</sup>H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.</li> <li>3. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).</li> </ol>	10
IV	<p><b>Chromatographic Separations</b></p> <ol style="list-style-type: none"> <li>1. Paper chromatographic separation of following metal ions: i. Ni (II) and Co (II) ii. Cu(II) and Cd(II)</li> <li>2. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer Chromatography (TLC)</li> <li>3. Separation and identification of the amino acids present in the given mixture by paper chromatography. Reporting the R<sub>f</sub> values</li> <li>4. TLC separation of a mixture of dyes (fluorescein and methylene blue)</li> </ol>	20

**Suggested Readings:**

1. Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis 6<sup>th</sup> 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.

**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 12<sup>th</sup> 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 class**

Suggested equivalent online courses:

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Further Suggestions:

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

Programme: Degree in Bachelor of Science	Year: Three	Semester: V
Paper-2 Theory	<b>Compulsory</b>	Subject: Chemistry
Course Code: B020501T	Course Title: <b>Organic Synthesis A</b>	
<p><b>Course outcomes:</b> 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"> <li>• Synthesis and chemical properties of aliphatic and aromatic hydrocarbons</li> <li>• Synthesis and chemical properties of alcohols, halides carbonyl compounds, carboxylic acids and esters</li> <li>• How to design and synthesize aliphatic and aromatic hydrocarbons.</li> <li>• How to convert aliphatic and aromatic hydrocarbons to other industrially important compounds</li> <li>• Functional group interconversion.</li> </ul>		
Credits: 4	Elective	
Max. Marks: 25+75	Min. Passing Marks:	
Total No. of Lectures- = 60		
Unit	Topics	No. of Lectures
I	<p><b>Chemistry of Alkanes and Cycloalkanes</b></p> <p><b>A) Alkanes :</b>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>B) Cycloalkanes:</b> 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><b>Chemistry of Alkenes</b></p> <p>Methods of formation of alkenes, Addition to <b>C=C</b>: 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; contra-thermodynamic isomerization of internal alkenes	
<b>III</b>	<b>Chemistry of Alkynes</b> 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
<b>IV</b>	<b>Aromaticity and Chemistry of Arenes</b> 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
<b>V</b>	<b>Chemistry of Alcohols</b> 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) <sub>4</sub> and HIO <sub>4</sub> ] and pinacol pinacolone rearrangement. Trihydric alcohols - nomenclature, methods of formation, chemical reactions of glycerol.	8
<b>VI</b>	<b>Chemistry of Phenols</b> : 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
<b>VII</b>	<b>Chemistry of Ethers and Epoxides</b> : 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
<b>VIII</b>	<b>Chemistry of Organic Halides</b> Nomenclature and classes of alkyl halides, methods of formation, chemical reactions, Mechanisms of nucleophilic substitution reactions of alkyl halides, SN <sub>2</sub> and SN <sub>1</sub> 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*, 2<sup>nd</sup> 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. \

**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 12<sup>th</sup> 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: Rearrangements and Chemistry of Group Elements**

Programme: Degree in Bachelor of Science	Year: Three	Semester: V
Paper-2 Theory	<b>Elective</b>	Subject: Chemistry
Course Code: B020502T	<b>Course Title: Rearrangements and Chemistry of Group Elements</b>	

**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.

- 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
<b>I</b>	<b>Rearrangements</b> A detailed study of the following rearrangements: Pinacol-pinacolone, Demjanov, BenzilBensilic acid, Favorskii, Hofman, Curtius, Schmidt, Baeyer-Villiger and Fries rearrangement	6
<b>II</b>	<b>Catalysis</b> 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, Lineweaver-Burk plot, turn-over number.	8
<b>III</b>	<b>Chemistry of Main Group Elements</b>	10

	<p><b>s-Block Elements:</b> 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><b>p-Block Elements:</b> 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><b>Chemistry of Noble Gases:</b> Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.</p>	
IV	<p><b>Chemistry of Transition Elements</b></p> <p><b>Chemistry of Elements of First Transition Series</b> -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><b>Chemistry of Elements of Second and Third Transition Series-</b> 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><b>Chemistry of Lanthanides</b></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><b>Chemistry of Actinides</b></p> <p>Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.</p>	4
VII	<p><b>Metal Carbonyls</b></p> <p>Metal carbonyls: 18-electron rule, preparation, structure and nature of bonding in the mononuclear and dinuclear carbonyls.</p>	6
VIII	<p><b>Bioinorganic Chemistry</b></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 <math>\text{Ca}^{2+}</math>. Nitrogen fixation.</p>	6

**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*, 2<sup>nd</sup> 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.

**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/introl.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<sup>th</sup> 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)
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04 Unit tests (Objective): Max marks of each unit test = 10 (average of all 04 unit tests)	(10 marks)
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Overall performance throughout the semester ( Discipline, participation in different activities)	(05 marks)
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**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**

<b>Programme:</b> Degree in Bachelor of Science	Year: Three	Semester: V
<b>Practical paper-3</b>		Subject: Chemistry
Course Code: B020503P	<b>Course Title: Qualitative Analysis</b>	
<p><b>Course outcomes:</b></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"> <li>• Identification of acidic and basic radicals in inorganic mixtures</li> <li>• Separation of organic compounds from mixture</li> <li>• Elemental analysis in organic compounds</li> <li>• Identification of functional group in organic compounds</li> <li>• Identification of organic compound</li> </ul>		
Credits: 2	Elective	
Max. Marks: 25+75	Min. Passing Marks:	
<b>Practical</b>		<b>60 h</b>
<b>Unit</b>	<b>Topics</b>	<b>No of lectures</b>
<b>I</b>	<b>Inorganic Qualitative Analysis</b> 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	<b>16</b>
<b>II</b>	<b>Elemental analysis and identification of functional groups</b> 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.	<b>14</b>
<b>III</b>	<b>Separation of Organic Mixture</b> Analysis of an organic mixture containing two solid components using water, NaHCO <sub>3</sub> , NaOH for separation and preparation of suitable derivatives	<b>18</b>
<b>IV</b>	<b>Identification of organic compounds</b> Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.	<b>12</b>

**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*, 9<sup>th</sup> 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 12<sup>th</sup> 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	<b>Compulsory</b>	Subject: Chemistry
Course Code: B020601T	<b>Course Title: Organic Synthesis B</b>	

**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.

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
<b>I</b>	<p><b>Reagents in Organic Synthesis</b></p> <p>A detailed study of the following reagents in organic transformations</p> <p>Oxidation with DDQ, CAN and SeO<sub>2</sub>, mCPBA, Jones Oxidation, PCC, PDC, PFC, Collin's reagent and ruthenium tetroxide. Reduction with NaBH<sub>4</sub>, LiAlH<sub>4</sub>, Meerwein-Ponndorf-Verley (MPV) reduction, Wilkinson's catalyst, Birch reduction, DIBAL-H</p>	6
<b>II</b>	<p><b>Organometallic Compounds</b>-Organomagnesium compounds: the Grignard reagents, formation, structure and chemical reactions. Organozinc compounds: formation and chemical reactions. Organolithium compounds: formation and chemical reactions.</p>	4

III	<p><b>Chemistry of Aldehydes and ketones:</b> Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acidchlorides, 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, <math>\text{LiAlH}_4</math> and <math>\text{NaBH}_4</math> reductions. Halogenation of enolizable ketones An introduction to <math>\alpha</math>, <math>\beta</math> unsaturated aldehydes and Ketones.</p>	10
IV	<p><b>Carboxylic acids and their Functional Derivatives</b> 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.</p>	8
V	<p><b>Organic Synthesis via Enolates</b> Acidity of <math>\alpha</math>-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.</p>	5
VI	<p><b>Organic Compounds of Nitrogen-</b> 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 substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling</p>	10

<b>VII</b>	<p><b>Heterocyclic Chemistry</b> 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
<b>VIII</b>	<p><b>Natural Products</b> <b>Alkaloids &amp; Terpenes:</b> 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:**

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

**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/introl.htm>

<https://nptel.ac.in/courses/104/103/104103071/#>

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

**This course compulsory for the students of following subjects: Chemistry in 12<sup>th</sup> 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	<b>Course Title: Chemical Energetics and Radio Chemistry</b>	
<p><b>Course outcomes:</b> 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</p>		
Credits: 4	Elective	
Max. Marks: 25+75	Min. Passing Marks:	
Total No. of Lectures- = 60		
Unit	Topics	No. of Lectures
I	<p><b>Thermodynamics-1 :</b></p> <p><b>First Law of Thermodynamics :</b> 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 &amp; dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.</p> <p><b>Thermochemistry:</b> 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.</p>	8
II	<p><b>Thermodynamics II</b></p> <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 &amp; T, entropy as a function of P &amp; 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 &amp; 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>	10

III	<p><b>Electrochemistry:</b> 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><b>Ionic Equilibrium:</b> Types of reversible electrodes – Gas-metal ion, metal-metal ion, metal insoluble salt-anion and redox electrodes. 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. Calculation of thermodynamic quantities of cell reactions (<math>\Delta G</math>, <math>\Delta H</math> and <math>K</math>). 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><b>Photo Chemistry:</b> Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus- 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><b>Colligative Properties</b>-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



<b>VI I</b>	<p><b>Surface Chemistry</b></p> <p><b>Adsorption:</b> 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><b>Colloids:</b> 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> <p><b>Dipole moment and polarizability:</b> Polarizability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules; Clausius-Mosotti equation and Debye equation (both without derivation) and their application; Determination of dipole moments</p>	07
<b>VI II</b>	<p><b>Radiochemistry</b></p> <p>Natural and induced radioactivity; radioactive decay-<math>\alpha</math>-decay, <math>\beta</math>-decay, <math>\gamma</math>-decay; neutron emission, positron emission, electron capture; unit of radioactivity (Curie); half life period; Geiger-Nuttall 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-<math>^{99m}\text{Tc}</math> 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.

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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 12<sup>th</sup> 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)
<b>Course prerequisites: To study this course, a student must have had the chemistry in class 12<sup>th</sup> , Physics in 12<sup>th</sup></b>	
Suggested equivalent online courses: .....	
Further Suggestions: .....	

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

<b>Programme:</b> Degree in Bachelor of Science	Year: Three	Semester: IV
<b>Practical paper-3</b>		Subject: Chemistry
Course Code: B020603P	<b>Course Title: Analytical Methods</b>	
<p><b>Course Outcomes:</b> Upon successful completion of this course students should be able to quantify the product obtained through gravimetric method; determination of <math>R_f</math> 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:	
<b>Practical</b>		<b>60 h</b>
Unit	Topics	No of Lectures
<b>I</b>	<p><b>Gravimetric Analysis</b></p> <ol style="list-style-type: none"> <li>1. Analysis of Cu as CuSCN,</li> <li>2. Analysis of Ni as Ni (dimethylgloxime)</li> <li>3. Analysis of Ba as BaSO<sub>4</sub>.</li> </ol>	30
<b>II</b>	<p><b>Paper Chromatography</b></p> <p>Ascending and Circular. Determination of <math>R_f</math> 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</p>	8
<b>III</b>	<p><b>Thin Layer Chromatography</b></p> <p>Determination of <math>R_f</math> 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

<b>IV</b>	<p><b>Thermochemistry</b></p> <ol style="list-style-type: none"> <li>To determine the solubility of benzoic acid at different temperatures and to determine <math>\Delta H</math> of the dissolution process</li> <li>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</li> <li>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</li> </ol>	14
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**Suggested Readings:**

- Skoog .D.A., West.D.M and Holler .F.J., “Analytical Chemistry: An Introduction”, 7th edition, Saunders college publishing, Philadelphia,(2010).
- 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**

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

**This course can be opted as an elective by the students of following subjects: Chemistry in 12<sup>th</sup> 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 12<sup>th</sup> class**

**Suggested equivalent online courses:**

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**Further Suggestions:**

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