



**SMIT** SIKKIM  
MANIPAL  
UNIVERSITY  
SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

**B.Sc. Chemistry Syllabus Revision-2025**  
**B.Sc. 3 years Chemistry**  
**B.Sc. 4 Years Chemistry (Honors)**  
**B.Sc. 4 Years Chemistry (Honors with Research)**



**DEPARTMENT OF CHEMISTRY**  
**SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY**  
**MAJHITAR, RANGPO, EAST - SIKKIM, INDIA**

## **SIKKIM MANIPAL UNIVERSITY**

### **VISION:**

- Global Leadership in Human Development, Excellence in Education and Healthcare.

### **MISSION:**

- Develop professionals of excellent technical calibre in the field of Health Sciences, Engineering, Management and Social Sciences with a humane approach capable of shouldering the responsibility of building the nation and be globally competent.

### **OBJECTIVE:**

- To support, promote and undertake the advancement of academics.
- To promote use of ICT and modern education technologies.
- To encourage research, creation and dissemination of knowledge.
- To facilitate extension and community service.
- To empower people of Sikkim and contribute to human development in Northeast.
- To create environmental and social responsibilities among students and employees.
- To ensure steady growth of the University.

## **SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY**

### **VISION:**

- To achieve eminence in the field of quality technological education and research.

### **MISSION:**

- To develop SMIT into an Institution of Excellence capable of producing competent techno-managers who can contribute effectively to the advancement of the society.

### **OBJECTIVE:**

- To provide wholesome education to meet the intellectual aspirations of the students.
- To equip students with techno-managerial skills to enable them to take their assigned role in the industry.
- To inculcate essential ethics and values to meet the spiritual needs to the students.
- To provide a sound institutional environment nurturing emotional strength, healthy mind, body and resilience amongst the students.

## DEPARTMENT OF CHEMISTRY

### VISION:

- To emerge as a centre of excellence in teaching and research.

### MISSION:

- To equip the students with latest knowledge in science and technology such as to contribute as valuable members of the society.

### OBJECTIVE:

- To provide quality teaching and research.
- Inculcate societal responsibility in the students.
- To provide sufficient training in terms of latest developments in the field of chemistry.

### PO's

1. Develop and refine fundamental knowledge of Chemistry.
2. Cultivate in –depth knowledge in Organic chemistry, Inorganic chemistry, Physical chemistry, Analytical chemistry and Spectroscopy.
3. To improve analytical and logical capability to import the ability to solve new and complex problems.
4. Developing the teamwork philosophy.
5. Imbibing research acumen and innovative thinking to become a good researcher.
6. Motivating and developing the knack for clearing competitive exams.
7. Developing presentation skill and improving / fine tuning personal interaction.
8. To use the knowledge for the betterment of the society.
9. Acquire hands on experience in experimental chemistry.

### PSO

1. To develop up-to-date knowledge in different fields of chemistry.
2. Ability to carry out challenging research work in the frontier areas.

### PEO

1. To motivate and prepare post graduate students through effective coaching for higher education and research.
2. To impart education and training to the students for better employment.

**Department of Chemistry**  
**Proceedings of Board of Studies Meeting conducted on 29<sup>th</sup> May/04<sup>th</sup> June 2025 at**  
**Room No: A-301 of Chemistry, SMIT at 03.00 PM**

The following members were present:

1. Dr. Satadru Jha, Chairperson, BOS, Department of Chemistry
2. Prof. (Dr.) Sangeeta Jha, Internal Member, BOS, Department of Chemistry.
3. Dr. Manoranjan Pandey, Internal Member, BOS, Department of Chemistry.
4. Dr. Ramesh Sharma, Internal Member, BOS, Department of Chemistry.
5. Dr. Santanu Gupta, Internal Member, BOS, Department of Chemistry.
6. Dr. Moazzam Ali, Internal Member, BOS, Department of Chemistry.
7. Prof. (Dr.) Prasenjit Maity, School of Engineering and Technology, National Forensic sciences University, Guwahati– External Expert BOS.
8. Dr. Tabrez Khan, Associate Professor, School of Basic Sciences, IIT- Bhubaneswar, External Expert, BOS.
9. Dr. Gautam Patel, Deputy General Manager, Medicinal Chemistry, Zydus Ahmedabad, Gujarat, External Expert, BOS.
10. Dr. Parita Basnet, Assistant Professor, Dept. of Chemistry, Sikkim Institute of Science and Technology Chisopani, Namchi – Alumni Expert, BOS.

**Agenda:** The Board met for syllabus revision of the following:

1. B.Sc. 3 years Chemistry
2. B.Sc. 4 years Chemistry (Honors/Honors with research)

**Resolution:**

- i) There is a major revision (more than 20%) in the syllabus of B. Sc. 3 years and 4 years program for continuous improvement in cutting edge progress era.
- ii) The total credit of B.Sc. Chemistry 3 years and B.Sc. Chemistry 4 years program is reduced by 1 i.e. 125 from 126 (B.Sc. 3 years) and 167 from 168 (B.Sc. 4years).
- iii) To build up research interest among students a mini project of 4 credits and Research/Dissertations of 8 credits are incorporated in the VI & VIII semester respectively of B.Sc. 4 years honors with research program.
- iv) To build up research interest among students a mini project of 4 credits & Dissertations of 4 credits are incorporated in the VI & VIII semester respectively of B.Sc. 4 years honors program.
- v) B.Sc. VII & VIII Semester syllabus of B.Sc. 4 years honors program are exactly same with the subjects kept in I<sup>st</sup> & II<sup>nd</sup> Semester of M.Sc. 2 years program.
- vi) The syllabus of each course is divided into 5 Modules, and each module carries one CO.
- vii) The subject codes are changed as per university policy.
- viii) The Summary of modification are given as Annexure I.
- ix) Detailed modification of B.Sc. 3 years and 4 years (honors/honors with research) program is carried out and given as Annexure II.

Dr. Satadru Jha  
Chairman/HOD Chemistry  
SMIT, Sikkim

Prof. (Dr.) Sangeeta Jha  
Internal Members  
Department of Chemistry  
SMIT, Sikkim

Prof. (Dr.) Prasenjit Maity  
External Expert  
School of E&T  
NFSU, Guwahati

Dr. Tabrez Khan  
External Expert  
School of Basic Sciences  
IIT-Bhubaneswar  
Odissa

Dr. Gautam Patel  
External Expert  
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Dr. Parita Basnet  
External Member  
Sikkim Institute of Science and Technology  
Namchi, Sikkim

## ANNEXURE 1

**B.Sc. Chemistry Curriculum**  
**B.Sc. Chemistry: 3 years (125 Credits)**  
**B.Sc. Chemistry (Honours):4 years (167 Credits)**  
**B.Sc. Chemistry (Honours) with Research: 4 years (167 Credits)**

Semester	Subject Code	Subject Name	Credit	Remarks
I	CH103B1	Inorganic Chemistry - I	4	Major
	CH104B1	Physical Chemistry - I	4	Major
	BA101A1	Communication Skill	2	Ability enhancement
	GN201A1	UHV	3	Value added
	**	Elective-I	3	Interdisciplinary/Minor
	**	Elective - I Lab	1	Interdisciplinary/Minor
	BC103A1	Computer Programming (C)	4	Skill enhancement
	BC101A4	Computer Programming (C) Lab	1	Skill enhancement
		<b>TOTAL CREDIT OF SEM I</b>	<b>22</b>	
II	CH105B1	Organic Chemistry-I	4	Major
	CH106B1	Physical Chemistry-II	4	Major
	GN121A2	English Literature/Functional English/MIL/Hindi/Foreign Language (SWAYAM/NPTEL) (EL-2)	2	Ability enhancement
	BP101A1	Constitutions of India /	1	Value added
	CH107B1	Environmental Studies		
	**	Elective-3	3	Interdisciplinary/Minor
	**	Elective-3 Lab	1	Interdisciplinary/Minor
	CH108B1	Advanced Instrumentation Techniques	4	Skill Based
	CH106B4	Physical Chemistry-I Lab	2	Major
	PE108A4	Fitness and Yoga	2	Value added
	<b>TOTAL CREDIT OF SEM II</b>	<b>23</b>		
III	CH201B1	Inorganic Chemistry-II	4	Major
	CH202B1	Organic Chemistry-II	4	Major
	GN301A1	Leadership and Behavior Management/Emotional Intelligence/Alternative English/ Nepali/Sanskrit (SWAYAM, NPTEL) EL-4)	2	Ability enhancement
	**	Minor Specialization (EL-5)	4	Minor
	CH201B4	Inorganic Chemistry-I Lab	2	Major
	CH202B4	Organic Chemistry-I Lab	2	Major
	CH201B5	Project BASED learning I	2	Major
		<b>TOTAL CREDIT OF SEM III</b>	<b>20</b>	

IV	CH203B1	Inorganic Chemistry-III	4	Major
	CH204B1	Physical Chemistry-III	4	Major
	**	Minor specialization (EL-6)	4	Minor
		Community based Participatory Research (FIELD WORK)	2	Ability enhancement/Summer Training
	CH203B4	Inorganic Chemistry-II Lab	2	Major
	CH204B4	Physical Chemistry-II Lab	2	Major
	CH202B5	Project based learning II	2	Major
		<b>TOTAL CREDIT OF SEM IV</b>	<b>20</b>	
V	CH301B1	Organic Chemistry-III	4	Major
	CH302B1	Inorganic Chemistry-IV	4	Major
	**	DSE I (EL-7)	4	Minor/ Interdisciplinary
	**	Minor specialization (EL-9)	4	Interdisciplinary/Minor
	CH301B4	Organic Chemistry-II Lab	2	Major
	CH301A5	Summer Internship	2	Summer Internship
		<b>TOTAL CREDIT OF SEM V</b>	<b>20</b>	
Summer internship/Vocational: (2 - 4 CR) (Required for UG diploma)	Workshop skills, Carpentry, Plumbing, Web design, Surveying, Electrical Wiring, Financial s/w, digital photography & editing, Video editing for social media, photoshop, Computer assembling and networking, Research & Technical writing etc.			
VI	CH303B1	Organic Chemistry-IV	4	Major
	CH304B1	Physical Chemistry-IV	4	Major
	**	DSE II (EL-10)	4	Minor
	**	Minor specialization (EL-12)	4	Interdisciplinary/Minor
	CH303B5	Mini Project	4	Major
	<b>TOTAL CREDIT OF SEM VI</b>	<b>20</b>		
VII	CH401B1	Principles of Inorganic Chemistry	4	Major
	CH402B1	Principles of Organic Chemistry	4	Major
	CH403B1	Chemical Thermodynamics	4	Major
	CH404B1	Analytical Chemistry	4	Minor
	CH403B4	Physical Chemistry Lab	3	
	CH404B4	Analytical Chemistry Lab	3	Major
		<b>TOTAL CREDIT OF SEM VII</b>	<b>22</b>	
VIII	CH405B1	Modern Spectroscopic Techniques	4	Major
	CH406B1	Organic Reactions and Mechanisms	4	Major
	CH401B6	Project/Dissertation* (1 year project)	8	Project

	CH407B1	Biochemistry	4	Major
	CH408B1	Quantum Chemistry- I	4	Major
	CH402B6	Dissertation (6 Months)	4	Major
	* In place of Project, students with honours will take 3 theory subjects of 12 credit			
	<b>TOTAL CREDIT OF SEM VIII</b>		<b>20</b>	

<b>**Electives (Interdisciplinary/Minor)</b>				
Semester	Subject Code	Subject Name	Credit	Remarks
I	MA107A1	Mathematics-I (Theory+Tutorial)	4	Elective 1
	CH101B2	Ecology and Environment-I	3	Elective 1
	CH104B4	Ecology and Environment-I Lab	1	Elective 1 Lab
	CH102B2	Chemistry-I	3	Elective-I (for other Dept)
	CH105B4	Chemistry-I Lab	1	Elective-I Lab (for other Dept.)
	PY102A1	Fundamentals of Psychology	4	Elective 1
II	MA108A1	Mathematics-II	4	Elective 3
	CH103B2	Ecology and Environment II	3	Elective 3
	CH108B4	Ecology and Environment II Lab	1	Elective 3 Lab
	CH104B2	Chemistry-II	3	Elective-3 (for other Dept)
	CH109B4	Chemistry-II Lab	1	Elective-3 Lab (for other Dept.)
Note: In case of Mathematics as Elective, the total credit will be 4 which includes both Theory and Tutorial. In case of other Electives, student has to take respective lab.				
III	CH201B2	Environmental Science-I	4	EL-5 Minor Elective
IV	CH202B2	Environmental Science-II	4	EL-6 Minor Elective
V	CH301B3	Application of Computers in Chemistry	4	DSE I (EL-7) Minor/Interdisciplinary
	CH301B2	Environmental Science-	4	Minor Elective (EL-9)

		III		
VI	CH302B3	Novel Inorganic Solids	4	DSE II (EL-10)
	CH302B2	Environmental Science-IV	4	Minor elective (EL-12)

Note: If students complete 24 credits of minor paper from same pull of subjects, minor degree will also be awarded along with the main degree.

For example, if a student chooses Ecology & Environment in 1st and 2nd semester and

Environmental Science - I, II, III & IV in remaining semesters (Total 24 CR), after completion of 4 years, degree will be awarded as B.Sc. Chemistry (Honours) with Minor in Environmental Science.

\*Elective may be added depending on the availability of subject.

# **ANNEXURE II**

**B.Sc. Chemistry - Semester I**  
**Inorganic Chemistry I**  
**Subject Code:CH103B1**

**(Credits: Theory-04)**

**Course Objectives**

This course aims at giving students theoretical understanding about the electronic structure and reactivity of elements. Periodic classification of elements in the periodic table and changes in properties along the periods and groups to be studied in detail. The different types of chemical bonds will be covered in detail.

**Course/Learning Outcome:** At the end of the course, the students will be able to:

CO1: Analyse the electronic structure of atoms

CO2: Compare the properties of elements across the periods and down the groups.

CO3: Assess the general characteristics of ionic bonds

CO4: Derive the structure of covalent compounds

CO5: Identify the characteristic features of metallic bonds and weak chemical forces.

**Module I**

**Atomic Structure**

(10 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, electronic configuration of elements, Variation of orbital energy with atomic number.

**Module II**

**Periodicity of Elements**

(10 Lectures)

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block.

a. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. b. Atomic radii (van der Waals) c. Ionic and crystal radii.

d. Covalent radii (octahedral and tetrahedral) e. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

f. Electron affinity, trends of electron affinity, Born-Haber's cycle to determine electron affinity. g. Electronegativity, Pauling's electronegativity scale.

**Module III**

**Chemical Bonding**

(10 Lectures)

(i) ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle to determine lattice energy, Solvation energy.

## Module IV

### Chemical Bonding

(10 Lectures)

Covalent bond: Lewis's structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules  $N_2$ ,  $O_2$ ,  $C_2$ ,  $B_2$ ,  $F_2$ ,  $CO$ ,  $NO$ , and their ions;  $HCl$ ,  $BeF_2$ ,  $CO_2$ , (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ( $\sigma$  and  $\pi$  bond approach) and bond lengths.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

## Module V

### Metallic Bond

(08 Lectures)

Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

### Textbooks/Reference Books:

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
2. Douglas, B.E. and Mc Daniel, D.H., Concepts and Models of Inorganic Chemistry, 3rd Ed. Wiley India, 2006.
3. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley, 2007.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH, 2007.
5. Atkins, P.W. & Paula, J. Physical Chemistry, 11th Ed., Oxford University Press, 2018.
6. Housecroft, C. E. and Sharpe, A. G. Inorganic Chemistry, 5th Ed., Pearson, 2018.
7. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, Literary Licensing, LLC, 2012.

**B.Sc. Chemistry - Semester I**  
**Physical Chemistry I**  
**Subject Code: CH104B1**

**(Credits: Theory-04)**

**Course Objective**

To develop basic and advance concepts regarding the three states of matter. To derive the expressions for determining the physical properties of gases, liquids and solids. To study the concept of ionization in aqueous solution, pH, buffers and various applications of ionization.

**Course/Learning Outcome**

CO1: Apply mathematical expressions to different properties of gas, liquid and solids and understand their physical significance.

CO2: Explain the crystal structure and calculate related properties of cubic systems.

CO3: Explain the concept of ionization of electrolytes with emphasis on weak acid and base and hydrolysis of salt.

CO4: Apply the concepts of gas equations, pH and electrolytes while studying other chemistry courses and everyday life.

CO5: Apply the concepts of Molecular and Crystal Symmetry and Crystallography.

**Module I**

**Gaseous State**

(10 Lectures)

Postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of  $\sigma$  from  $\eta$ ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy.

**Module II**

**Behaviour of Real Gases**

(10 Lectures)

Deviations from ideal gas behaviour, compressibility factor,  $Z$ , and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Van der Waals equation of state, its derivation and application in explaining real gas behaviour, Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

**Module III**

**Liquid State**

(10 Lectures)

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of

cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water. Effect. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

#### **Module IV**

##### **Molecular and Crystal Symmetry** (10 Lectures)

Elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices.

#### **Module IV**

##### **Crystallography** (08 Lectures)

Miller indices, X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Liquid crystals (Introductory idea).

#### **Textbooks/Reference Books**

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
2. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.; 47th Ed. (2017)
3. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 1) McGraw Hill Education; Sixth edition (2019)

**B.Sc. Chemistry - Semester I**  
**Communication Skill**  
**Subject Code: BA101A1**

**(Credits: Theory- 02) (L-2,T-0,P-0)**

**Course Objectives**

- The course is intended to familiarize students with effective communication strategies by improving their verbal and non-verbal communication style.
- The course enhances interpersonal skills of students by focusing on the four macro communication skills LSRW (Listening, Speaking, Reading, and Writing), which makes them job and industry ready.

**Course/Learning Outcomes (CO)**

CO1: To comprehend and apply a variety of communications (verbal/Non – verbal, formal/informal) techniques in the Professional Environment and to overcome the barriers of communication.

CO2: To develop and expand writing skills through controlled and guided activities on vocabulary and comprehension.

CO3: To write and draft different kinds of effective business correspondences such as reports, letters, memos, email and resume with clarity and aptness.

CO4: To demonstrate the ability to write error free while making an optimum use of correct Business Vocabulary and Grammar.

CO5: To develop coherence, cohesion and competence in oral discourse through appropriate pronunciation.

**Module I**

**Introduction to Communication Skills**

(04 Lectures)

Fundamentals of Communication Skills, Process of Communication, Types of Communication, Flows of Communication, Barriers to Communication, Types of Listening 7 C's of Communication, Verbal Communication- 3 V's of Communication, Non Verbal Communication- Types of Body Language

**Module II**

**Vocabulary and Comprehension Skills**

(04 Lectures)

Precise Writing, Expansion of ideas, Comprehension Skills, Vocabulary: One Word substitution, Foreign Words Commonly used in English, Synonyms, Antonyms, Idioms.

### **Module III**

#### **Writing Skills** (06 Lectures)

Paragraph Writing, Summarizing, Paraphrasing and Note making, Reported Speech. Report Writing: Performance Appraisal Report, Disciplinary Report, Inspection Report, Site Survey Report, Market Survey report, Event Management Report. Business Correspondence: Kinds of Business Letters, Enquiries and Replies, Letters to Newspapers, Circulars and Memorandum, Floating Tenders, Inviting Quotations, Submission of Quotation, Placing an Order, Notice, Agenda and Minutes of Meeting, Job application (including Resume / Bio data), E-mail Writing.

### **Module IV**

#### **Grammar** (02 Lectures)

Parts of Speech, Time, Tense and Aspect, Correct Usage of Adjectives, Adverbs, Nouns, and Prepositions.

### **Module V**

#### **Phonetics** (04 Lectures)

Study of Speech sounds- Pure vowels, Diphthongs, Consonants, Description of Consonant Sounds, Place of Articulation, Manner of Articulation. Syllable, Stress, Problem Sound for Indian Speakers, Intonation.

#### **Textbooks/Reference Books**

1. Sen, Leena. Communication Skills. (Prentice Hall)
2. Raman, Menashi & Sharma, Sangeeta. Technical Communication – Principles and Practice (Oxford)
3. Wren, R.C. & Martin, H. English Grammar and Composition (S Chand & Co Ltd)
4. Mehra, Payal, Business Communication for Managers. (Pearson)
5. Miglani, Seema & Goyal, Shikha. English for Professional. (VEI)

**B.Sc. Chemistry - Semester I**  
**UHV**  
**Subject Code: CH201A1**

**(Credits: Theory-03)**

**B.Sc. Chemistry - Semester I**  
**Mathematics I**  
**Subject Code: MA107A1**

**(Credits: Theory-04)**

**Course Objectives**

To impart the basic understanding of differential, integral calculus and 3-dimensional geometry.

**Course/Learning Outcome**

CO1: Identify and analyse various functions using the concepts of single variable calculus.

CO2: Associate and use the concepts of multi variable differential calculus in various problems.

CO3: Apply the concepts of integral calculus in various geometrical and physical problems.

CO4: Apply the concepts of solid geometry to visualize various solids and determine their parameters.

CO5: Identify and examine the nature of various infinite series.

**Module I**

**Single Variable Differential Calculus** (08 Lectures)

Successive differentiation, Leibnitz's theorem, Polar curves, Angle of intersection of two curves, Derivatives of arcs (Cartesian and polar), Curvature, Radius of curvature, Rolle's theorem, Mean value theorems, Expansion of functions in Taylor's and Maclaurin's series.

**Module II**

**Application of Differential Calculus and Partial Differentiation** (08 Lectures)

Asymptotes, Multiple points, Points of inflection, Concavity, Convexity, Tracing of standard curves. Indeterminate forms. Partial differentiation, Euler's theorem, Total differential, Errors and approximation, Differentiation of composite and implicit functions.

**Module III**

**Integral Calculus** (08 Lectures)

Reduction formulae for standard integrals. Length, Area and Volume of revolution involving simple curves.

**Module IV**

**Analytical Solid Geometry** (08 Lectures)

Direction Cosines, Planes, Straight lines, Spheres, Right circular cone and Right circular cylinder.

**Module V**

**Infinite Series** (08 Lectures)

Convergence, Divergence, Comparison test, Ratio test, Cauchy's root test, Cauchy's integral test, Alternating series, Leibnitz's test, absolute and conditional convergence.

### **Textbooks/Reference Books**

1. Erwin Kreyszig: Advanced Engineering Mathematics, Wiley, VIII Ed. ,2008
2. Shanti Narayan: Differential Calculus, S Chand & Company, 2016.
3. Shanti Narayan: Integral Calculus, S Chand & Company, 2016.
4. R. K. Jain & S R K Iyengar: Advanced Engineering Mathematics, Narosa, Publs. VI Ed., 2016.
5. G. B. Thomas, Jr. and R. L. Finney: Calculus and Analytical Geometry, Addison Wesley, VI Ed., 1984
6. B. S. Grewal, Engineering Mathematics, Khanna Publisher, 35<sup>th</sup> Ed., 2000.

**B.Sc. Chemistry - Semester I**  
**Ecology and Environment I**  
**Subject Code: CH101B2**

**(Credits: Theory-03)**

**Course Objective**

Objective of Ecology and Environment I (minor paper) is to introduce basic concepts of Environmental Sciences like physical components of earth, structure & functions of ecosystem, and important environmental issues.

**Course/Learning Outcome**

CO1: Apply basic understanding of the environment and understand the interdisciplinary nature of the subject.

CO2: Apply basic understanding of atmosphere, hydrosphere and Lithosphere

CO3: Apply fundamental knowledge about the structure & functions of ecosystem

CO4: Demonstrate the ability to solve numerical problems of Biochemical Oxygen Demand (BOD)

CO5: Explain the concept of green-house effect and idea about global warming

**Module I**

**Basic Concepts of Environment** (06 Lectures)

Define environment, current environmental issues, socio-economic reasons behind degradation of environment, environmental realities and possible solutions, Tragedy of Commons & Ecological Footprint, Environmental Science – an interdisciplinary subject, Difference between Environmental Science and Ecology. Unique geo-chemical and biological features of earth, earth – a natural close system, Earth's resources - perpetual, renewable and nonrenewable resources of earth, natural capitals and natural services.

**Module II**

**Components of Environment** (06 Lectures)

Internal layers of earth – Lithosphere, Aesthenosphere & Mesosphere, physico-chemical properties of crust, mantle and core, theory of plate tectonics – convergent, divergent plates & transform fault, types of rocks – igneous, sedimentary and metamorphic, minerals, polarity of water, intra molecular and inter molecular hydrogen bond involving water molecule, unique properties of water due to hydrogen bond, importance of hydrogen bond in biomolecules, amphipathic substances, composition of atmosphere, layers of atmosphere, and transformation of atmosphere from early reducing to present oxidizing form

**Module III**

**Ecology** (06 Lectures)

Define ecosystem, basic components and functions of ecosystems, ecosystem cybernetics, technoecosystems, and quality of energy in food-chains. Fundamental concepts related to energy: The laws of thermodynamics, solar radiation and the energy environment, concept of productivity. Biological control of the Geochemical Environment: The Gaia Hypothesis.

## **Module IV**

### **BOD and Adiabatic Lapse Rate**

(06 Lectures)

Define BOD, unseeded and seeded BOD test, BOD as first order reactions, numerical regarding measurement of carbonaceous BOD

## **Module V**

### **Global Environmental Issues**

(06 Lectures)

Global temperature model, green-house effect, green-house gases – their sources, green-house contribution, IR spectrum, effects on climate change, prevention of global warming and adaptation to climate change.

### **Textbooks/Reference Books**

1. Introduction to Environmental Engineering and Science by Gilbert M Masters
2. Environmental Science by G Tyler Miller
3. Fundamentals of Ecology by Eugene P Odum
4. Environmental Chemistry by A K Dey
5. Environmental Chemistry by Stanley E Manahan
6. Ecology, Environmental Sc and Conservation by J S Singh and S P Singh

**B.Sc. Chemistry - Semester I**  
**Ecology and Environment I Lab**  
**Subject Code: CH104B4**

**(Credits: Lab-01)**

**Course Objective**

To have a comprehensive understanding of different air and soil quality parameter testing methods with hands on training

**Course/Learning Outcome**

CO1: Collection and preparation of water and soil samples

CO2: Apply acquired lab experience in analysis of different physical parameters of surface and drinking water

CO3: Apply acquired lab experience in analysis of different chemical parameters of surface and drinking water

CO4: Apply acquired lab experience in analysis of different physical parameters of different kinds of soil samples.

CO5: Apply acquired lab experience in analysis of different chemical parameters of different kinds of soil samples.

**List of Experiments**

1. Collection and preparation of surface and drinking water sample
2. To determine the total hardness of given water sample by Complexometric Titration
3. To determine dissolved oxygen in the given sample of water (Winkler's method)
4. To determine the amount of free chlorine in each water sample.
5. To determine pH of a given water sample
6. To determine conductivity of a given water sample
7. Collection and preparation of soil sample for analysis
8. Estimation of available phosphorous in soil sample
9. Estimation of soil organic matter (Walkley-Black method, 1934)
10. Measure pH of a soil sample
11. Measure conductivity of a soil sample
12. Determination of soil moisture

**Textbooks/Reference Books**

1. Ecology Workbook by R Mishra
2. Student Resource Manual Ecology and field biology by R L Smith
3. Biostatistics by B N Mishra and M K Mishra
4. Agriculture Statistics by R Rangaswamy
5. Environmental Management by Dr. Biswarup Mukherjee
6. Practical Methods in Ecology and Environmental Science by Trivedi
7. Chemical analysis of fishpond soil and water by G N Chattopadhyay
8. Introduction to biostatistics by Pranab Kumar Banerjee

**B.Sc. Chemistry - Semester I**  
**Chemistry I**  
**Subject Code: CH102B2**

**(Credits: Theory-03)**

**Course Objective**

This course aims at giving students theoretical understanding about the electronic structure and reactivity of elements. Periodic classification of elements in the periodic table and changes in properties along the periods and groups to be studied in detail.

To derive the expressions for determining the physical properties of solids. To study the concept of ionization in aqueous solution, pH, buffers and various applications of ionization.

**Course/Learning Outcomes:** At the end of the course, the students will be able to:

CO1: Analyse the electronic structure of atoms.

CO2: Compare the properties of elements across the periods and down the groups.

CO3: Explain crystal symmetry.

CO4: Analyse common crystal structures.

CO5: Discuss the characteristic features ionic equilibria.

**Module I**

**Atomic Structure**

(12 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, electronic configuration of elements, Variation of orbital energy with atomic number.

**Module II**

**Periodicity of Elements**

(12 Lectures)

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block.

a. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. b. Atomic radii (van der Waals) c. Ionic and crystal radii.

d. Covalent radii (octahedral and tetrahedral) e. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

f. Electron affinity, trends of electron affinity, Born-Haber's cycle to determine electron affinity. g. Electronegativity, Pauling's electronegativity scale.

**Module III**

**Molecular and Crystal Symmetry**

(06 Lectures)

Elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices.

## Module IV

### Solid State

(10 Lectures)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Liquid crystals (Introductory idea).

## Module V

### Ionic Equilibria

(12 Lectures)

Strong, moderate, and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

### Textbooks / Reference Books

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley, 2007.
3. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH, 2007.
4. Atkins, P.W. & Paula, J. Physical Chemistry, 11th Ed., Oxford University Press, 2018.
5. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
6. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
7. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 1) McGraw Hill Education; Sixth edition (2019)

**B.Sc. Chemistry - Semester I**  
**Chemistry I Lab**  
**Subject Code: CH105B4**

**(Credits: Lab-01)**

**Course Objective**

The students will learn how to perform acid base titrations, surface tension and viscosity experiments and analyze and interpret the results.

**Course/Learning Outcome:** After completing the course, the students will be able to:

CO1: Learn to prepare standard solutions.

CO2: Apply the knowledge of calibration to common laboratory apparatus and instruments.

CO3: Prepare and understand working of buffer solutions.

CO4: Analyse the data obtained from the experiments.

CO5: Interpret the results obtained from various experiments.

**List of Experiments**

**(A) Titrimetric Analysis**

(i) Calibration and use of common laboratory apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants.

**(B) Acid-Base Titrations**

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents.

**(C) Surface tension measurements.**

a. Determine the surface tension by (i) drop number (ii) drop weight method.

b. Study the variation of surface tension of detergent solutions with concentration.

**(D) Viscosity measurement using Ostwald's viscometer.**

a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

b. Study the variation of viscosity of sucrose solution with the concentration of solute.

**Textbooks/Reference Books**

1. Mendham, J. et al.: Vogel's Textbook of Quantitative Chemical Analysis; 6th Ed. Pearson Education, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003). 12
4. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**B.Sc. Chemistry - Semester I**  
**Fundamental of Psychology**  
**Subject Code: PY102A1**

**(Credits: Theory-04)**

**Course Objectives**

Students will be able to understand basic concepts related to some foundational themes of study in Psychology such as learning, memory, perception, thinking etc

**Course/Learning Outcomes**

CO1: Understanding what psychology all is about.

CO2: Appreciation of the scope and the field of psychology.

CO3: Developing familiarity with basic concepts related to some foundational themes of study in Psychology such as learning, memory, perception, thinking, emotion, motivation and human biological system including brain.

CO4: Developing familiarity with individual level phenomenon such as intelligence, and personality.

**Module I**

**Introduction**

(12 Lectures)

1.1 Nature of Psychology: Definition, Fields of psychology, Schools of modern psychology

1.2 Psychology in India: History and current status

1.3 Methods of psychology (with special emphasis. on Experimentation)

1.4 Biological basis of human behaviour (with emphasis on brain)

**Module II**

**Learning, Memory and Perception**

(12 Lectures)

2.1 Learning: Classical conditioning, instrumental learning, observational learning (socio-cognitive learning)

2.2 Memory: Models of memory: Information processing model (Sensory register, STM, LTM and concept of working memory), Levels of processing, Parallel Distributed Processing model, Reconstructive nature of memory; Forgetting, Improving memory

2.3. Perception: Top down and Bottom-Up processes, Size Constancy, Depth Perception

**Module III**

**Motivation & Emotion –**

(12 Lectures)

3.1 Approaches to understanding motivation and Types of Motives

3.2 Approaches and Elements of Emotions (components), Emotional Intelligence and Gender, Culture & emotions

**Module IV**

**Intelligence**

(12 Lectures)

4.1 Intelligence: Nature and Theories

**Textbooks/Reference Books**

1. Ciccarelli, S.K. & White, J.N. & Misra, G. (2018). Psychology. New Delhi: Pearson Education.

2. Feldman R. S. Understanding Psychology, IV edition, (1996) McGraw Hill India
3. Robert A. Baron, Psychology, III edition (1995) Prentice Hall India.
4. Wortman and Loftus, Psychology, IV edition (1992) McGraw Hill International.
5. Zimbardo, Johnson & Vivian(2012). Psychology: Core Concepts,7/E, Pearson Education
6. Morgan, C T., King, R., Weisz, J. & Schopler, J. (2017). *Introduction to Psychology* (7th Ed). Tata McGraw Hills.
7. Holt, N., Bremner, A., Sutherland, E., Vliek, M. and Passer, M., & Smith, R.(2015). Psychology: The Science of Mind and Behaviour. London: Tata McGraw-Hill
- Baron, R. & Misra, G. (2013). Psychology. Pearson.
- Chadha, N.K. & Seth, S. (2014). The Psychological Realm: An Introduction. Pinnacle Learning, New Delhi.

**B.Sc. Chemistry - Semester I**  
**Computer Programming (C)**  
**Subject Code: BC103A1**

**(Credits: Theory-04)**

**Course Objectives**

1. The main aim of the course is to teach basic computer programming concepts and apply them to computer-based problem-solving methods.
2. To teach the student problem solving using C.
3. To introduce the student to data structures such as lists, stacks etc.

**Course/Learning Outcomes:**

CO1: Upon completion of the course, students will be able to:

CO2: Solve moderately difficult problems using C language.

CO3: Write error free code in C.

CO4: Debug syntax errors prompted by the C compiler.

**Module I**

**Introduction to Computer Fundamentals & Programming Language** (24 Lectures)

Introduction, Basic anatomy of the computer, ALU, Memory Devices and Memory Types, I/O Devices, Number Systems & Logic Gates. Levels of Programming Language, Application Programs, System Programs, Operating Systems, editor, translator, linker, loader, Structured and Object-Oriented Programming Algorithms and Flowcharts, History of C, Basic structure of a C program, Sample programs, Programming style, Executing a C program.

**Constants, variables, and data types**

Character set, C tokens, Keywords and identifiers, Constants, variables, Data types, Declaration of variables, Declaration of storage class, Assigning of storage class, Defining symbolic constants, Declaring a variable as constant, Declaring a variable as volatile, Overflow and underflow of data.

**Operators and expressions**

Different categories of operators in C language, Arithmetic expressions, Evaluation of expressions, Precedence of arithmetic operators, Type conversions in expression, Operator precedence and associativity, Mathematical functions Reading a character, Writing a character, Formatted input,

**Decision making and branching & Looping**

Decision making with IF statement, Simple IF statement, The IF---ELSE statement, Nesting of IF--ELSE statement, The ELSE IF ladder, The switch statement, The ? : operator, The GOTO statement. The WHILE statement, The DO statement, The FOR statement, Jumps in loops, Concise test expressions.

## Module II

### Arrays

(24 Lectures)

One-dimensional arrays, Declaration, initialization of one-dimensional array, Two-dimensional arrays,

Declaration, initialization of one-dimensional array, Multidimensional arrays and Dynamic arrays, Declaring and initializing string variables, Reading strings from terminal, Writing strings to screen, Arithmetic operations on strings, Putting strings together, Comparison of two strings, String handling

functions, Table of strings. Introduction to Pointers, Accessing a variable through its pointer, Chain of

pointers, Pointer expressions, Pointers and arrays, Pointers and character strings, Array of pointers. Dynamic Memory allocation- malloc, calloc, free, realloc, linked list and its applications.

### User defined functions & Macro

Elements of user defined functions, Definitions of functions, Return values and their types, Function calls,

Function declaration, Category of functions, No arguments and no return values, Arguments but no return

values, Arguments with return values, No Arguments but returns a value, Function that return multiple

values, Nesting of functions, Recursion, passing arrays to functions, Passing string to functions, Scope,

Visibility and lifetime of variables, Pointers and function arguments, Functions returning pointers, Pointers

to functions Preprocessor Directive - macro substitution.

### Structures and unions

Defining a structure, Declaration of structure variables, Accessing structure members, Structure initialization, Copying and comparing structure variables, Operations on individual members, Arrays of

structures, Arrays within structures, Structures within structures, Structures and functions, Union, Size of

structures, Bit fields, Pointers and structures, Troubles with pointers.

### File management in C

Defining and opening a file, closing a file, Input/output operations on a file, Error handling during I/O operations, Random access to files, Command line arguments.

### Textbooks/Reference Books:

1. "Programming in ANSI C" by E. Balaguruswamy.
2. "Mastering in C" by K. Venugopal.
3. "Fundamentals of C" by Gottfried.
4. "The C Programming" by Kerningham and Ritchie.
5. "Let Us C" by Y. Kanetkar.

**B.Sc. Chemistry - Semester I  
Computer Programming (C) Lab  
Subject Code: BC101A4**

**(Credits: Lab -01)**

**The Faculty of EC Department will conduct the lab.**

**B.Sc. Chemistry - Semester II**  
**Organic Chemistry -I**  
**Subject Code: CH105B1**

**(Credits: Theory-04)**

**Course Objectives**

This course is introduced to explain students with an introduction to organic compounds, electron displacement, type of reagents and reaction intermediates. The chemistry of aliphatic and aromatic hydrocarbon, conformational analysis of cycloalkanes and basic stereochemical phenomena are included.

**Course/Learning Outcome:**

CO1: To demonstrate the basic concepts of organic chemistry.

CO2: To assess and apply the concept of organic chemistry.

CO3: To understand the chemistry of aliphatic hydrocarbons.

CO4: To create nomenclature for organic molecules.

CO5: To assess the concept of stereochemistry in organic molecules.

**Module I**

**Basics of Organic Chemistry** (10 Lectures)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges.

Electrophiles and Nucleophiles; Nucleophilicity and basicity.

**Module II**

**Concept of Acids and Bases** (08 Lectures)

Introduction about acids and bases (Lewis theory), Concept of pK<sub>a</sub> and pK<sub>b</sub>, Origin of the acidity and basicity with various factors, acid and bases catalysis, Application of pK<sub>a</sub> in nucleophilic substitution reaction, Application of HSAB principle in organic reactions.

**Module III**

**Chemistry of Aliphatic Hydrocarbons**

**A. Carbon-Carbon sigma bonds** (10 Lectures)

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

**B. Carbon-Carbon pi bonds:**

Formation of alkenes and alkynes by elimination reactions, Mechanism of E<sub>1</sub>, E<sub>2</sub>, E<sub>1c</sub>b reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions and their mechanisms (Markownikoff/ Anti-Markownikoff addition).

**Module IV**

**IUPAC Nomenclature** (08 Lectures)

IUPAC's recommendations for nomenclature. Naming alkanes, alkenes, alkynes, aromatic hydrocarbons, and functional groups like alcohols, aldehydes, ketones, and carboxylic acids.

## Module V

### Stereochemistry

(12 Lectures)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Diastereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

### Textbooks/Reference Books

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
4. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6. Subrata Sen Gupta, Basic Stereochemistry of Organic Molecules, Oxford Higher Education.
7. Dhillon, R. S.; Singh, I. P. & Baskar, C. Stereochemistry, Narosa.
8. Loudon, G. M. Organic Chemistry, Oxford.
9. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
10. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012.

**B.Sc. Chemistry - Semester II**  
**Physical Chemistry -II**  
**Subject Code: CH106B1**

**(Credits: Theory-04)**

**Course Objective**

The aim of this course is to make students understand thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics and their correlation with other branches of physical chemistry and make them able to apply thermodynamic concepts to the system of variable compositions, and equilibrium.

**Course/Leaning Outcome**

CO1: Explain the three laws of thermodynamics.

CO2: Analyse the concepts of State and Path functions.

CO3: Explain extensive and intensive properties.

CO4: Analyse expressions of  $\Delta U$ ,  $\Delta H$ ,  $\Delta S$ ,  $\Delta G$ ,  $\Delta A$  for ideal gases under different conditions.

CO5: Explain the concept of Chemical Equilibrium.

**Module I**

**Chemical Thermodynamics**

(10 Lectures)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat,  $q$ , work,  $w$ , internal energy,  $U$ , and statement of first law; enthalpy,  $H$ , relation between heat capacities, calculations of  $q$ ,  $w$ ,  $U$  and  $H$  for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

**Module II**

**Thermochemistry**

(10 Lectures)

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Concept Carnot cycle and calculation of efficiency.

**Module III**

**Second Law**

(10 Lectures)

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

## Module IV

### Free Energy Functions

(10 Lectures)

Gibbs and Helmholtz energy; variation of  $S$ ,  $G$ ,  $A$  with  $T$ ,  $V$ ,  $P$ ; spontaneous process-enthalpy change, entropy change and free energy change considerations. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

## Module V

### Chemical Equilibrium

(08 Lectures)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants  $K_p$ ,  $K_c$  and  $K_x$ .

### Textbooks/Reference Books

1. Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
2. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
3. Levine, I.N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010). 7. Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006).
4. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.; 47th Ed. (2017).
5. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 2) McGraw Hill Education; Sixth edition (2019).

**B.Sc. Chemistry - Semester II**  
**Functional English**  
**Subject Code: GN121A2**

**(Credits: Theory-02)**

**Course objectives**

The objective of this course to familiarize the students with the basic understanding and usages of English language and literature.

**Course/Learning Outcome (COs)**

The aim of the course is to help the students:

CO1: To analyse the correct usage of various aspects of English Grammar.

CO2: To evaluate the syntax pertaining to various components of English Grammar.

CO3: To assess English comprehensions reading and answering questions based on it.

CO4: To identify the students with the problems within the literary texts and authors.

CO5: To compare between different types and usages of literary texts.

**Module I**

**Sentences: Its Types and Usages** (10 Lectures)

Sentences-Meaning, Parts, Components, Types of sentences with usage. Parts of Speech-Types and functions. Voices-Active and Passive, Examples of Active voice and Passive voices, Direct and Indirect Speech-Direct Speech, Indirect Speech, Examples and various aspects of direct and indirect speech.

**Module II**

**Concepts of Vocabulary Building** (10 Lectures)

Word formation, gaining precision in the use of words, same word used in different parts of speech, Homonyms, Tenses in English-Present, Past and Future, Usage and functions.

**Module III**

**Reading Comprehension** (10 Lectures)

Reading strategies, how to do reading comprehension and attempting questions and answers.

**Module IV**

**Understanding Literary Texts I: Short Story (Any One)** (10 Lectures)

Ernest Hemingway: Old Man at the Bridge.

Rabindranath Tagore: Kabuliwala

**Module V**

**Understanding Literary Texts II: Poetry (Any One)** (08 Lectures)

Robert Frost: Stopping by Woods on A Snowy Evening. Kamala Das: Summer in Calcutta

**Textbooks/Reference Books**

1. Pit Corder: An Intermediate English Grammar
2. Thompson and Martinet: A Practical English Grammar (ELBS – Oxford University Press)

3. Intermediate Grammar, Usage and Composition by M. L. Tickoo, A. E. Subramaniam and P.R. Subramaniam (Orient Longman).
4. English Composition and Grammar: Complete Course, Benchmark Edition by John E. Warinner (Holt McDougal; Benchmark Annotated Teacher's Edition (January 1, 1988).
5. Modern English: A Book of Grammar, Usage and Composition by N.Krishnaswamy (Macmillian India Pvt. Ltd.)
6. Eastwood, John. Oxford Practice Grammar (OUP).

**B.Sc. Chemistry - Semester II**  
**Constitution of India**  
**Subject Code: BP101A1**

**(Credit: Theory-01) (L-2,T-0,P-0)**

**Course Objective**

To familiarize students with the structure and functioning of the Indian government  
To enable students to understand the foundational principles, structure, and functioning of the Indian Constitution, fostering informed, responsible, and constitutionally aware citizenship.

**Course/Learning Outcome**

CO1: Knowledge about constitution of India its evolution and composition.

CO2: Understanding the federal structure of Governance.

CO3: Knowledge of the role of the executive, legislature and judiciary, their power and function.

CO4: Analyse party system in India.

CO5: Understand grassroot level of governance through 73rd and 74th Amendment Act.

**Module I**

**Meaning of Constitution law and Constitutionalism** (04 Lectures)

Meaning of constitution, constitution law and constitutionalism; differentiate between constitution law and constitutionalism

**Module II**

**Evolution of Indian Constitution** (04 Lectures)

Historical development of the Indian constitution through nationalist movements; Philosophical foundations of the constitution of India; Preamble of Indian Constitution

**Indian Federation** (04 Lectures)

Features of Indian federation; Centre-State Relations- recent trends of federalism; Fundamental rights and Fundamental Duties; Directive Principle of State Policy (DPSP) - Nature, Relation between DPSP and Fundamental Rights

**Module III**

**Parliamentary Form of Government** (04 Lectures)

Legislature- Lok Sabha and Rajya Sabha- Composition, Powers and functions

Executive- Union Executive- President, Prime Minister, Union Council of Ministers- Role, Powers and functions

State Executive- Governor, Chief Minister, State Council of Ministers – Role, Powers and functions

Judiciary- Features of Indian judiciary, Supreme Court and High Court – Powers and Functions;

Judicial Review and Judicial Activism

**Module IV**

**Party System** (02 Lectures)

National and Regional parties- Eligibility criteria and examples; Trends in the party system in India; Election Commission- Role, powers and functions; Electoral reform and Voting Behaviour

## **Module V**

### **Rural Local Government**

(02 Lectures)

Evolution, Structure and function; 73<sup>rd</sup> Amendment Act; Gram Sabha; Gram Panchayat; Panchayat Samiti; Zilla parishads

### **Urban Local Government**

(01 Lectures)

Evolution, Structure and Function; 74<sup>th</sup> Amendment Act; Municipal Corporation; Nagar Panchayat

### **Textbooks/Reference Books**

1. Our Constitution: An Introduction to India's Constitution and Constitutional law by Kashyap Subhash
2. Introduction to the Constitution of India by D. D. Basu
3. Encyclopaedia of Social Sciences (Vol.4, 1931)
4. History of Political Theories from Luther to Montesquieu by Dunning
5. The Indian Constitution: Cornerstone of a Nation by Austin Graville
6. Indian Government and Politics by S. S. Awasthy
7. Contemporary Indian Politics by Limaye Madhu
8. Indian polity by M. Laxmikanth

**B.Sc. Chemistry - Semester II**  
**Environmental Studies**  
**Subject Code: CH107B1**

**(Credit: Theory-01)**

**Course Objective**

The course exposes students to various types of environmental problems, their mitigation and prevention. It aims to generate awareness and active participation in environment related issues in workplace and society

**Course/Learning Outcome**

CO1: Identify different environmental degradation and the underlying reasons.

CO2: Identify different physical components like atmosphere, hydrosphere and Lithosphere.

CO3: Analyse structure and functions of ecosystem.

CO4: Apply formulas of Biochemical Oxygen Demand in real life problem solving.

CO5: Assess global warming & adiabatic lapse rate & stable & unstable atmosphere.

**Module I**

**Fundamentals of Environmental Science** (04 Lectures)

Current environmental issues, socio-economic reasons behind degradation of environment, Environmental Science as an interdisciplinary subject, Difference between Environmental Science and Ecology. (2 hrs), Unique features of earth and types of natural resources (1hr.), Tragedy of commons & Ecological Footprint (1 hr.)

**Module II**

**Atmosphere, Lithosphere and Hydrosphere** (06 Lectures)

Lithosphere and Aesthenosphere. Physico-chemical properties of crust, mantle and core, theory of plate tectonics (1 hr)

Types of rocks – igneous, sedimentary and metamorphic. (1 hr)

Polarity of water, unique properties of water. (1hr), importance of hydrogen bond in biomolecules, amphipathic substances, composition & characteristics of sea & river water. (1hr)

Atmospheric composition (1 hr), Layers of atmosphere. (1hr)

**Module III**

**Ecology** (02 Lectures)

Components and functions of Ecosystem. (1 hrs), Cybernetics in ecosystem and analysis of Technoecosytem as case study (1 hr)

**Module IV**

**Biochemical Oxygen Demand** (04 Lectures)

Carbonaceous BOD test. (1 hr), BOD formulas & numerical (2 hrs). BOD numerical practice (1hr)

## **Module V**

### **Global Environmental Issue**

(04 Lectures)

Simple global temperature model and numerical (1hr), Green-house effect, global warming and its impact (1 hr), Mathematical model of dry adiabatic lapse rate (1hr), atmospheric stability and air pollution, radiation inversion (1hr)

### **Textbooks/Reference Books**

1. Fundamentals of Ecology - Eugene P. Odum & Garry W. Barrett
2. Environmental Chemistry - A. K. De
3. Introduction to Environmental Science & Engineering – G M Masters

**B.Sc. Chemistry - Semester II**  
**Mathematics-II**  
**Subject Code: MA108A1**

**(Credits: Theory-04) (L-3, T-1, P-0)**

**Course Objective**

To impart the basic understanding of ordinary differential equations and multivariate calculus.

**Course/Learning Outcome**

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

CO1: Identify and solve different types of Differential equations.

CO2: Use differential equations to model and analyze different types of Engineering problems.

CO3: Evaluate Laplace and Apply Laplace Transform in various engineering problems.

CO4: Use Linear Algebra to analyze a matrix and various system of linear equations.

CO5: Use multivariate calculus to compute extreme values and area, volume of a surface.

**Module I**

**Ordinary Differential Equation I** (10 Lectures)

Formation of ODE, Definition of order, degree and solutions of ODE. Different types and solutions of differential equations: Homogeneous and non-homogeneous equations, exact equations, integrating factor, process to find integrating factor in different cases, Linear equations, Bernoulli's equations and their solutions.

**Module II**

**Ordinary Differential Equation II** (10 Lectures)

General linear differential equations: Homogeneous equations, Linear equations with constant coefficients, Non homogeneous equations, Method of variation of parameters and Inverse differential operators, Solution of Cauchy's homogeneous linear equations. Solution of simple simultaneous equations.

**Module III**

**Laplace Transformation** (10 Lectures)

Definition of Laplace transform, Laplace Transforms of elementary functions, Linear property, First shifting theorem, Change of Scale, Transforms of derivatives, Integrals, Division and Multiplication by  $t^n$ . Inverse transforms, Transform of periodic functions, Unit step function, Second Shifting theorem, solutions of differential equations and problems related to LRC circuits using Laplace transform.

## **Module IV**

### **Linear Algebra**

(10 Lectures)

Concept of vectors and its generalization to higher dimensions, Vector spaces and subspaces, Simple examples. Linear Combinations, Linear dependence and independence of vectors. Basis, Dimension of a vector space, Matrices, Elementary row operations, Row reduced Echelon form, Application to find Inverse, Rank of a matrix. System of linear equations, Consistency and solutions.

## **Module V**

### **Multivariate Calculus**

(08 Lectures)

Introduction to function of severable variables. Taylor's theorem for a function of two variables. Maxima and minima of a function of two variables, Lagrange's method of undetermined Multipliers-Simple problems. Multiple integrals: Definitions, Evaluation by change of order of integration, Changing of variables. Jacobians. Evaluation of areas and volumes. Beta and Gamma functions: Definition, elementary results, simple problems.

### **Textbooks/Reference Books**

1. Erwin Kreyszig: Advanced Engineering Mathematics, Wiley, VIII Ed. ,2008
2. Shanti Narayan: Differential Calculus, S Chand & Company, 2016.
3. Shanti Narayan: Integral Calculus, S Chand & Company, 2016.
4. R. K. Jain & S R K Iyengar: Advanced Engineering Mathematics, Narosa, Publs. VI Ed., 2016.
5. G. B. Thomas, Jr. and R. L. Finney: Calculus and Analytical Geometry, Addison Wesley, VI Ed., 1984
6. B. S. Grewal, Engineering Mathematics, Khanna Publisher,35<sup>th</sup> Ed., 2000.

**B.Sc. Chemistry - Semester II**  
**Ecology and Environment II**  
**Subject Code: CH103B2**

**(Credits: Theory-03)**

**Course Objective**

Objective of Ecology and Environment II (minor paper) is to introduce different essential parts of Environmental Sciences like concept of biodiversity, vegetation sampling methods, introductory biostatistics, water treatment methods (Environmental Chemistry) & natural hazards like earthquake (Environmental Geology).

**Course/Learning Outcome**

CO1: Explain the concept of ecological niche and biodiversity.

CO2: Apply different methods of vegetation sampling and data analysis.

CO3: Apply basic understanding of biostatistics.

CO4: Demonstrate different techniques of a standard drinking water treatment plant

CO5: Analyse different cause and effect relationship of earthquake.

**Module I**

**Ecological Niche & Biodiversity**

(06 Lectures)

Concepts of habitat, ecological niche & guild. Ecosystem diversity: Richness and relative abundance, Levels of biodiversity: species diversity, genetic diversity and habitat diversity, Shannon and Simpson diversity index. Why to conserve biodiversity? Rare and endangered species. How to protect biodiversity? - Genetic resources for human use, botanic gardens, seed banks, cryopreservation, field gene banks, zoos.

**Module II**

**Vegetation Sampling Methods and Data Analysis**

(06 Lectures)

Sampling approaches, what is measured and how? Quadrat method – shape, size and number of quadrats. Frequency, density, cover and Importance Value Index (IVI). Square quadrat and Belt transect method. Formulas and calculations for Density, relative density, basal area, frequency, relative frequency, and Importance Value Index (IVI)

**Module III**

**Biostatistics**

(06 Lectures)

Basic concepts of biostatistics, measurement scales, variables and attributes, types of data, population and sample. Frequency distribution, frequency distribution tables and cumulative frequency distribution. Bar diagram. pie diagram and histogram.

## **Module IV**

### **Water Treatment Systems**

(06 Lectures)

Municipal water and wastewater systems, Drinking water treatment: Sedimentation, coagulation and flocculation, filtration, disinfection, hardness and water softening.

## **Module V**

### **Earthquake**

(06 Lectures)

What causes earthquakes? Fractures and Faults. Earthquake Mechanisms: The elastic rebound theory. Seismographs. Seismic waves: body waves and surface waves. Focus and Epicenter. Locating the Epicenter. Determining Richter magnitude. Earthquake hazards.

### **Textbooks/Reference Books**

1. Introduction to Environmental Engineering and Science by Gilbert M Masters
2. Environmental Science by G Tyler Miller
3. Fundamentals of Ecology by Eugene P Odum
4. Environmental Chemistry by A K Dey
5. Environmental Chemistry by Stanley E Manahan
6. Environmental Geology by Murck, Skinner and Porter
7. Ecology, Environmental Sc and Conservation by J S Singh and S P Singh
8. A textbook of Agricultural Statistics by R Rangaswamy
9. Biological Science by Taylor & Green

**B.Sc. Chemistry - Semester II**  
**Ecology and Environment II Lab**  
**Subject Code: CH108B4**

**(Credits: Lab-01)**

**Course Objective**

To have a comprehensive understanding and on field experience of different vegetation sampling methods and basic social survey on environmental parameters

**Course/Learning Outcome**

CO1: Apply species-area curve to determine optimum size of quadrats.

CO2: Apply species-area curve to determine optimum number of quadrats.

CO3: Apply acquired practical experience in vegetation sampling and data analysis of different forest community structure in nearby natural forest.

CO4: Conduct a pilot-survey to determine important social environmental parameters.

CO5: Apply acquired practical experience in collection and analysis of different kinds of social environmental data and interpretations through statistical analysis.

1. Vegetation sampling by quadrat method.
2. Vegetation sampling by transect method.
3. Measurement of frequency, density, cover and basal area of plant community
4. Measuring Importance Value Index (IVI) of plant community
5. Statistical measurements of mean, mode and median (numerical exercise)
6. Statistical measurements of variance, standard deviation, and standard error of means (numerical exercise)
7. Student's t – test (numerical exercise)
8. Chi square test (numerical exercise)
9. Social environments: Field study on village ecosystem (reconnaissance)
10. Household survey: close and open-ended questions (practical framing in a village ecosystem)
11. Data analysis and short report writing exercise on village ecosystem.
12. Secondary environmental data analysis (from source)

**Textbooks/Reference Books**

1. Ecology Workbook by R Mishra
2. Student Resource Manual Ecology and field biology by R L Smith
3. Biostatistics by B N Mishra and M K Mishra
4. Agriculture Statistics by R Rangaswamy
5. Environmental Management by Dr. Biswarup Mukherjee
6. Practical Methods in Ecology and Environmental Science by Trivedi
7. Chemical analysis of fishpond soil and water by G N Chattopadhyay
8. Introduction to biostatistics by Pranab Kumar Banerjee

**B.Sc. Chemistry - Semester II**  
**Chemistry-II**  
**Subject Code: CH104B2**

**(Credits: Theory-03)**

**Course Objectives**

This course is introduced to explain students with introduction to organic compounds, electron displacement, type of reagents and reaction intermediates. The chemistry of aliphatic and aromatic hydrocarbon, conformational analysis of cycloalkanes and basic stereochemical phenomena are included. Students are expected to learn basics of organic chemistry and analyze different classes of organic compounds, their reactivities and mechanisms along with stereochemical considerations. Students will be able to learn basics of chemical equilibrium and colligative properties of solutions.

**Course/Learning Outcome:**

CO1: To demonstrate the basic concepts of organic chemistry.

CO2: To assess and apply the concept of organic chemistry.

CO3: To explain and identify the chemistry of aliphatic hydrocarbons.

CO4: Explain the concept of Chemical equilibrium and free energy of mixing.

CO5: Explain the concept of Solutions and Colligative Properties.

**Module I**

**Basics of Organic Chemistry**

(08 Lectures)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

**Module II**

**Stereochemistry**

(16 Lectures)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis-trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Diastereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

### Module III

#### Chemistry of Aliphatic Hydrocarbons

(10 Lectures)

##### A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

##### B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions and their mechanisms (Markownikoff/ Anti-Markownikoff addition).

### Module IV

#### Chemical Equilibrium

(08 Lectures)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants  $K_p$ ,  $K_c$  and  $K_x$ . Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

### Module V

#### Solutions and Colligative Properties

(08 Lectures)

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

#### Textbooks/Reference Books

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
4. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
7. Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
8. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
9. Levine, I.N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010). 7. Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006)
10. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.; 47th Ed. (2017)

**B.Sc. Chemistry - Semester II**  
**Chemistry-II Lab**  
**Subject Code: CH109B4**

**(Credits: Lab-01)**

**Course Objective**

Students will understand about the basic techniques used in chemistry lab such as crystallization, calibration, enthalpy of hydration, basicity.

**Course/Learning Outcome**

CO1: To apply the knowledge of calibration

CO2: To explain recrystallization of a compound in different media

CO3: To check the purity of an organic compound via determination of melting points.

CO4: Apply enthalpy of hydration to solution of copper sulphate

CO5: Apply concept of solubility for determination of enthalpy changes

**List of Experiments:**

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
  - a. Water
  - b. Alcohol
  - c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic Compounds.
4. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
5. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of enthalpy of hydration of copper sulphate.
7. Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .

**Textbooks/Reference Books**

1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
3. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001)

**B.Sc. Chemistry - Semester II**  
**Advanced Instrumentation Techniques**  
**(Skill Based Course)**  
**Subject Code: CH108B1**

**(Credits: Theory-04)**

**Course Objective**

This is a skill-based course designed to introduce fundamental concepts, instrumentation and application of sampling, separation as well as qualitative/quantitative techniques of analysis of materials to students. The content of this course aims to cover some of the widely used instrumental techniques for separation, analysis and characterization of samples

**Course Outcome:** On successful completion of the course, the students will be able to:

CO1: Analyse data statistically for accuracy.

CO2: Assess qualitatively and quantitatively the different aspects of solvent extraction.

CO3: Differentiate between the various chromatographic techniques.

CO4: Analyse Lambert-Beer's law.

CO5: Discuss Electroanalytical & Thermal methods.

**Module I**

**Errors and Sampling**

(12 Lectures)

Errors in analytical chemistry: classification of errors, determination of the accuracy of a method by absolute and comparative methods, accuracy and precision, minimization of systemic errors. Statistical analysis of errors: mean, average deviation, average deviation of the mean, standard deviation, standard deviation of the mean, relative standard deviation, median value, range and rejection of results.

**Module II**

**Solvent Extraction**

(12 Lectures)

Solvent Extraction: Partition theory of extraction, aqueous and organic phases, factors affecting solvent extraction, ion association complexes, chelates, solvation, extraction reagents used specifically for inorganic ions. Technique of extraction: batch, continuous and counter current extractions, qualitative and quantitative aspects of solvent extraction, application of solvent extraction, solid phase extraction

**Module III**

**III Partition and Electro Chromatography**

(12 Lectures)

Chromatography: Classification, principle and efficiency of the technique.

Principles of liquid-liquid partition chromatography, reversed phase partition chromatography, paper chromatography, techniques in paper chromatography, thin layer chromatography.

Electrochromatography: Principles of electrophoresis, experimental techniques, curtain electrophoresis, applications of electrochromatography, reverse osmosis, electro dialysis. capillary electrophoresis and its applications.

## Module IV

### Optical Methods of Analysis

(12 Lectures)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (Choice of source, monochromator, and detector, choice of flame and Burner designs.

Techniques of atomization and sample introduction. Techniques for the quantitative estimation of trace level of metal ions from water samples.

## Module V

### Electroanalytical & Thermal Methods

(12 Lectures)

Electroanalytical methods: Nerst equation, standard electrode potential, Classification of electroanalytical methods Electrodes used in potentiometry, potentiometric titrations.

Theory of thermogravimetry (TG), basic principle of instrumentation.

Techniques for quantitative estimation of Ca and Mg from their mixture, analysis of alloys.

### Textbooks/Reference Books

1. Mendham, J. et al.: Vogel's Textbook of Quantitative Chemical Analysis; 6th Ed. Pearson Education, 2009.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. CBS Publishers & Distributors, 2004.
3. Christian, Gary D: Analytical Chemistry, 6th Ed. Wiley India (P) Ltd., 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, 4th Ed. W. H. Freeman, 2008.
5. Khopkar, S.M.: Basic Concepts of Analytical Chemistry, 3rd Ed. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, 6th Ed. Thomson Asia Pvt. Ltd. Singapore.

**B.Sc. Chemistry - Semester II**  
**Physical Chemistry I Lab**  
**Subject Code: CH106B4**

**(Credits: Lab -02)**

**Course Objective**

Students will understand about the basic techniques used in chemistry lab such as viscometry, conductometry and electrochemistry.

**Course/Learning Outcomes**

CO1: Apply Viscometric techniques to solutions.

CO2: Apply conductometric methods to pre and post micellar solutions.

CO3: Apply UV-Visible spectroscopic methods for determination of association of probe.

CO4: Apply The techniques of Chemical Kinetics to chemical reactions.

CO5: Apply Electrochemical techniques for explaining redox reactions.

**List of Experiments**

1. Surface tension measurements.
  - a. Determine the surface tension by (i) drop number (ii) drop weight method.
  - b. Study the variation of surface tension of detergent solutions with concentration.
2. Viscosity measurement using Ostwald's viscometer.
  - a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
  - b. Study the variation of viscosity of sucrose solution with the concentration of solute.
3. Indexing of a given powder diffraction pattern of a cubic crystalline system.
4. pH metry
  - a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
  - b. Preparation of buffer solutions of different pH
    - i. Sodium acetate-acetic acid
    - ii. Ammonium chloride-ammonium hydroxide
  - c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
  - d. Determination of dissociation constant of a weak acid.

**Textbooks/Reference Books**

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003). 12
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**B.Sc. Chemistry - Semester II**  
**Fitness and Yoga**  
**Subject Code: PE108A4**

**(Credits: Practical-02) (L-0, T-0, P-8)**

**Course/Learning Outcome (CO):** On successful completion of this course, student will be able to

- CO 1 Explores the relationship between yoga and mental/physical health
- CO 2 Execute effective warm-up, general exercise, cooling down, and diet plans, and assess the impact of physical activity on overall health and wellness.
- CO 3 Define, practice, and honor Asana to create a healthy physical and mental lifestyle.
- CO 4 Explain difference between pranayama and deep breathing, and practice different pranayama techniques.
- CO 5 Explain and implement the principles and practices of bandhas, mudras, meditation, and Shuddhi kriyas, and apply them to their own yoga practice.

**Module I**

**Historical Aspect of Yoga** (4 Hrs)  
Mean and Definition, Types of yoga, Scopes & Importance of yoga

**Module II**

**Warm-up, General Exercise and Cooling Down. Demonstration** (4 Hrs)  
Aerobics, Circuit Training and Calisthenics, Diet chart & measurement of BMI

**Module III**

**Asana, Differences Between, Asana and Physical exercise** (4 Hrs)  
Suraya-Namaskar, 02 Standing Asanas, 02 Sleeping (Supine Position) Asanas, 02 Sitting Asanas

**Module IV**

**Pranayama Practices** (4 Hrs)  
Difference between pranayama and 2 deep breathing

**Module V**

**Asana** (4 Hrs)  
Bandhas, Mudras Meditation, and Shuddhi Kriya Pranayama

**B.Sc. Chemistry - Semester III**  
**Inorganic Chemistry -II**  
**Subject Code: CH201B1**

**(Credits: Theory-04)**

**Course Objective**

This course aims to acquaint the students with the application of the redox chemistry in metallurgy. Concepts of protonic and non-protonic acids and bases are introduced for students to appreciate different types of chemical reactions. Periodic behaviour of s and p block elements related to their electronic structure and their reactivity is included to acquaint students with the principles governing their reactivity. This course further intends to apprise students about the variety of compounds of the main group elements including oxides, hydrides, nitrides, interhalogens, noble gases and inorganic polymers.

**Course/Learning outcome:** On successful completion of this course students would be able to

CO1: Differentiate between the various types of acids and bases.

CO2: Compare the chemistry of s and p block elements

CO3: Discuss the various classes of compounds of s and p block elements

CO4: Apply VBT, MOT and VSEPR theory to Xe compounds

CO5: Describe the various types of inorganic polymers

**Module I**

**Acids and Bases**

(10 Lectures)

Arrhenius Concept, Brønsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle, Concept of pH and pKa

**Module II**

**Chemistry of s and p Block Elements I**

(10 Lectures)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

**Module III**

**Chemistry of s and p Block Elements II**

(10 Lectures)

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrogen compounds, boranes, carboranes and graphitic compounds, oxides and oxoacids of nitrogen, phosphorus and chlorine.

Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

## Module IV

### Noble Gases

(10 Lectures)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of noble gas compounds including  $\text{XeF}_2$ ,  $\text{XeF}_4$  and  $\text{XeF}_6$ ; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for  $\text{XeF}_2$  and  $\text{XeF}_4$ ). Molecular shapes of other noble gas compounds using VSEPR theory.

## Module V

### Inorganic Polymers

(8 Lectures)

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of organosilicon compounds and silanes. Silicates: Ortho, pyro, cyclic, sheet and chain silicates, zeolites, phosphazenes

### Textbooks / Reference Books

1. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.19
2. Douglas, B.E. and Mc Daniel, D.H., Concepts and Models of Inorganic Chemistry, 3<sup>rd</sup> Ed. Wiley India, 2006.
3. Greenwood, N.N. & Earnshaw, A., Chemistry of the Elements, 2nd Ed., Elsevier India, 2010.
4. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley, 2007.
5. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH, 2007.
6. Miessler, G. L. & Tarr, D. A., Inorganic Chemistry 4th Ed., Pearson, 2010.
7. Weller, M., Armstrong, F., Rourke, J. & Overton, T., Inorganic Chemistry 6th Ed. 2015.

**B.Sc. Chemistry - Semester III**  
**Organic Chemistry -II**  
**Subject Code: CH202B1**

**(Credits: Theory-04)**

**Course Objectives**

This course is intended to apprise students about different classes of organic compounds, including halogenated hydrocarbons, alcohols, phenols, epoxides, carbonyl compounds and carboxylic and sulfonic acids. Students are expected to learn and differentiate between various organic functional groups; explain, analyse and design transformations between different functional groups.

**Course/Learning Outcome:**

CO1: To evaluate the chemistry of halogenated hydrocarbons.

CO2: To assess the preparation, properties and reactions of alcohols, phenols, ethers and epoxide.

CO3: To understand the preparation, properties and reactions of carboxylic acids and their derivatives.

CO4: To assess the preparations, properties, structures and reactions of carbonyl compounds.

CO5: To evaluate the preparations and reactions of unsaturated carbonyl compounds and sulfur containing compounds.

**Module I**

**Chemistry of Halogenated Hydrocarbons**

(10 Lectures)

Alkyl halides: Methods of preparation, nucleophilic substitution reactions –  $S_N1$ ,  $S_N2$  and  $S_Ni$  mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution;  $S_NAr$ , Benzyne mechanism.

**Module II**

**Alcohols, Phenols, Ethers and Epoxide**

(12 Lectures)

Preparation, properties, and relative reactivity of  $1^\circ$ ,  $2^\circ$ ,  $3^\circ$  alcohols, Bouveault-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement; Phenols: Preparation and properties; Acidity and factors affecting it, Ring substitution reactions. Ethers and Epoxides: Preparation and reactions with acids.

**Module III**

**Carboxylic Acids and Their Derivatives**

(10 Lectures)

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions.

## Module IV

### Carbonyl Compounds 1

(08 Lectures)

Preparation, properties, structure and reactivity; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanisms; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction. Oxidations and reductions (Clemmensen, Wolff-Kishner,  $\text{LiAlH}_4$ ,  $\text{NaBH}_4$ , MPV, PDC and PGC).

## Module V

### Carbonyl Compounds 2

(04 Lectures)

Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

### Sulfur Containing Compounds

(04 Lectures)

Preparation and reactions of thiols, thioethers and sulphonic acids.

### Textbooks/Reference Books

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
4. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012.
5. Keeler, J., Wothers, P. Chemical Structure and Reactivity – An Integrated approach, Oxford University Press.
6. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
7. Carey, F. A.; Sundberg, R. J. Advanced Organic Chemistry: Reactions and Synthesis (Part B), Springers.

**B.Sc. Chemistry – Semester III**  
**Leadership and Behaviour Management**  
**Subject Code: GN301A1**

**(Credits: Theory-02)**

**Course Objectives**

- To improve personality by enhancing life skills for a meaningful contribution to self and society.
- To understand the nature of emotions and feelings for better interpersonal relationships.
- To develop constructive and empathetic global leaders.
- To develop professional and personal skills for a successful life.

**Course/Learning Outcome**

CO1: Evaluate self-awareness, self-management concepts to help others understand themselves better.

CO2: Judge ethical issues and values in professional/personal situations and decision making.

CO3: Demonstrate enhanced ability to think and reason creatively while solving problems.

CO4: Estimate Stress levels and causes and develop strategies for managing stress.

CO5: Acquire better capabilities to communicate and forge interpersonal relationships.

CO6: Develop abilities to build teams and lead them.

**Module I**

**Self-Awareness And Self-Management**

(06 Lectures)

Understanding self, dimensions of self, Concept and Importance of self-esteem, positive and negative self-esteem, Developing positive self-esteem, Self-development and happiness. Role of motivation in self-growth, nature and types of motivation, factors affecting motivation, Achievement motivation, Relationship between achievement motivation and emotions. Nature and Significance of self-management skills, Aspects of self-management, Social competency behavior.

**Module II**

**Values & Ethics**

(06 Lectures)

Meaning, types and determinants of Values, Concept of Ethics, Relationship between Values and Ethics Its implication in one's life. Concept of Moral Development, factors responsible for moral development. Ethical Decision making, Challenges in its implementation. Prevention of Corruption & Crime; Personal Values-Empathy, honesty, courage, commitment. Professional Values-Work ethics, respect for others, Its role in personality development.

**Module III**

**Thinking And Reasoning**

(05 Lectures)

Nature and types of thinking, Problem Solving- Types of problems, Approaches to problem solving, Steps and styles of problem solving, Hindrances to Problem Solving Process- Perception, Expression, Emotion, Intellect; Creative Thinking- Meaning, nature and characteristics of creativity, factors affecting creativity, stages of creativity, personality of a creative person, factors enhancing creativity. Reasoning-types of reasoning, Distortion in thinking and reasoning.

## Module IV

### **Emotional Intelligence & Coping with Stress** (06 Lectures)

Nature of Emotions, biology of emotions, Need for and importance of Emotions, Emotion Anger: Introduction to Anger, types of anger, causes of anger, consequences of anger, Expression of anger-passive and aggressive anger, Anger management; Introduction to Emotional Intelligence, Competencies in emotional intelligence, Types of emotional intelligence, Strategies to enhance emotional intelligence; Expected outcomes of emotional intelligence; Nature of stress, relation between demands and coping, types and causes of stress, Indicators of stress, coping strategies to manage stress, Effective time management strategies.

### **Communication** (04 Lectures)

Nature and importance of communication, types of communication-indicators of verbal and non-verbal communication, communication styles; Assertiveness-Introduction, types of behavior, nature of assertiveness, Assumptions and Rights in Interpersonal communication, strategies to become assertive, Assertiveness in daily life, Characteristics of an assertive person.

## Module V

### **Interpersonal Relationships** (05 Lectures)

Importance of interpersonal relations, Types of Interpersonal Relationships, Barriers to effective communication in relationships, steps to improve interpersonal communication, Role of feedback in interpersonal communication, Conflict management, strategies for maintaining good interpersonal relations, relating to others in virtual world.

### **Leadership & Team Building** (04 Lectures)

Leadership- Definition, Meaning, Nature and Functions of leader, Types of leaders, Leadership styles, Functions of a Leader, Decision-making, personality traits of an effective leader; Significance and nature of team building, Stages of team building, types of teams, factors influencing the effectiveness of a team.

### **Textbooks/References Books**

1. Wadkar A (2016). Life Skills for Success, Sage Publications, New Delhi, India
2. Smither Robert D. (1994). The Psychology of Work and Human Performance, Harper Collins College Publishers
3. Singh A. January (2013); Achieving Behavioural Excellence for Success; Wiley Publication.
4. Raman, A.T. (2003) Knowledge Management: A Resource Book. Excel Books, Delhi.
5. Bates, A. P. and Julian, J.: Sociology - Understanding Social Behaviour
6. J William Pfeiffer (ed.) Theories and Models in Applied Behavioural Science, Vol 2, Group (1996); Pfeiffer & Company
7. Pestonjee, D.M.; Stress and Coping: The Indian Experience
8. Clegg, Brian; Instant Stress Management – Bring calm to your life now
9. Phil Lowe Koge Page: Creativity and Problem Solving, New Delhi, 1996
10. Bensley, Alan D.: Critical Thinking in Psychology – A Unified Skills Approach, (1998), Brooks/Cole Publishing Company.
11. Vangelist L. Anita, Mark N. Knapp, Interpersonal Communication and Human Relationships: Third Edition, Allyn and Bacon

12. Julia T. Wood. Interpersonal Communication everyday encounter
13. Simons, Christine, Naylor, Belinda: Effective Communication for Managers, 1997 1st Edition Cassel
14. Hoover, Judhith D. Effective Small Group and Team Communication, 2002, Harcourt College Publishers
15. Dick, Mc Cann & Margerison, Charles: Team Management, 1992 Edition, viva books

**B.Sc. Chemistry – Semester III**  
**Environmental Science-I (Minor Specialization)**  
**Subject Code: CH201B2**

**(Credit: Theory-04)**

**Course Objective**

Objective of Ecology and Environment I (minor paper) is to introduce basic concepts of Environmental Sciences like physical components of earth, structure & functions of ecosystem, and important environmental issues.

**Course/Learning Outcome**

CO1: Assess the process of ecological succession.

CO2: Apply basic ideas of sustainable development.

CO3: Analyse why and how floods take place at any place on earth.

CO4: Explain basics of atmospheric chemistry.

CO5: Apply basics of measuring central tendency and solve numerical problems.

**Module I**

**Ecological Succession**

(10 Lectures)

What is ecological succession? Types of succession: Primary & secondary succession, xerarch & hydrarch succession, autotrophic & heterotrophic succession. Mechanism of succession: Clementsian hypothesis. Changes involved in ecological succession. Concept of climax. Monoclimax theory. Polyclimax Theory: Climatic climax, Edaphic climax, Topographic climax, Fire climax & Zootic climax. Examples of succession

**Module II**

**Sustainable Development**

(10 Lectures)

What is sustainable development? Concept of sustainable development. Changing perceptions of development. Relationships between development and population change. Changing perception of the environment. About Human Development Index.

**Module III**

**Flood as Geological Hazard**

(10 Lectures)

Hydrological cycle. Streams and their features. Sediment transport. Velocity, gradient and base level. Velocity, sediment sorting and deposition. Channel and floodplain evolution. Flooding. Factors governing flood severity. Flood characteristics. Stream hydrographs. Consequences of development in floodplains. Strategies for reducing flood hazards: Restrictive zoning and floodproofing. Retention pond and diversion channels. Channelization. Levees. Flood-control dams and reservoirs. Flood warnings.

## **Module IV**

### **Atmospheric Chemistry** (10 Lectures)

Composition of the atmosphere. Atmospheric structure. Evolution of the atmosphere. Earth's radiation balance. Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic particulate matter. Chemical processes for formation of organic particulate matter. Ions and radicals. Chemical and photochemical reactions in the atmosphere. Oxygen and ozone chemistry. Chemistry of Stratospheric Ozone depletion.

## **Module V**

### **Basics of Biostatistics** (8 Lectures)

Measurement of central tendency, Mean: Arithmetic mean, geometric mean, harmonic mean and percentiles. Median and mode. Numerical examples.

### **Textbooks/Reference Books**

1. Fundamentals of Ecology by E P Odum
2. Ecology Environmental Science & Conservation by J S Singh & S P Singh
3. Biological Science by D J Taylor and N P O Green
4. Environmental Chemistry by Anil Kumar De
5. Environmental Impact Assessment by Larry W Canter
6. Environmental Geology by Carla Montgomery
7. Environmental Science by G Tyler Miller
8. Environmental Geology by Barbara Murck & Skinner
9. Statistics in Biology & Psychology by Debajyoti Das
10. A textbook of Agricultural Statistics by R Rangaswamy

**B.Sc. Chemistry – Semester III**  
**Inorganic Chemistry-I Lab**  
**Subject Code: CH201B4**

**(Credits: Lab-02)**

**Course Objective**

The course aims to provide students with hands-on experience in performing, analysing and interpreting results with respect to neutralization and redox titrations.

**Course/Learning Outcomes**

After completing the course, the students will be able to:

CO1: Learn to prepare standard solutions

CO2: Apply the knowledge of calibration to common laboratory apparatus and instruments.

CO3: Learn to use indicators and buffer solutions.

CO4: Analyse the data obtained from acid-base and redox titrations.

CO5: Interpret the results obtained from various experiments

**List of Experiments**

(A) Titrimetric Analysis

(i) Calibration and use of common laboratory apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants.

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents.

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized  $\text{KMnO}_4$  solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(ii) Estimation of Fe(II) with  $\text{K}_2\text{Cr}_2\text{O}_7$  using internal (diphenylamine, anthranilic acid) and external indicator.

**Textbook**

1. Mendham, J. et al.: Vogel's Textbook of Quantitative Chemical Analysis; 6th Ed. Pearson Education, 2009.

**B.Sc. Chemistry - Semester III**  
**Organic Chemistry- I Lab**  
**Subject Code: CH202B4**

**(Credits: Lab -02)**

**Course Objective:**

The course will meet the criteria of basic technics used in organic chemistry lab such as calibration, recrystallization, determination of melting point, check in purity through melting point, separation through paper and thin layer chromatography about various organic transformations such as substitution, oxidation, reduction, rearrangement etc. This hand on experiences will grow an interest among students in organic chemistry.

**Course/Learning Outcome**

CO1: To apply the knowledge of calibration

CO2: To explain recrystallization of a compound in different media

CO3: To check the purity of an organic compound via determination of melting points.

CO4: To demonstrate how to find out boiling point of an organic solvent.

CO5: To apply chromatographic techniques for separation of organic compounds

**List of Experiments**

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
  - a. Water
  - b. Alcohol
  - c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic Compounds.
4. Effect of impurities on the melting point - mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
  - a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.
  - b. Separation of a mixture of two sugars by ascending paper chromatography.
  - c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

**Textbooks/References Books**

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
3. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
4. Bhattacharyya, R. C, A Manual of Practical Chemistry.
5. Dutta, S, B. Sc. Honours Practical Chemistry, Bharati Book Stall.

**B.Sc. Chemistry - Semester III**  
**Project Based Learning I**  
**Sub Code: CH201B5**

**(Credits: Project based learning-02)**

**B.Sc. Chemistry - Semester IV**  
**Inorganic Chemistry-III**  
**Subject Code: CH203B1**

**(Credits: Theory-04)**

**Course Objective**

This course introduces students to the various aspects of coordination chemistry like nomenclature, structure, bonding, variety and reactivity of the coordination compounds etc. Bioinorganic chemistry is included in this course to acquaint students on the useful and harmful aspects of metals in biological systems.

**Course/Learning Outcome:** On successful completion of this course students would be able to

CO1: Understand the basics of coordination chemistry.

CO2: Compare the bonding (VBT, CFT) and properties of coordination compounds.

CO3: Discuss the various properties of transition elements.

CO4: Differentiate between the properties of lanthanides and actinides.

CO5: Elucidate the role of metal ions in biological systems.

**Module I**

**Coordination Chemistry I**

(08 Lectures)

Coordination compounds, types of ligands, Werner's theory, Effective Atomic number rule, IUPAC nomenclature and isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers.

**Module II**

**Coordination Chemistry II**

(12 Lectures)

Valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of  $10 Dq$  ( $\Delta_o$ ), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of  $10 Dq$  ( $\Delta_o$ ,  $\Delta_t$ ). Effect of CFSE on Lattice energy, enthalpy of hydration and ionic radii of the first transition series, Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry.

**Module III**

**Transition Elements**

(12 Lectures)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Frost diagrams). Difference between the first, second and third transition series.

Chemistry of Ti, V, Cr Mn, Fe and Co (Chemistry of first -row transition elements) in various oxidation states as halides, oxides, hydroxides.

## Module IV

### Lanthanoids and Actinoids

(08 Lectures)

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). Differences between lanthanides and actinides with respect to their electronic configuration and oxidation states.

## Module V

### Bioinorganic Chemistry

(10 Lectures)

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine.

Iron and its application in bio-systems, Haemoglobin, myoglobin and storage and transfer of oxygen, cytochromes.

### Textbooks/Reference Books

1. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley, 2007.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed., Pearson Education India, 2006.

**B.Sc. Chemistry - Semester IV**  
**Physical Chemistry-III**  
**Subject Code: CH204B1**

**(Credits: Theory-04)**

**Course Objective**

The aim of this course is to make students understand phase, co-existence of phases, phase diagram, CST and distribution law and concepts of electrochemical cells, electrode potential, electrochemical series and learn about surface phenomenon, adsorption isotherms, BET Equation.

**Course/Learning Outcome**

CO1: Analyse phase equilibrium, criteria, CST, Gibbs-Duhem-Margules equation.

CO2: Explain the working of electrochemical cells, galvanic cell,

CO3: Explain corrosion in surroundings related to electrochemistry.

CO4: Explain the kinetics of some complex reactions.

CO5: Explain the concepts related to catalysis.

**Module I**

**Phase Equilibria**

(10 Lectures)

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Clausius-Clapeyron equation and its applications to solidliquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.

**Module II**

**Binary Solutions**

(10 Lectures)

Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

**Module III**

**Kinetics**

(12 Lectures)

Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

**Module IV**

**Catalysis**

(10 Lectures)

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

**Module V**

**Surface Chemistry**

(06 Lectures)

Physical adsorption, chemisorption, adsorption isotherms, nature of adsorbed state.

**Textbooks/Reference Books**

1. Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
2. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
3. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.; 47th Ed. (2017)
4. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 5) McGraw Hill Education; 5th edition (2017)

**B.Sc. Chemistry – Semester IV**  
**Environmental Science-II (Minor Specialization)**  
**Subject Code: CH202B2**

**(Credits: Theory – 04)**

**Course Objective**

Objectives of Environmental Sciences II (minor paper) are to understand basics of nutrient cycles (Ecology), to understand the nature of population growth and the recent patterns of human population growth. To understand the patterns of urbanization in present world along with the advantages and disadvantages of it. To understand the concept of standard deviation from average (Biostatistics). To understand the statistical significance of difference in means (t significance test) and basic concept of Environmental Impact Assessment (EIA).

**Course/Learning Outcome**

CO1: Assess various processes of nutrient cycles.

CO2: Analyse the patterns of human population growth and urbanization.

CO3: Apply the concept of standard deviation and solve problems.

CO4: Calculate different processes of statistical significance of difference in means (t-test) and solve problems.

CO5: Apply the concept of environmental impact assessment (EIA).

**Module I**

**Biogeochemical Cycles**

(10 Lectures)

Basic types of Biogeochemical cycles - cycling of nitrogen, cycling of carbon, cycling of phosphorous, cycling of sulphur.

**Module II**

**The Human Population & Urbanization**

(10 Lectures)

J-Curves and S-Curves of population growth. How long can the Human Population keep growing? What factors influence the size of the Human Population? How does a population's age structure affect its growth or decline? How can we slow Human Population growth? What are the major urban resource & environmental problems? How does transportation affect urban environmental impacts? How can cities become more sustainable & liveable?

**Module III**

**Biostatistics: Mean Deviation, Standard Deviation and Variance**

(10 Lectures)

Measures of dispersion: Range, Mean Deviation, Standard Deviation & Variance. Sampling statistics: sampling errors, sampling distributions, standard errors, and standard scores. Numerical examples.

## **Module IV**

### **Biostatistics: Student's t Test**

(10 Lectures)

Student's t-test, degrees of freedom, unpaired t-test, paired t- test, 0.5 significance. Numerical examples.

## **Module V**

### **Environmental Impact Assessment (EIA)**

(08 Lectures)

Environmental Inventory, Environmental Assessment, Environmental Impact Statement Basic contents of an Impact Statement, Framework for Environmental Assessment: Environmental Assessment Process, Basics to the process, Description of Environmental Setting, Impact Prediction & Assessment, Selection of Proposed Action, Preparation of Environmental Impact Statement.

### **Textbooks/Reference Books**

1. Fundamentals of Ecology by E P Odum
2. Ecology Environmental Science & Conservation by J S Singh & S P Singh
3. Introduction to Biostatistics by Dr. Pranab Kumar Banerjee
4. Environmental Chemistry by Anil Kumar De
5. Environmental Impact Assessment by Larry W Canter
6. Environmental Geology by Carla Montgomery
7. Environmental Science by G Tyler Miller
8. Environmental Geology by Barbara Murck & Skinner
9. Statistics in Biology & Psychology by Debajyoti Das

**B.Sc. Chemistry – Semester IV**  
**Community Based Participatory Research Work (Field Work)**  
**Subject Code:**

**(Credit: Theory-02)**

**Course Objective**

1. To develop an appreciation of rural culture, lifestyle and wisdom amongst students.
2. To learn about the status of various agricultural and development programmes.
3. To understand the causes of distress and poverty faced by vulnerable households and explore solutions for the same.
4. To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.

**Course/Learning Outcome**

CO1: Gain an understanding of rural life, Indian culture and ethos and social realities.

CO2: Develop a sense of empathy and bonds of mutuality with the local community.

CO3: Appreciate significant contributions of local communities to Indian society and Economy.

CO4: Learn to value the local knowledge and wisdom of the community.

CO5: Identify opportunities for contributing to community's socio-economic improvements.

**Module I**

**Appreciation of Rural Society** (10 Lectures)

Field Visit: Concept, Ethics and Spectrum of Community engagement. Local community, Rural culture and Practice of community engagement. Rural lifestyle, rural society, caste and gender relations, rural values with respect to community, nature and resources, elaboration of “soul of India lies in villages’ (Gandhi), rural infrastructure.

Assignment Topics: Prepare a map (physical, visual or digital) of the village you visited and write an essay about inter-family relations in that village.

**Module II**

**Understanding Rural and Local Economy and Livelihood** (10 Lectures)

Stages, Components and Principles of community development, Utility of public resources. Contributions of self-help groups. Agriculture, farming, land ownership, water management, animal husbandry, non-farm livelihoods and artisans, rural entrepreneurs, rural markets, migrant labour. Describe your analysis of the rural house hold economy, its challenges and possible pathways to address. Circular economy and migration patterns

**Module III**

**Rural and Local Institutions** (10 Lectures)

Rural Development Programs and Rural institutions. Local Administration and Community Involvement. Traditional rural and community organisations, Self-help Groups, Panchayati raj institutions (Gram Sabha, Gram Panchayat, Standing Committees), Nagarpalikas and

municipalities, local civil society, local Administration How effectively are Panchayati Raj and Urban Local Bodies (ULBs) institutions functioning in the village? What would you suggest to improve their effectiveness? Present a case study (written or audio-visual)

#### **Module IV**

##### **Rural and National Development Programmes (10 Lectures)**

Social contribution of community networking, Various government schemes. Programmes of community engagement and their evaluation.

History of rural development and current national programmes in India: Sarva Shiksha Abhiyan, Beti Bachao, Beti Padhao, Ayushman Bharat, Swachh Bharat, PM Awaas Yojana, Skill India, Gram Panchayat Decentralised Planning, National Rural Livelihood Mission (NRLM), Mahatma Gandhi National Rural Employment Guarantee Act 2005 (MGNREGA), SHRAM, Jal Jeevan Mission, Scheme of Fund for Regeneration of Traditional Industries (SFURTI), Atma Nirbhar Bharat, etc. Describe the benefits received and challenges faced in the delivery of one of these programmes in the local community; give suggestions about improving the implementation of the programme for the poor. Special focus on the urban informal sector and migrant households

#### **Module V**

##### **Community Issues (08 Lectures)**

Community Engaged Research and Ethics in Community Engaged Research.

Rural Distress, Rural Poverty, Impact of COVID-19 on Migrant Laborers, Mitigation of Disaster. Final Report Compilation.

##### **Textbooks/Reference Books**

1. Principles of Community Engagement, 2nd Edition, NIH Publication No. 11-7782, Printed June 2011.
2. Community Engagement- [https://www.uvm.edu/sites/default/files/community\\_engagement\\_handout.pdf](https://www.uvm.edu/sites/default/files/community_engagement_handout.pdf)
3. Perspectives of Community – [https://www.atsdr.cdc.gov/communityengagement/pce\\_concepts.html](https://www.atsdr.cdc.gov/communityengagement/pce_concepts.html)
4. Ethics of community engagement - <https://sustainingcommunity.wordpress.com/2013/07/09/ethics-and-community-engagement/> Government programmes for rural development - <https://www.mapsofindia.com/my-india/government/schemes-for-rural-development-launched-by-government-of-india>
5. SWAYAM online course on Community Engagement and Social Responsibility – 10 Weeks online

**B.Sc. Chemistry – Semester IV**  
**Inorganic Chemistry-II Lab**  
**Subject Code: CH203B4**

**(Credits: Lab-02)**

**Course Objective**

The course aims to provide students with hands-on experience in performing, analysing and interpreting results with respect to iodometric titrations. Expertise in preparation of some common inorganic will be imparted

**Course/Learning Outcome**

After completing the course, the students will be able to:

CO1: Learn to prepare standard solutions.

CO2: Learn to use indicators in redox reactions.

CO3: Apply the knowledge of redox reactions to iodometric titrations.

CO4: Analyse the data obtained from the experiments like UV-Vis spectra, FTIR etc.

CO5: Quantify the yields from preparation experiments.

**List of Experiments**

(A) Iodo/Iodimetric Titrations

(i) Estimation of Cu(II) in brass/ copper sulphate etc and  $K_2Cr_2O_7$  using sodium thiosulphate solution

(Iodimetrically).

(ii) Estimation of dissolved oxygen iodimetrically

(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous Chloride,  $CuCl$

(ii) Preparation of manganese (III) phosphate,  $MnPO_4 \cdot H_2O$

(iii) Preparation of aluminium potassium sulphate  $KAl(SO_4)_2 \cdot 12H_2O$  (Potash alum) or Chrome alum.

**Textbooks/Reference Books**

1. Mendham, J. et al.: Vogel's Textbook of Quantitative Chemical Analysis; 6th Ed. Pearson Education, 2009.

2. Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.

**B.Sc. Chemistry – Semester IV**  
**Physical Chemistry-II Lab**  
**Subject Code: CH204B4**

**(Credits: Lab -02)**

**Course Objective**

The course introduces students to concepts of heat capacity and enthalpy of hydration to chemical reactions.

**Course/Learning Outcome**

CO1: Analyse heat capacity of a calorimeter

CO2: Apply the enthalpy of ionization

CO3: Apply thermochemical method in terms of the changes of temperatures

CO4: Explain enthalpy of hydration

CO5: Apply concept of the solubility of benzoic acid in water

**List of Experiments**

Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(f) Determination of enthalpy of hydration of copper sulphate.

(g) Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .

Any other experiment carried out in the class.

**Textbooks/Reference Books**

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

**B.Sc. Chemistry - Semester IV**  
**Project Based Learning II**  
**Sub Code: CH202B5**

**(Credits: Project based learning-02)**

**B.Sc. Chemistry - Semester V**  
**Organic Chemistry-III**  
**Subject Code: CH301B1**

**(Credits: Theory-04)**

**Course Objectives**

The course introduces students to different classes of N-based compounds, including alkaloids and terpenoids and their potential application. Students are expected to learn about different classes of N-based compounds, their structures, synthesis and reactivity.

**Course/Learning Outcome**

CO1: To evaluate the preparations and reactions of nitrogen containing functional groups.

CO2: To demonstrate the preparations, reactions and structure elucidations of polynuclear hydrocarbons.

CO3: To assess the classifications, structures, aromaticity, syntheses and reactions of heterocyclic compounds.

CO4: To assess the IUPAC nomenclature of heterocycles.

CO5: To evaluate the concept of aromaticity and anti-aromaticity for organic compounds.

**Module I**

**Nitrogen Containing Functional Groups** (13 Lectures)

Preparation and important reactions of nitro compounds, nitriles and isonitriles. Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications.

**Module II**

**Polynuclear Hydrocarbons** (8 Lectures)

Reactions of naphthalene, phenanthrene and anthracene. Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

**Module III**

**Heterocyclic Compounds** (11 Lectures)

Classification, Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine. Indole: Fischer indole synthesis and Madelung synthesis).

**Module IV**

**IUPAC Nomenclature of Heterocycles** (8 Lectures)

IUPAC's recommendations for the nomenclature of heterocycles.

Systematic Nomenclature (IUPAC) in Heterocyclic Compounds: Hantzsch-Widman nomenclature.

Rules for systematic nomenclature (IUPAC) in heterocyclic compounds. Naming of heterocyclic compounds: 3-membered, 4-membered, 5-membered, and 6-membered rings containing one or two heteroatoms.

## Module V

### Aromaticity

(8 Lectures)

Concept of Aromaticity and anti-aromaticity, Properties, Annulene (Benzenoid and Non-benzenoid), Aromaticity in charged ring, Homoaromaticity, Fused ring system, Heterocyclic ring. Aromatic Electrophilic Substitution: Role of sigma- and pi-complex in aromatic electrophilic substitution, Electrophilic substitution reaction of Benzene- Nitration, Halogenation, Friedel-Craft reaction, Sulphonation, Mercuration. Effect of substituent, the ortho-para ratio, Substitution in disubstituted benzenes- competition between substituents.

### Textbooks / Reference Books

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
5. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub. 6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
6. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry.

**B.Sc. Chemistry - Semester V**  
**Inorganic Chemistry-IV**  
**Subject Code: CH302B1**

**(Credits: Theory-04)**

**Course Objective**

The unit on reaction mechanism is included for the students to get acquainted with the kinetic and thermodynamic factors governing the reaction path and stability of inorganic compounds. Organometallic compounds are introduced so as to apprise students about the importance of metal carbon bond to form complexes and their application as catalysts. Students will learn factors leading to stability of organometallic compounds, their synthesis, reactivity and uses. Qualitative inorganic analysis is included to give students an idea and hands on experience of application of inorganic chemistry. Students should learn how differential reactivity under different conditions of pH can be used to identify variety of ions in a complex mixture. Experiments related to synthesis and characterization of coordination compounds are included to supplement their theoretical knowledge.

**Course/Learning Outcome**

CO1: Explain fundamental concepts of inorganic reaction mechanisms involving square planar complexes.

CO2: Explain and identify kinetics of octahedral substitution, mechanism of substitution in octahedral complexes. electron transfer reactions.

CO3: Demonstrate and apply 18 electron rules, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series, the synthesis, structure, bonding, properties, and reactivity of Metal carbonyls, Zeise's salt.

CO4: Demonstrate and identify the role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst), Ferrocene: preparation and reactions.

CO5: Explain and identify transition metals in catalysis, general principles and properties of catalysts, some industrial processes and their mechanism.

**Module I**

**Mechanism of Inorganic Reactions I**

(10 Lectures)

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, kinetics and stereochemistry of square planar substitutions, Evidence for associative reactions. Thermodynamic and Kinetic stability.

**Module II**

**Mechanism of Inorganic Reactions II**

(10 Lectures)

Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes. Reaction rates influenced by acids and bases, racemization and isomerization reactions, Electron transfer reactions, outer and inner sphere mechanisms, conditions for high and low oxidation number.

## Module III

### Organometallic Compounds I

(10 Lectures)

Definition and classification of organometallic compounds based on bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.  $\pi$ -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

## Module IV

### Organometallic Compounds II

(10 Lectures)

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

## Module V

### Transition Metals in Catalysis

(08 Lectures)

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples), Deactivation or regeneration of catalysts. Study of the industrial processes and their mechanism: Alkene hydrogenation (Wilkinson's Catalyst), Hydroformylation (Co catalysts), Wacker Process, Synthetic gasoline (Fischer Tropsch reaction), Synthesis gas by metal carbonyl complexes.

### Textbooks/Reference Books

1. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley, 2007.
2. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH, 2007.
3. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed., Pearson Education India, 2006.
4. Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
5. Douglas, B.E. and Mc Daniel, D.H., Concepts and Models of Inorganic Chemistry, 3rd Ed. Wiley India, 2006.
6. Greenwood, N.N. & Earnshaw, A., Chemistry of the Elements, 2nd Ed., Elsevier India, 2010.
7. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
8. Shriver, D.D. & Atkins, P., Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
9. Miessler, G. L. & Tarr, D. A., Inorganic Chemistry 4th Ed., Pearson, 2010.

**B.Sc. Chemistry - Semester V**  
**(DSE – I, Discipline Specific Elective Paper)**  
**Application of Computers in Chemistry (DSE-I)**  
**Subject Code: CH301B3**

**(Credits: Theory-04)**

**Course Objective:** On successful completion of this course students would be able to

1. Understand the basics of C language.
2. Apply loops and conditional statements in C programs
3. Use 1&2 dimensional arrays in common problems
4. Evaluate roots of equations using various numerical methods
5. Apply numerical methods for differentiation and integration

**Course/Learning Outcome**

On successful completion of this course students would be able to

CO1: Understand the basics of C language.

CO2: Apply loops and conditional statements in C programs

CO3: Use 1&2 dimensional arrays in common problems

CO4: Evaluate roots of equations using various numerical methods

CO5: Apply numerical methods for differentiation and integration

**Module I**

**Basics of C**

(10 Lectures)

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of C language. C keywords and commands, relative operators.

**Module II**

**Loops in C**

(10 Lectures)

Conditional statements, while, do while and for loops, logical operators. Typical programs using these loops.

**Module III**

**Arrays and Functions**

(10 Lectures)

1 Dimensional and 2 Dimensional arrays, Matrix addition and multiplication, Functions/ sub routines in C and related programs.

**Module IV**

**Numerical Methods I**

(08 Lectures)

Roots of equations: Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.

## Module V

### Numerical Methods II

(10 Lectures)

Differential calculus: Numerical differentiation.

Integral calculus: Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.

Simultaneous equations: Matrix manipulation: addition, multiplication. Gauss-Siedal method.

Interpolation, extrapolation and curve fitting: Handling of experimental data.

### Textbooks/Reference Books

1. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007)
2. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001)
3. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co. (1985).
4. Rajaraman, V. Computer programming in C. Prentice-Hall of India.
5. Balaguruswamy, E. Numerical Methods Tata McGraw Hill publication.

**B.Sc. Chemistry - Semester V**  
**Environmental Science-III (Minor Specialization)**  
**Subject Code: CH301B2**

**(Credits: Theory-04)**

**Course Objectives**

Objectives of Environmental Sciences III (minor paper) are to understand the hazards of different types of mass wasting (Environmental Hazards), concepts of biodiversity conservation, evolution and ecology, significance tests like chi square. Also to understand basics of correlation & analysis of variance (ANOVA).

**Course/Learning Outcome**

CO1: Ability to understand how and why landslides happen.

CO2: Ability to understand the process of biodiversity conservation.

CO3: Ability to understand the linkage between ecology and evolution.

CO4: Ability to understand the chi square significance test with problem solving ability.

CO5: Ability to understand the ANOVA test and its significance with problem solving ability.

**Module 1**

**Landslides**

(10 Lectures)

Mass-wasting and its impacts. Types of mass-wasting: a) Slope failures – slumps, falls and slides. b) Flows – slurry flows & granular flows. Mass-wasting in cold climates. Subaqueous mass-wasting. Factors that influence slope stability – gravity & slope gradient, water, and troublesome earth materials. Liquefaction. Expansive & hydro compacting soils. Landslide triggering events – earthquakes, volcanic eruptions, slope modifications and undercutting, and changes in hydrologic characteristics. Prevention and mitigation of landslide hazards.

**Module II**

**Biodiversity Conservation**

(10 Lectures)

In situ conservation strategies – Protected Areas (Pas), terrestrial Protected Areas, marine Protected Areas, & Biosphere Reserves. Marine Biosphere Reserves. Restoration of endangered species. Sustainable use of biodiversity and public participation. India's biodiversity & its conservation: status of India's biodiversity, threatened plants & animals, biodiversity hotspots, some important Protected Areas of India, project tiger & project elephant, & Biosphere Reserves. International efforts for conserving biodiversity: IUCN, CITES, Convention on Biodiversity, & Ramsar Convention.

**Module III**

**Evolution and Ecology**

(10 Lectures)

What is evolution? What is Fitness? Adaptation. Coevolution. Evolution and “Arms Races”. Units of Selection – Gametic Selection, Kin Selection, and Group Selection.

## **Module IV**

### **Biostatistics: Chi Square Test & Correlation** (10 Lectures)

Chi ( $\chi^2$ ) square test: Test for Goodness of Fit (Pearsonian -  $\chi^2$ ), Contingency chi-square, Homogeneity chi-square. Numerical examples.

Correlation: Co-efficient of correlation. Properties of Co-efficient of correlation. Types of correlation: a. Perfect positive correlation. b. Perfect negative correlation. c. Partial positive correlation. d. Partial negative correlation. e. Absolutely no correlation f. Perfect and imperfect correlation Simple and multiple correlation. Partial and total correlation. Linear and non-linear correlation. Numerical examples.

## **Module V**

### **Analysis of Variances (ANOVA)** (08 Lectures)

Variance, mean square, & assumptions in the analysis of variance. Technique for analysis of variance. Working procedure. Steps of calculation & numerical examples.

### **Textbooks / Reference Books**

1. Fundamentals of Ecology by E P Odum
2. Ecology Environmental Science & Conservation by J S Singh & S P Singh
3. Biological Science by D J Taylor and N P O Green
4. Environmental Geology by Barbara Murck & Skinner
5. Introduction to Biostatistics by Dr. Pranab Kumar Banerjee

**B.Sc. Chemistry - Semester V**  
**Organic Chemistry-II Lab**  
**Subject Code: CH301B4**

**(Credits: Lab-02)**

**Course Objective**

To have a comprehensive understanding about various organic transformations such as substitution, oxidation, reduction, rearrangement etc. This hand on experiences will grow an interest among students in organic chemistry.

**Course/Learning Outcome**

CO1: To apply the knowledge of acetylation and benzylation of organic functional group.

CO2: To demonstrate how to use iodine as an oxidizing agent.

CO3: To identify the reagents used for bromination & nitration.

CO4: To identify the chemical used for reduction of nitro groups.

CO5: To demonstrate a green synthesis.

**List of Experiments**

**Organic Preparations**

1. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines o-, m-, p-anisidine) and phenols ( $\beta$ -naphthol, vanillin, salicylic acid) by any one method: (a) Using conventional method. (b) Using green approach.
2. Benzoylation of one of the following amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) and one of the following phenols ( $\beta$ -naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
3. Oxidation of ethanol/ isopropanol (Iodoform reaction).
4. Bromination of any one of the following: (a) Acetanilide by conventional methods. (b) Acetanilide using green approach (Bromate-bromide method).
5. Nitration of any one of the following: (a) Acetanilide/nitrobenzene by conventional method. (b) Salicylic acid by green approach (using ceric ammonium nitrate).
6. Selective reduction of meta dinitrobenzene to m-nitroaniline.
7. Reduction of p-nitrobenzaldehyde by sodium borohydride.
8. Hydrolysis of amides and esters.
9. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
10. S-Benzylisothiuronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
11. Aldol condensation using either conventional or green method.
12. Benzil-Benzilic acid rearrangement.

The above preparations should be done using 0.5-1 g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point, and TLC.

**Textbooks/Reference Books**

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).
5. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers, and Distributors.

**B.Sc. Chemistry - Semester V**  
**Summer Internship**  
**Subject Code: CH301A5**

**(Credits: Internship-02)**

**B.Sc. Chemistry - Semester VI**  
**Organic Chemistry-IV**  
**Subject Code: CH303B1**

**(Credits: Theory-03)**

**Course Objective**

This course introduces students to nucleic acids, amino acids and enzymes, lipids and carbohydrates. Students will be familiarized with the importance of nucleic acids, amino acids and develop basic understanding of enzymes, lipids and carbohydrates.

**Course/Learning Outcomes**

CO1: To assess the structure, synthesis and reactions of nuclei acids.

CO2: To evaluate the synthesis, properties, and reactions of amino acids and peptides.

CO3: To demonstrate the classifications and characteristics of enzymes.

CO4: To understand the basics of oils and fats.

CO5: To assess the occurrence, classification and biological importance of carbohydrates.

**Module I**

**Nucleic Acids** (08 Lectures)

Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

**Module II**

**Amino Acids, Peptides, and Proteins** (10 Lectures)

Amino acids, Peptides and their classification.

$\alpha$ -Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis.

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

**Module III**

**Enzymes** (10 Lectures)

Introduction, classification and characteristics of enzymes. Salient features of the active site of enzymes. Mechanism of enzyme action (taking trypsin as an example), factors affecting enzyme action, coenzymes and cofactors, and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors, and their importance.

**Module IV**

**Lipids** (08 Lectures)

Introduction to oils and fats; saturated and unsaturated fatty acids present in oils and fats and their structures. Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

## Module V

### Carbohydrates

(12 Lectures)

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation. Disaccharides – Structure elucidation of maltose, lactose and sucrose.

### Textbooks/Reference Books

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) Biochemistry. VI<sup>th</sup> Edition. W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M. and Lehninger, A. L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.

**B.Sc. Chemistry - Semester VI**  
**Physical Chemistry-IV**  
**Subject Code: CH304B1**

**(Credits: Theory-03)**

**Course Objective**

To develop a comprehensive understanding of electrochemical principles including EMF measurement, Nernst equation, electrode potentials, and conductance. Students will learn the theoretical and practical aspects of ionic mobility, transference numbers, and conductometric and potentiometric techniques. Applications such as determining thermodynamic parameters, pH, solubility, and hydrolysis constants will be explored, along with the industrial relevance of electrolysis.

**Course/Learning Outcome**

CO1: Analyse the fundamental concepts and applications of electrochemistry.

CO2: Apply the Nernst equation and apply standard electrode potentials to various systems.

CO3: Analyse the behavior of strong and weak electrolytes and understand concepts such as ionic mobility and transference numbers.

CO4: Apply electrochemical techniques in calculating thermodynamic properties, equilibrium constants, pH values, and in conducting titrations.

CO5: Explain the industrial significance of electrolysis and electrochemical processes.

**Module I**

**Electrochemistry**

(10 Lectures)

Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Reference electrodes and applications, Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone. Concentration cells with and without transference, liquid junction potential.

**Module II**

**Conductance I**

(10 Lectures)

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law. Primary Kinetic Salt Effect. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

**Module III**

**Conductance II**

(10 Lectures)

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods.

Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

#### **Module IV**

##### **Quantitative Aspects of Electrochemistry** (10 Lectures)

Electrochemistry Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials. Chemical cells, reversible and irreversible cells with examples. EMF of a cell and Free energy change, Thermodynamics of cells.

#### **Module V**

##### **Potentiometric Titration** (08 Lectures)

Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Solubility product and solubility, Determination of solubility product from EMF, Buffers.

##### **Textbooks/Reference Books**

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
2. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.; 47th Ed. (2017)
3. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 1) McGraw Hill Education; Sixth edition (2019)

**B.Sc. Chemistry - Semester VI**  
**(DSE – II, Discipline Specific Elective Paper)**  
**Novel Inorganic Solids**  
**Subject Code: CH302B3**

**(Credit: Theory 04)**

**Course Objective**

This introductory course aims to introduce learners to a wide variety of technologically important and emerging materials. By the end of the course, students will be able to demonstrate different synthetic approaches for the synthesis of novel inorganic solids, to identify how technologically important materials work and their applications in different fields. It will prepare the learners for studying materials further at the master's level.

**Course/Learning outcome:** After the completion of this course, it will also be possible for the students to choose for studying an interdisciplinary master's programme with an emphasis on the synthesis and applications of various materials or take up a job in the materials production and/or processing industry, where prior knowledge in introductory UG level course is always essential.

CO1- Understanding of synthesis of various methods of nanomaterials.

CO2- To understand the inorganic materials having technological importance.

CO3- To understand synthesis of nano-metals and self-assembled nano structures.

CO4- understanding of composite materials and its applications.

CO5- To understand the properties and application of ceramic and refractory.

**Module I**

**Synthesis and Modification of Inorganic Solids** (09 Lectures)

Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods.

**Module II**

**Inorganic Solids of Technological Importance** (10 Lectures)

Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments. Molecular material, fullerene & fullerenes, molecular materials & chemistry – one-dimensional metals, molecular magnets, metal containing liquid crystals.

**Module III**

**Nanomaterials** (10 Lectures)

Overview of nanostructures and nanomaterials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures, Carbon nanofiber, carbon nanotube and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, bio-nano composites.

**Module IV**

**Composite Materials** (10 Lectures)

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

## Module V

### Speciality Polymers

(09 Lectures)

Ceramics & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

### Textbooks/Reference Books

1. West A. R. Solid State Chemistry and its Applications, 2nd Edition, Wiley
2. Shriver & Atkins. Inorganic Chemistry, Peter Atkins, Tina Overton, Jonathan Rourke, Mark
3. Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
4. Smart, L. E., Moore, E. A., Solid State Chemistry: An Introduction, 4th Ed., CRC Press, 2012
5. Cao G., Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004

**B.Sc. Chemistry - Semester VI**  
**Environmental Science-IV**  
**Subject Code: CH302B2**

**(Credits: Theory-04)**

**Course Objective**

Objectives of Environmental Sciences IV (minor paper) are to understand the hazards of air pollution and toxic chemicals on natural environment. To understand the process of municipal solid waste management. To understand the impact on human action on overall health of ecosystem and to understand basics of environmental economics

**Course/Learning Outcomes**

CO1: Analyze the impacts of different primary and secondary air pollutants along with their overall impact on human health.

CO2: Explain biochemical pathways of different toxic heavy metals along with their physiological impact.

CO3: Assess efficiency of different solid waste management techniques.

CO4: Assess overall health of ecosystems and the impact of human interferences.

CO5: Identify and understand basic concepts of environmental economics.

**Module I**

**Air Pollution**

(10 Lectures)

Primary air pollutants: CO, NO<sub>2</sub>, SO<sub>2</sub>, HC & particulates – Sources, concentration & control. Secondary Pollutants: Photochemical smog & Acid rain. Effects of particulates on humans and material. Control of particulate emission. Man-made sources of radioactivity. Indoor reactions of air pollutants. Air pollutant accidents: Bhopal disaster & Chernobyl disaster

**Module II**

**Chemical Toxicology**

(10 Lectures)

Toxic chemicals in the environment. Impact of toxic chemicals on enzymes. Biochemical effects of Arsenic. Biochemical effects of lead. Biochemical effects of Mercury. Biochemical effects of Carbon Monoxide. Biochemical effects of Sulphur Dioxide. Biochemical effects of Ozone & PAN. Biochemical effects of Pesticides. Pollution and public health issues.

**Module III**

**Solid Waste Management**

(10 Lectures)

Characteristics of solid wastes. Changes in Municipal solid waste (MSW). Consideration in Solid Waste Management: Protection of public health, source reduction, recycling and recovery of energy. Collection systems. Separation and processing of MSW: At source or Central separation. Conversion of MSW: Incineration, Composting and landfilling.

## **Module IV**

### **Ecosystem Health and Human Impact**

(08 Lectures)

Human population growth. Current patterns of population growth. The Demographic Transition: An evolutionary dilemma. What is population momentum? Carrying capacity of the Earth. How to calculate an Ecological Footprint. Invasive species. Ecosystem Services. Economics of Ecosystem Services. Ecological impact of biofuels. Sustainability. Ecosystem health.

## **Module V**

### **Environmental Economics**

(10 Lectures)

How are Economic Systems related to the Biosphere? Economists disagree over the importance of natural capital and the sustainability of economic growth. How can we use economic tools to deal with environmental problems? Most things cost more than we might think. Environmental Economic Indicators could help us reduce our environmental impact. We can reward environmentally sustainable businesses. Tax pollution & wastes instead of wages & profits. Environmental laws and regulations can discourage or encourage innovation. Using the marketplace to reduce pollution & resource waste. Reducing pollution & resource waste by selling services instead of things. Reducing poverty can help us to deal with environmental problems. We can use lessons from nature to shift to more Environmentally Sustainable Economies.

### **Textbooks/Reference Books**

1. Ecology by Charles J Krebs
2. Environmental Science by Miller
3. Environmental Science & Engineering by Henry & Heinke
4. Environmental Chemistry by Anil Kumar De

**B.Sc. Chemistry - Semester VI**  
**Mini project**  
**Subject Code: CH303B5**

**(Credit: Mini Project-04)**

**B.Sc. Chemistry - Semester VII**  
**Principles of Inorganic Chemistry**  
**Sub Code: CH401B1**

**(Credit: Theory-04)**

**Course Objective**

The course aims to strengthen the fundamentals of inorganic chemistry covering main group elements and inner transition elements.

**Course/Learning Outcome**

CO1: Identify and explain periodic properties of elements, structure and bonding in molecules, to assign structure and deduce properties of a given molecules.

CO2: Explain magnetic properties of molecules, and their application in deducing properties of a molecule.

CO3: Demonstrate synthesis, properties bonding of p-block elements and their compounds and applications.

CO4: Enable student to understand the synthesis, properties bonding of Boranes, Carboranes, Metallo-carboranes, Borazines, Phosphazenes, Sulfur-Nitrogen compounds, silicates, silicones. Iso- and Hetero-poly anions. Understand the concept of allotropy and its significance.

CO5: Enable student to understand Metal-Metal bonds, industrial importance of the compounds of main group elements. Brief review of inorganic chains, rings and cages, organometallic compounds of non-transition elements.

**Module I**

**Structure and Bonding**

(10 Lectures)

Structure and bonding in homo- and heteronuclear molecules: VSEPR Theory, VBT, MOT, Bent's rule, Fajan's rule, physical properties of molecules, (bond energies, force constants, bond lengths bond polarities and electronegativity).

**Module II**

**Magnetic Properties**

(08 Lectures)

Introduction of magnetic properties, paramagnetism, ferro and antiferro magnetism, diamagnetism, Pascal constants, Currie equation, determination of magnetic susceptibility. Orbital magnetic moment, spin magnetic moment, spin-orbit coupling, Russell-Saunders, j-j coupling scheme, quenching of orbital angular momentum by ligand fields, the Zeeman effect.

**Module III**

**Main Group Elements and Their Compounds**

(12 Lectures)

Synthesis, properties, structure and bonding of nitrogen, phosphorous, sulfur, pseudohalogen, Interhalogen and xenon compounds.

**Module IV**

**Brief Review of Inorganic Chains, Rings and Cages**

(10 Lectures)

Boranes, carboranes, metallo-carboranes, the isolobal analogy Borazines, phosphazenes, sulfur-nitrogen compounds, silicates, silicones. iso- and hetero-poly anions, allotropy.

## Module V

### General Periodic Trends

(08 Lectures)

Metals, compounds containing metal-metal bonds, metal clusters metal-metal quadruple and triple bonds, some reactions of compounds involving metal-metal multiple bonds, organometallic compounds of non-transition elements.

### Textbooks/Reference Books

1. Inorganic Chemistry, Principles of Structure and Reactivity - James E. Huheey, Ellen A. Keiter, Richard L. Keiter
2. Advanced Inorganic chemistry – F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann
3. Inorganic Chemistry - Shriver and Atkins
4. Inorganic Chemistry – G. L. Miessler, P. J. Fischer & D. A. Tarr

**B.Sc. CHEMISTRY – SEMESTER VII**  
**Principle of Organic Chemistry**  
**Subject Code: CH402B1**

**(Credits: Theory-04)**

**Course Objective:** This course gives the idea of MO's theory, acid-base concept, stereochemistry, Organic reaction intermediate.

**Course Outcome:**

CO1: Apply MOT for predicting reaction mechanisms.

CO2: Identify problems related to stereochemistry.

CO3: Explain and identify the role of carbocation in organic synthesis and nucleophilic substitution reaction.

CO4: Explain and identify the role of carbanion in organic synthesis and nucleophilic substitution reaction.

CO5: Explain and identify the role of neutral intermediate in organic synthesis and nucleophilic substitution reaction.

**Module - I**

**Principle of MO's Theory and its Application to Reactivity** (10 Lectures)  
Introduction, Molecular orbital - homonuclear, heteronuclear (both sigma and pi-bonded molecule), delocalization, tautomerism, aromaticity, anti-aromaticity etc. Huckel molecular orbital theory.

**Module -II**

**Stereochemistry II** (10 Lectures)  
Isomers – Classes of isomers, Isomerism – optical and geometrical Isomerism, Nomenclature of enantiomers – R.S. & E.Z. system. Elements of symmetry, Concept of chirality, Centre of chirality - molecules with C, N, S based chiral centers, molecules with more than one chiral center. Methods of resolution, optical activity in absence of chiral carbon, atropisomerism.  
Conformation analysis of cycloalkanes: Meaning of conformation, Effect of conformation on the stability and reactivity, Stereochemistry of six-membered rings, Mono-substituted and disubstituted cyclohexane, Decalines, Gauch butane interactions in substituted cyclohexanes and decalines.

**Module -III**

**Reactive Intermediates - I** (08 Lectures)  
Carbocation: Structure, and stability of carbocations, Classical and non-classical carbocation, C-C bond formation involving carbocations, Oxymercuration, halolactonisation. Acetal formation, Friedel-crafts reaction, Wagner-Meerwein rearrangement, Hydroperoxide rearrangement

**Module -IV**

**Reactive Intermediates - II** (08 Lectures)  
Carbanion: Structure and stability, Chemistry of enolates and enamines, Kinetic and thermodynamic enolates, alkylation and acylation of enolates, Nucleophilic additions to carbonyls, Introduction of Favorskii and Neber rearrangement.

## Module -V

### Reactive Intermediates - III

(12 Lectures)

Free radicals: Generation, structure, and stability of radical intermediates and their (a) addition to alkenes, alkynes (inter & intramolecular) for C-C bond formation (b) fragmentation and rearrangements.

Carbenes: Generation, structure and stability, Addition and insertion reactions.

Nitrenes: Generation, structure and stability, Reactions of nitrene and related electron deficient nitrogen intermediates, Hoffmann, Schmidt, Beckmann rearrangement reactions. Curtius rearrangement –mechanism challenges. Effect of structure on reactivity, The Hammett equation and linear free energy relationship (sigma-rho), Taft equation.

### Textbooks/Reference Books

1. Organic Chemistry, vol. I & II (ELBS)- Finar, I.L
2. Advanced Organic Chemistry -J. March, Willey Interscience
3. Organic Chemistry - O.P. Agrawal
4. A Guidebook to Mechanism in Organic Chemistry by Peter Sykes
5. Stereochemistry – Eliel
6. Stereochemistry – D. Nasipuri
7. Organic Chemistry – J. Clayden, N Greeves, S. Warren & P. Wothers

**B.Sc. Chemistry - Semester VII**  
**Chemical Thermodynamics**  
**Sub Code: CH403B1**

**(Credits: Theory-04)**

**Course Objective**

The study of entropy, free energy and work function relation with the change of various conditions and their mathematical application to understand third law, chemical potential, the phase equilibrium and statistical thermodynamics

**Course/Learning Outcome:**

CO1: Analyse fundamental concepts of solution thermodynamics involving ideal and non-ideal systems.

CO2: Explain solution thermodynamic concepts and phase equilibria in two-component and multi-component systems.

CO3: Explain Entropy of mixing and Work function.

CO4: Explain colligative properties and Raoult's law.

CO5: Explain Gibbs Duhem equation.

**Module I**

**Concept of Entropy**

(10 Lectures)

Entropy, Nature of  $dq$  and  $dq/T$ , Physical Significance of Entropy, Entropy of a Perfect Gas, Change of entropy with temperature and pressure, Entropy of mixing, Work function or Helmholtz free energy  $A$  and Gibbs free energy or Gibbs potential & their variation with the parameters of the system, Maxwell thermodynamic relation and its applications

**Module II**

**Colligative Properties**

(10 Lectures)

Clapeyron Clausius equation with derivation & application to various phase equilibrium, & Colligative properties - elevation of boiling point and depression of freezing points, Van't Hoff law of mass action & reaction isotherm, isochore, Raoult's law and its application.

**Module III**

**Gibb's Helmholtz Equations**

(08 Lectures)

Limitation of Gibb's Helmholtz concepts, Nernst heat theorem, its proof and application, Third law of thermodynamics, its application and exception of third law.

**Module IV**

**Gibbs Duhem Equation**

(10 Lectures)

Gibbs Duhem equation for open system, Thermodynamic criteria for equilibrium in open system, Concept of Fugacity & Activity, their significance, variation of Fugacity & Activity of a gas with pressure and temperature

**Module V**

**Reduced Phase Rule**

(10 Lectures)

Reduced Phase rule, Eutectic systems as lead silver system, potassium iodide-water system, Binary alloys system with congruent and incongruent melting points.

**Textbook/Reference Books**

1. Advance Physical Chemistry – D.N.Bajpai
2. Physical Chemistry – Silbey & Alberty
3. Physical Chemistry – Atkins
4. Physical Chemistry of Molecular Approach – Mc. Quarrie & Simon
5. Fundamentals of classical and Statistical Thermodynamics-B.N.Roy
6. Classical and Statistical Thermodynamics- A.H.Carter

**B.Sc. Chemistry - Semester VII**  
**Analytical Chemistry**  
**Subject Code: CH404B1**

**(Credits: Theory-04)**

**Course Objectives**

The course aims to introduce students to the fundamental principles of Analytical Chemistry. The course introduces the concept of errors and correct techniques for sampling and then delves into the various aspects of analytical chemistry viz, chemometrics, separation techniques followed by analytical techniques including instrumental methods of analysis

**Course/Learning Outcome:** On successful completion of this course students would be able to

CO1: Understand the scope of analytical chemistry and principles of chemometrics.

CO2: Discuss structure, factors and application of macrocyclic compounds and resins in separation.

CO3: Apply chromatographic techniques for separation of compounds.

CO4: Use solubility principles for quantitative precipitation of compounds.

CO5: Derive titration curves from basic principles of titrimetric analysis.

**Module I**

**Introduction to Analytical Chemistry** (10 Lectures)

Scope, methods of quantitative analysis, selection of method of analysis, steps in quantitative analysis and role of instrumentation in analytical chemistry.

**Errors**, classification of errors, determining and improving of accuracy in analysis, significant figures, distribution of random errors, Confidence interval, Comparison of results, student t-test, comparing the means of two samples, paired t test, F test, Q test, rejection of results, Correlation and Regression.

**Module II**

**Separation Techniques** (10 Lectures)

Crown ethers, cryptands and calixarenes in solvent extraction: classification, structure factors influencing solvent extraction and applications.

Ion exchange chromatography: characteristics of ion exchange resins, synthesis of ion exchange resin, classification of ion exchange resins, mechanism of ion exchange and equilibria, factors affecting ion exchange, Applications of ion exchange in deionization of water, metal separation

**Module III**

**Chromatography** (10 Lectures)

High performance liquid chromatography: Plate theory for chromatography, Van-Deemeter Equation, Instrumentation, working and applications of HPLC. Supercritical fluid chromatography: Instrumentation, working, applications and comparison with HPLC and GC.

Gas chromatography – Principles, instrumentation, working and applications

## Module IV

### **Gravimetric and Thermal Analysis** (10 Lectures)

Solubility, solubility product, fractional precipitation, quantitative effects of common ion. degree of dissociation of weak acids and bases. Gravimetric analysis, precipitation methods, purity of precipitate (co precipitation), optimum condition for precipitation, precipitation from homogeneous solution, washing and ignition of the precipitate, role of organic precipitate, criteria for choice of organic reagent, important organic precipitants. Numerical problems based on gravimetric analysis of mixtures.

Thermal Methods of Analysis: Thermogravimetric Analysis, DTA, DSC Instrumentation, Principles and their applications.

## Module V

### **Titrimetric Analysis** (08 Lectures)

Classification, basic principles of each class of titrations, theory of indicators, Titration curves for neutralization and redox titrations, Selectivity, Masking and demasking in complexometric titrations.

### **Textbooks/Reference Books**

1. Analytical Chemistry – S. M. Khopkar
2. Vogel's Quantitative Chemical Analysis – J Mendham, RC Denney, JD Barnes, MJK Thomas
3. Instrumental methods of analysis – Willard, Merit & Dean
4. Analytical Chemistry – Gray D. Christian

**B.Sc. Chemistry - Semester VII**  
**Physical Chemistry Lab**  
**Subject Code: CH403B4**

**(Credit – Lab 03)**

**Course Objectives:** The course aims to enable the students to understand the practical aspects of Physical Chemistry.

**Course/Learning Outcome:**

CO1: Ability to apply basic techniques of solution preparation and determine the aggregation process through Viscometric and conductometric methods.

CO2: Understand the experimental procedure to determine the kinetic parameters of selected reactions.

CO3: Ability to apply the knowledge of conductometric and potentiometric titration for determination of solubility of sparingly soluble salts.

CO4: Ability to determine the composition and complex formation through spectroscopic analysis.

CO5: Ability to execute electrochemical oxidation and reduction of  $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$  system by cyclic voltametric technique.

**List of Experiments**

1. To study the kinetics of iodination of acetone spectrophotometrically
2. To study the adsorption of acetic acid by activated charcoal from an aqueous solution
3. To determine the CMC of surfactant by surface tension method
4. To determine the CMC of surfactant by conductivity method
5. To determine the CMC of surfactant by spectrophotometer method
6. To determine the molecular mass of a polymer by viscosity method
7. To determine the energy of activation of hydrolysis of methyl acetate catalysed by hydrochloric acid
8. To determine the second order rate constant for the hydrolysis of ethyl acetate by sodium hydroxide conductometrically
9. To determine the dissociation constant of an indicator, methyl red by spectrophotometric method
10. Determination of the concentration of sulphuric acid, acetic acid and copper sulphate by conductometric titration
11. To determine the formula of the complex formed between copper (II) ion and ammonia
12. To study the redox behaviour of  $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$  by cyclic voltammetry

**Texts Books/Reference Books**

1. Experimental Physical Chemistry – V. D. Athawale & Parul Mathur
2. Practical in Physical Chemistry – A Modern Approach-P. S. Sindhu
3. Experimental Physical Chemistry – Shoemaker & Nibler
4. Experimental Physical Chemistry – Farrington Daniels
5. Findlay's Practical Physical Chemistry- B. P. Levitt

**B.Sc. Chemistry - Semester VII**  
**Analytical Chemistry Lab**  
**Sub Code: CH404B4**

**(Credits: Lab-03)**

**Course Objectives**

The course aims to enable the students to apply the principles of analytical chemistry to the analysis of unknown chemical samples. This course is meant to complement the theoretical course.

**Course/Learning Outcome**

CO1: Independently perform separation of components.

CO2: Perform accurately volumetric and gravimetric analysis.

CO3: Ability to analyse results.

CO4: Ability to perform quantitative estimation of alkali ions.

CO5: Interpret UV-Vis and FTIR Spectra.

**List of Experiment of Analytical Chemistry Laboratory**

1. Volumetric Analysis
  - i) Acid - Base – Neutralization
  - ii) Redox Titration (Including Iodometric Titration)
  - iii) Precipitation Titration
  - iv) Complexometric Titration
2. Gravimetric Analysis: At least one experiment involving each of the following:
  - i) High temperature ignition compounds
  - ii) Use of organic precipitants
  - iii) Precipitation from Homogenous solutions
3. Solvent Extraction Experiments (Separation Volumetric Analysis may be combined)
4. Flame Photometry
  - i) Estimation of Na<sup>+</sup>
  - ii) Estimation of K<sup>+</sup>
  - iii) Estimation of Na<sup>+</sup> and K<sup>+</sup> in a mixture
5. Spectrophotometric Analysis: Iron and Copper
6. Demonstration of the following experiments:
  - i) TGA & DSC
  - ii) Cyclic Voltammetry
  - iii) Florescence Spectroscopy

**Textbooks/Reference Books**

1. Analytical Chemistry – S.M. Khopkar
2. Vogel's Quantitative Chemical Analysis – J Mendhan, RC Denncy, JD Barnes, MJK Thomas
3. Instrumental methods of analysis – Willard, Merit & Dean
4. Analytical Chemistry- Gray D. Christian

**B.Sc. Chemistry - Semester VIII**  
**Modern Spectroscopy Techniques**  
**Subject Code: CH405B1**

**(Credits: Theory-04)**

**Course Objective**

Introduction to various techniques of spectroscopy used in chemistry. Detailed interpretation of spectra to identify unknown compounds. Introduction to advanced techniques for interpretation of complex spectra.

**Course/Learning Outcome**

CO1: Explain fundamentals of spectroscopy and solve numerical problems (determination of spectroscopic quantities, molar absorption coefficient).

CO2: Explain fundamentals of rotational spectroscopy, interpret spectra and solve numerical problems (determination of rotational constants, bond length).

CO3: Demonstrate fundamentals of vibrational spectroscopy, interpret spectra and solve numerical problems. (determination of force constant/bond energy). Explain fundamentals of Raman spectroscopy and structure determination.

CO4: Elucidate fundamentals of electronic spectroscopy of atoms and molecules, interpret spectra and solve numerical problems.

CO5: Explain fundamentals of NMR and EPR spectroscopy, interpret spectra and solve numerical problems.

**Module I**

**Introduction to Molecular Spectroscopy** (08 Lectures)

Characterization of electromagnetic radiation, quantization of energy, S/N ratio, width and spectral intensity of spectral transition, F.T. Spectroscopy, stimulated emission. Types of molecular spectroscopy different types of molecular energies, Boltzmann distribution.

**Module II**

**Microwave Spectroscopy** (08 Lectures)

Introduction, rotational energy level, selection rule, simple harmonic oscillator, anharmonic oscillator, bond-distance of a diatomic molecule, relative population and intensity of the absorption peaks, polyatomic molecules, limitations of microwave spectroscopy.

**Module III**

**Infrared and Raman Spectroscopy** (12 Lectures)

Introduction, the range of infrared spectroscopy, theory of I.R., SHO, vibrating diatomic molecule as anharmonic oscillator, diatomic molecule as a harmonic oscillator and a rigid rotator, interaction of rotations and vibrations, polyatomic molecules, limitations of I. R. spectroscopy.

Raman Spectroscopy – pure rotational Raman spectra, vibrational Raman spectra, polarization of light and the Raman effect, structure determination from Raman and I. R. spectroscopy, techniques and instrumentation, near IR FT-Raman spectroscopy.

## Module IV

### Electronic Spectroscopy (12 Lectures)

Electronic Spectroscopy of Atoms – Electronic wave functions, energies of atomic orbitals, electronic angular momentum, hydrogen atom spectrum, spectrum of many electron atoms, term symbols, microstate table, photoelectron spectroscopy, Zeeman effect.

Electronic Spectroscopy of Molecules – Born-Oppenheimer Approximation, vibrational-electronic spectra, Franck Condon Principle, dissociation energy and products, fine structure, Fortrat diagram, change of shape on excitation, chemical analysis by electronic spectroscopy.

## Module V

### Spin Resonance Spectroscopy (08 Lectures)

NMR; NMR absorption by nuclei. Theory of NMR spectra, Spin-Spin and Spin-Lattice Relaxation, Multiple Pulse FT, chemical shift, shielding effects, deshielding effects, coupling constant, exchange phenomena, simplification of complex spectra, <sup>13</sup>C NMR, Spectroscopy - double resonance. Application- structure determination, Keto-enol Tautomerism, limitations of NMR spectroscopy. Electron paramagnetic resonance – Theory of EPR spectra. Application- structure determination

### Texts Books/Reference Books

1. Fundamentals of Molecular Spectroscopy – C.N. Banwell and E.N. McCash
2. Modern Spectroscopy – J. Michael Hollas
3. Symmetry and Spectroscopy – Daniel C. Harris
4. Spectroscopic Methods in Organic Chemistry – H. D. Williams and I. Flemming
5. Organic Spectroscopy – William Kemp
6. Spectroscopy of Organic Compounds – P.S. Kalsi

**B.Sc. Chemistry - Semester VIII**  
**Organic Reactions and Mechanisms**  
**Sub Code: CH406B1**

**(Credits: Theory-04)**

**Course Objective**

This course will give an idea about organic reaction mechanism, substitution, elimination, addition reaction. This will also highlight molecular rearrangement reactions

**Course/Learning Outcome:**

CO1: Assess various aspects of a reaction mechanism to establish it.

CO2: Identify and apply substitution reaction based on substrate nature, used reagents and reaction conditions in organic synthesis.

CO3: Explain and identify the type of rearrangement reactions

CO4: Identify and apply elimination reaction based on substrate nature, used reagents and reaction conditions in organic synthesis.

CO5: Identify and apply addition reaction based on substrate nature, used reagents and reaction conditions in organic synthesis.

**Module I**

**Mechanism and its Investigation**

(10 Lectures)

Introduction, Energy profile diagram, Thermodynamics and kinetics requirement for reactions, Thermodynamic vs kinetic control, Hammond's postulate. Methods of determining mechanism - characterization of intermediate, nature of products, solvent effect, isotope effect, kinetic evidence, stereochemical evidence, microscopic reversibility, conclusion

**Module II**

**Aliphatic & Aromatic Nucleophilic Substitutions**

(08 Lectures)

Definition of substitution reaction, types, The SN1, SN2 mechanisms, factors affecting the mechanism, neighbouring group effect, SNi, SN1', SN2/Nucleophilic substitution at an allylic, vinyl carbon, Nucleophilic aromatic substitutions, Benzyne, SNAr mechanism.

**Module III**

**Molecular Rearrangement**

(09 Lectures)

Definition, Types of rearrangement reaction, 1,2-Rearrangement – types and examples, Pinacol-pinacolone rearrangement, Dienone-phenol rearrangement, Benzil-benzilic acid rearrangement, Wolff rearrangement, Tiemann rearrangement, The Arndt-Eistert synthesis, The Baeyer -Villiger rearrangement, The Wittig Rearrangement, The Wallach rearrangement.

**Module IV**

**Elimination Reactions**

(09 Lectures)

Definition, types and examples, Beta Elimination, Alpha elimination, Cis eliminations, Discussion of E1, E2, E1CB Mechanism and orientation. Orientation of the double bond, Saytzeff and Hofmann rules. Stereochemistry of E2 reactions. Pyrolytic eliminations, Stereochemistry of syn- elimination, Eliminations Vs substitutions.

Reaction formation of Carbon-carbon and carbon-heteroatom multiple bonds - Shapiro reaction, Peterson reaction, Julia reaction, deoxygenation of *vic*-diol, Ramberg-Backlund reaction, Dehalogenation of vicinal dihalides.

## Module V

### Addition Reactions

(12 Lectures)

Definition, Addition to multiple bonds, electrophilic addition mechanism, Markownikoff's rule, Kharasch effect, Nucleophilic mechanism, Addition to diene, Cyclic mechanism (Diels-Alder reaction), Addition to C-C double and C-C triple bond - halogenations, addition of amine, ene reaction, Michael reaction, 1,4-addition, alkylation, acylation, reaction with OsO<sub>4</sub>, and KMnO<sub>4</sub>, Prevost reaction, 1,3-dipolar addition,

Addition to C-O double bond - Formation of acetal and ketal, formation of dithiane, Formation of imine and enamine, Stork enamination reaction, Mannich reaction, Grignard reaction, Claisen condensation, Strecker synthesis, Prins reaction.

Addition to C-N double and C-N triple bond - hydrolysis (acid or base catalysis), addition to amine, Thorpe reaction, Ritter reaction.

### Textbooks / Reference Books

1. Advanced Organic Chemistry – J. March, Wiley Interscience
2. Mechanism and Structure in Organic Chemistry – E. S. Gould (Holt, Rinehart and Winston) A
3. Guidebook to Mechanism in Organic Chemistry – Peter Sykes
4. Organic Chemistry – J. Clayden; N. Greeves; S. Warren; P. Wothers

**B.Sc. Chemistry - Semester VIII**  
**Project/Dissertation\*(1 year project)**  
**Subject Code: CH401B6**

**(Credit – Project/Dissertation-08)**

**B.Sc. Chemistry - Semester VIII**  
**Biochemistry**  
**Subject Code: CH407B1**

**(Credits: Theory-04)**

**Course Objective**

The objective of this paper is to introduce the chemical nature of biomolecules and various types of biochemical reactions involved in chemistry of life. Biochemistry is a well-established exciting discipline, and a very promising research area for M.Sc. Chemistry pass outs.

**Course/Learning Outcomes**

CO1: Apply basic knowledge of biomolecules, biochemical solvents, important functional groups, importance of non-covalent bonds in biochemistry and biochemical thermodynamics.

CO2: Demonstrate fundamental knowledge of four classes of protein structure and their associated functions.

CO3: Demonstrate basic knowledge of different classes of carbohydrate and lipid structures and their associated functions.

CO4: Apply knowledge and understanding of different types of enzymes and enzyme kinetics

CO5: Apply basic understanding of DNA and RNA structure, genetic code, protein synthesis and genetic control.

**Module I**

**Introduction to Biochemistry**

(10 Lectures)

Functional groups of biochemical importance.

Water as a biochemical solvent, unique physico-chemical properties of water, importance of hydrogen bond in water and biomolecules, Biochemical evolution of life, how do cells use energy? – connection between metabolic reactions and energy, Spontaneity in biochemical reactions – connections thermodynamics and life, Biochemical aspects of cellular structure, Microscopy in biochemistry – standard light microscope, scanning and transmission electron microscopes – SEM & TEM

**Module II**

**Protein**

(10 Lectures)

Basic structure of amino acids, stereoisomerism, classification of 20 essential amino acids.

Peptide bond and primary structure of protein, Alpha helix and beta pleated sheet structure of protein (secondary structure), Supramolecular structure of collagen triple helix with functional importance, Tertiary structure of protein with special reference to myoglobin, important non-covalent and hydrophobic interactions in tertiary structures, Application of XRD and NMR techniques to delineate tertiary structures, Quaternary structures of protein with special reference to Haemoglobin

**Module III**

**Carbohydrate and Lipid**

(08 Lectures)

Carbohydrate – Monosaccharide, disaccharide and polysaccharide.

Lipid metabolism – Fatty acids, fatty acid breakdown, properties and functions of triglycerides, phospholipids and glycolipids.

#### **Module IV**

##### **Enzymes and Enzyme kinetics**

(10 Lectures)

General characteristics and the role of enzymes, holoenzyme, apoenzyme, coenzymes, prosthetic groups. Factors affecting enzyme activity- pH, temperature, enzyme and substrate concentrations, Allosteric enzymes, Cooperativity, concerted and sequential models.

What makes enzymes such effective biological catalysts? How can we describe enzyme kinetics in mathematical terms? How do substrates bind to enzymes? Michaelis-Menten equation for unimolecular reaction.

Reversible and irreversible inhibition; competitive, non-competitive and uncompetitive inhibitions with determination of  $K_M$  and  $V_{max}$ .

#### **Module V**

##### **Nucleic Acids**

(10 Lectures)

Basic structure of nucleotides. Formation of dinucleotides and polynucleotides. Structure of DNA. X-ray diffraction double helix model of DNA. Features of DNA molecule. Structure of RNA. DNA replication. DNA replication is semiconservative. About genes. Genetic code. Genetic code is triplet code. Evidence for a triplet code. Breaking the genetic code. Features of genetic code. Transcription. Protein synthesis. Non-coding DNA. Introns and exons. Gene control. Jacob-Monod hypothesis of gene control. Enzyme Induction. Control of metabolic pathways. Modification to the operon hypothesis.

##### **Textbooks/Reference Books**

1. Biochemistry – Lehninger
2. Instant Notes in Biochemistry – B D Hames, N M Hooper & J D Houghton Viva Books Private Limited
3. Biochemistry – Mathews & Holde Pearson Education
4. Biochemistry – Campbell & Farrell Thompson
5. Biological Science by Taylor & Green Cambridge University Press
6. Biochemistry – Rastogi Tata McGrawHill
7. Modern Biotechnology – S B Primrose Blackwell Scientific Publication

**B.Sc. Chemistry - Semester VIII**  
**Quantum Chemistry-I**  
**Subject Code: CH408B1**

**(Credits: Theory-04)**

**Course Objective**

The aim of this course is to make students understand the limitations of classical mechanics and the need of quantum chemistry, familiarize them with postulates of quantum chemistry and apply the same to derive equations for various models and hydrogen atoms. Understand the basis of molecular spectroscopy and its applications.

**Course/Learning Outcome**

CO1: Analyse limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.

CO2: Explain and understand of quantum mechanical operators.

CO3: Analyse quantization, probability distribution, uncertainty principle.

CO4: Identify application of quantization to spectroscopy.

CO5: Interpret various types of spectra and know about their application in structure elucidation.

**Module I**

**Beginning of Quantum Mechanics** (10 Lectures)

Black body radiation, Planck's hypothesis of Black Body radiation. Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Uncertainty relations (with proof). Uncertainty of energy and time.

**Module II**

**Concept of Operators** (10 Lectures)

Elementary concepts of operators, Algebra of Operators, quantum mechanical operators: Commutation of operators, commutator and uncertainty relation, Linear operators, linear and Angular momentum operators, eigenfunctions and eigenvalues; Linear operators; Expectation value; Properties of Hermitian operator. Postulates of quantum mechanics.

**Module III**

**Wave Equation** (10 Lectures)

Theory of wave motion, Classical wave equation, separation of variables, Wave functions and meaning, Acceptable wave functions, Normality and Orthogonality of wave functions, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy Extension to two and three dimensional boxes, separation of variables, degeneracy.

## Module IV

### Rigid Rotator

(08 Lectures)

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

## Module V

### Vibrational Spectroscopy

(10 Lectures)

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

### Textbooks/Reference Books

1. R. K. Prasad. Quantum Chemistry, New Age International Publishers (Fourth revised Edition).
2. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.; 47th Ed. (2017)
3. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 1) McGraw Hill Education; Sixth edition (2019)

**B.Sc. Chemistry - Semester VIII  
Dissertation  
Subject Code: CH402B6**

**(Credits: Dissertation-04)**