B.Sc. CHEMISTRY – SEMESTER I
Communication Skills
SUBJECT CODE: BA10101A

(Credits: Theory-02)

Course Objectives:
The course is intended to familiarize students with effective communication strategies by improvingtheir 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.

Pre-requisites: No departmental pre-requisites required

Learning Outcomes:
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 andcomprehension.
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.

**not more than 20% of total topics to be allotted for assignment

Module I

Introduction to Communication Skills:
Theory of Communication, Types and modes of Communication
Fundamentals of Communication SkillsProcess of Communication
Types of Communication Flows of Communication Barriers to CommunicationTypes of Listening
7 C's of Communication
Verbal Communication- 3 V's ofCommunication
Non Verbal Communication- Types ofBody Language. **(6 Lectures)**
****AssignmentTopics**

Module II

Vocabulary and Comprehension Skills:
Precise Writing Expansion of ideas Comprehension Skills
Vocabulary: One Word substitution,Foreign Words Commonly used in
English, Synonyms, Antonyms, Idioms. **(6 Lectures)**
****AssignmentTopics**

Module III

Writing Skills:
Paragraph Writing, Summarizing,Paraphrasing and Note making Reported Speech.
Report Writing: Performance AppraisalReport, Disciplinary Report, InspectionReport, 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 ofMeeting,
Job application (including Resume /Bio data)

E-mail Writing. **(6 Lectures)**
****AssignmentTopics**

Module IV

Grammar:
Parts of Speech
Time, Tense and Aspect
Correct Usage of Adjectives, Adverbs,Nouns, and Prepositions. **(6 Lectures)**
****AssignmentTopics**

Module V

Phonetics:
Study of Speech sounds- Pure vowels,Diphthongs, Consonants
Description of Consonant SoundsPlace of Articulation
Manner of Articulation.
Syllable, Stress, Problem Sound forIndian Speakers.
Intonation. **(6 Lectures)**
****AssignmentTopics**

Text 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)

Reference Books:

1. Mehra, Payal, Business Communication for Managers. (Pearson)
2. Miglani, Seema & Goyal, Shikha. English for Professional. (VEI)

B.Sc. CHEMISTRY – SEMESTER I
Inorganic Chemistry - I
SUBJECT CODE: CH10101A

(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. Accompanying laboratory course is designed for students to have hands-on experience of basic quantitative analytical techniques related to volumetric titrations.

Learning Outcome: On successful completion, students would have a clear understanding of the concepts related to atomic and molecular structure, chemical bonding, periodic properties and redox behaviour of chemical species. Students will also have hands on experience of standard solution preparation in different concentration units and learn volumetric estimation through acid-base and redox reactions.

Module I

Atomic Structure:
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 ψ and $\psi 2$. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. **(12 Lectures)**

Module II

Periodicity of Elements:
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 gain enthalpy, trends of electron gain enthalpy. **(12 Lectures)**

Module III

Chemical Bonding:
(i) lonic 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 and its application, Solvation energy.
(ii) Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.
(iii) 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. **(12 Lectures)**

Module IV

Chemical Bonding:

Covalent bond: Lewis 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 (σ and π 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. **(12 Lectures)**

Module V

Oxidation-Reduction:

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class. **(12 Lectures)**

Recommended 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
Inorganic Chemistry Lab - I
SUBJECT CODE: CH10401A

(Credits: Practical – 02)

(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 $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(ii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Recommended Books:

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

B.Sc. CHEMISTRY – SEMESTER I
Physical Chemistry - I
SUBJECT CODE: CH10102A

(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.

Learning Outcome: By the end of the course, students will be able to: Derive mathematical expressions for different properties of gas, liquid and solids and understand their physical significance. Explain the crystal structure and calculate related properties of cubic systems. Explain the concept of ionization of electrolytes with emphasis on weak acid and base and hydrolysis of salt. Apply the concepts of gas equations, pH and electrolytes while studying other chemistry courses and everyday life.

Module I

Gaseous state: Kinetic molecular model of a gas: 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 σ from η; 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.

Behaviour of real gases: 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, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. 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. **(18 Lectures)**

Module II

Liquid state: 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. **(6 Lectures)**

Module III

Molecular and Crystal Symmetry: Elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices. **(6 Lectures)**

Module IV

Solid state: 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). **(10 Lectures)**

Module V

Ionic equilibria: 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. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants. **(20 Lectures)**

Recommended Books:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co. (2017)
6. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 1) McGraw Hill Education; Sixth edition (2019)

B.Sc. CHEMISTRY – SEMESTER I
Physical Chemistry Lab - I
SUBJECT CODE: CH10402A

(Credits: Practical-02)

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.

Recommended 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 I
Generic Elective- I
Chemistry - I
SUBJECT CODE: CH10201A

(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.
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.

Learning Outcome: On successful completion, students would have a clear understanding of the concepts related to atomic and molecular structure, chemical bonding, periodic properties and redox behaviour of chemical species.
By the end of the course, students will be able to: Derive mathematical expressions for different properties of solids and understand their physical significance. Explain the crystal structure and calculate related properties of cubic systems. Explain the concept of ionization of electrolytes with emphasis on weak acid and base and hydrolysis of salt. Apply the concepts of gas equations, pH and electrolytes while studying other chemistry courses and everyday life.

Module I

Atomic Structure:
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 ψ and $\psi 2$. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. (**12 Lectures)**

Module II

Periodicity of Elements:
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.

g. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
h. Atomic radii (van der Waals)
i. Ionic and crystal radii.
j. Covalent radii (octahedral and tetrahedral)
k. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
l. Electron gain enthalpy, trends of electron gain enthalpy. (**12 Lectures)**

Module III

Molecular and Crystal Symmetry: Elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices. **(6 Lectures)**

Module IV

Solid state: 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). **(10 Lectures)**

Module V

Ionic equilibria: 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. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants. **(20 Lectures)**

Recommended 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
Generic Elective Lab - I
Chemistry Lab - I
SUBJECT CODE: CH10419A

(Credits: Practical – 02)

(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.

Recommended Books:

1. Mendham, J. et al.: Vogel's Text Book 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 II
Environmental Studies
SUBJECT CODE: CH10103A

(Credits: Theory-02)

Course Objective:
Investigate the complexities of the natural environment and our relationship with it.
Explore the problems we face in understanding our natural environment and in living sustainability.
Learning Outcome:
Graduate students will be able to become effective scientific communicators/collaborators in multidisciplinary teams providing technical leadership to engage with the challenging environmental problems of local, national and global nature.

Module I

Introduction to Environment:
Definition, Principles and Scope of Environmental Science.
Socio-economic reasons behind environmental problems. **(5 Lectures)**

Module II

Ecosystem:
Definition of Ecosystem. Structure and functions of ecosystem; Energy flow in an ecosystem: food chains, energy quality, energy and money, ecological succession. Concepts of carrying capacity and sustainability

Examples of ecosystems: Freshwater Ecosystems and Techno ecosystem **(7 Lectures)**

Module III

Atmosphere, hydrosphere and Lithosphere:
Evolution, composition and layers of atmosphere. Water chemistry and its environmental significance.
Lithosphere, rocks and minerals. **(6 Lectures)**

Module IV

Environmental Pollution:
Air Pollutants – Carbon Monoxide, Nitrogen di oxide and Sulphur Dioxide. Acid rain.
Toxicity – Biochemical effects of Lead and Mercury
Biochemical Oxygen Demand (BOD) – Carbonaceous and Nitrogenous with numerical
Global Issues: Global warming and Ozone Depletion **(7 Lectures)**

Module V

Biodiversity Conservation:
Definition of biodiversity, reasons behind conservation of biodiversity, Conservation of rare and endangered species. Field visit (Equivalent to one lecture, 1 Lectures) **(4+1=5 Lectures)**

References:

1. Introduction to Environmental Engineering and Science by Gilbert M Masters, Prentice Hall.
2. Fundamentals of Ecology by Eugene P Odum. Thompson.
3. Environmental Chemistry by A K De. New Age Internationals.
4. Environmental Geology by Carla Montgomery. McGraw Hill publication.
5. Environmental Science by G Tyler Miller. Cengage learning.
6. Biological Science by Taylor and Green. Cambridge low price edition.

B.Sc. CHEMISTRY – SEMESTER II
Universal Human Values
SUBJECT CODE: GN10101A

(Credits: Theory-02)

Course Objectives:

The aim of this course is to make students

- Understand of human values is the root cause of all problems and the sustained solution could emerge only through understanding of human values and value based living. Any solution brought out through fear, temptation or dogma will not be sustainable.
- Understanding Harmony in the Human Being, in the Family, in the Society, in the Nature and Implications of the above Holistic Understanding of Harmony on Professional Ethics.

Learning Outcomes:

By the end of the course, students will be able to:

• The students start exploring themselves;
• The students start finding that technical education without study of human values can generate more problems than solutions
• The students are able to see that respect is right evaluation, and only right evaluation leads to fulfillment in relationship among family, Society ad nature.
• The students are also able to make use of their understanding in the course for a happy and prosperous society.

Module I

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Understanding the need, basic guidelines, content and process for Value Education
2. Self- Exploration–what is it? - its content and process; „Natural Acceptance‟ and Experiential Validation- as the mechanism for self-exploration
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfill the above human aspirations: understanding and living in **harmony** at various levels. **(6 Lectures)**

Module II

Understanding Harmony in the Human Being - Harmony in Myself

7. Understanding human being as a co-existence of the sentient „I‟ and the material „Body‟
8. Understanding the needs of Self („I‟) and „Body‟ - Sukh and Suvidha.
9. Understanding the Body as an instrument of „I‟ (I being the doer, seer and enjoyer)
10. Understanding the characteristics and activities of „I‟ and harmony in „I‟
11. Understanding the harmony of I with the Body: *Sanyam* and *Swasthya*; correct appraisal of Physical needs, meaning of Prosperity in detail
12. Programs to ensure *Sanyam* and *Swasthya*

-Practice Exercises and Case Studies will be taken up in Practice Sessions. **(5 Lectures)**

Module III

Understanding Harmony in the Family - Harmony in Human- Human Relationship

13. Understanding harmony in the Family-the basic unit of human interaction
14. Understanding values in human-human relationship; meaning of *Nyaya* and program for its fulfillment to ensure *Ubhay-tripti*; Trust (*Vishwas)* and Respect (*Samman)* as the foundational values of relationship
15. Understanding the meaning of *Vishwas*; Difference between intention and competence.
16. Understanding the meaning of *Samman*, Difference between respect and differentiation; the other salient values in relationship. **(4 Lectures)**

Module IV

Understanding Harmony in the Society - Harmony in Human- Human Relationship and Harmony in the Nature and Existence - Whole existence as Co-existence

17. Understanding the harmony in the society (society being an extension of family): *Samadhan, Samridhi, Abhay, Sah-astitva* as comprehensive Human Goals
18. Visualizing a universal harmonious order in society- Undivided Society (*Akhand Samaj),* Universal Order (*Sarvabhaum Vyawastha)*- from family to world family.
    - Practice Exercises and Case Studies will be taken up in Practice Sessions.
19. Understanding the harmony in the Nature
20. Interconnectedness and mutual fulfillment among the four orders of nature - recyclability and self-regulation in nature
21. Understanding Existence as Co-existence (*Sah-astitva*) of mutually interacting units in all-pervasive space
22. Holistic perception of harmony at all levels of existence

- Practice Exercises and Case Studies will be taken up in Practice Sessions.

(9 Lectures)

Module V

Implications of the above Holistic Understanding of Harmony on Professional Ethics

23. Natural acceptance of human values
24. Definitiveness of Ethical Human Conduct
25. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
26. Competence in professional ethics:

a. Ability to utilize the professional competence for augmenting universal human order
b. Ability to identify the scope and characteristics of people-friendly and eco- friendly production systems,
c. Ability to identify and develop appropriate technologies and management patterns for above production systems.

27. Case studies of typical holistic technologies, management models and production systems
28. Strategy for transition from the present state to Universal Human Order:

d. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
e. At the level of society: as mutually enriching institutions and organizations

(6 Lectures)

B.Sc. CHEMISTRY – SEMESTER III
Leadership and Behaviour Management
SUBJECT CODE: GN10102A

(Credits: Theory-02)

Objectives of the course:

- 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.

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: 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. **(6 Lectures)**

Module II

VALUES & ETHICS: 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. **(6 Lectures)**

Module III

THINKING AND REASONING: 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- **M**eaning, 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. **(5 Lectures)**

Module IV

EMOTIONAL INTELLIGENCE & COPING WITH STRESS: 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.
(6 Lectures)

COMMUNICATION: 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. **(4 Lectures)**

Module V

INTERPERSONAL RELATIONSHIPS: 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. **(5 Lectures**)

LEADERSHIP & TEAM BUILDING: 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. **(4 Lectures)**

Text & References:

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 II
Organic Chemistry I
SUBJECT CODE: CH10104A

(Credits: Theory-04)

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 stereo chemical considerations.
Learning Outcome: Students will be able to identify different classes of organic compounds, describe their reactivity and explain/analyze their chemical and stereo chemical aspects.

Module I

Basics of Organic Chemistry
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; Nucleophlicity 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. **(8 Lectures)**

Module II

Stereochemistry:
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, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. **(16 Lectures)**

Module III

Chemistry of Aliphatic Hydrocarbons
A. Carbon-Carbon sigma bonds
Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity. **(10 Lectures)**

Module IV

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), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and antihydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.
Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.
C. Cycloalkanes and Conformational Analysis
Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams. **(14 Lectures)**

Module V

Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups. **(12 Lectures)**

Recommended 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
Organic Chemistry Lab I
SUBJECT CODE: CH10403A

(Credits: Practical-02)

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)

Recommended 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 II
Physical Chemistry II
SUBJECT CODE: CH10105A

(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, equilibrium and colligative properties.

Learning Outcome: By the end of the course, students will be able to: Understand the three laws of thermodynamics, concept of State and Path functions, extensive and intensive properties. Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for ideal gases under different conditions. Explain the concept of partial molar properties. Explain the thermodynamic basis of colligative properties and applications in surroundings.

Module I

Chemical Thermodynamics: 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. Law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. **(12 Lectures)**

Module II

Thermochemistry: 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. Adiabatic flame temperature, explosion temperature. Second Law: 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. **(12 Lectures)**

Module III

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. **(5 Lectures)**

Free Energy Functions: 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. **(7 Lectures)**

Systems of Variable Composition: Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **(8 Lectures)**

Module IV

Chemical Equilibrium: 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 Kp, Kc and Kx. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase. **(8 Lectures)**

Module V

Solutions and Colligative Properties: 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. **(8 Lectures)**

Recommended 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
Physical Chemistry Lab II
SUBJECT CODE: CH10404A

(Credits: Practical-02)

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 ΔH.

Any other experiment carried out in the class.

Recommended 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 II
Generic Elective- II
Chemistry- II
SUBJECT CODE: CH10202A

(Credits: Theory-04)

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 stereo chemical considerations.
Learning Outcome: Students will be able to identify different classes of organic compounds, describe their reactivity and explain/analyze their chemical and stereo chemical aspects.

Module I

Basics of Organic Chemistry
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; Nucleophlicity 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. **(8 Lectures)**

Module II

Stereochemistry:
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, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. **(16 Lectures)**

Module III

Chemistry of Aliphatic Hydrocarbons
A. Carbon-Carbon sigma bonds
Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity. **(10 Lectures)**

Module IV

Chemical Equilibrium: 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 Kp, Kc and Kx. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase. **(8 Lectures)**

Module V

Solutions and Colligative Properties: 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. **(8 Lectures)**

Recommended 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
Generic Elective Lab -II
Chemistry Lab - II
SUBJECT CODE: CH10420A

(Credits: Practical-02)

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 ΔH.

Recommended 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 III
Inorganic Chemistry II
SUBJECT CODE: CH10106A

(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. As part of the accompanying lab course, experiments involving iodo- and iodimetric titrations are included for the students to explore other varieties of redox titration. Preparation of simple inorganic compounds is introduced to give hands-on experience of inorganic synthesis.

Learning Outcome: On successful completion of this course students would be able to apply theoretical principles of redox chemistry in the understanding of metallurgical processes. Students will be able to identify the variety of s and p block compounds and comprehend their preparation, structure, bonding, properties and uses. Experiments in this course will boost their quantitative estimation skills and introduce the students to preparative methods in inorganic chemistry.

Module I

Acids and Bases
Brönsted-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. **[10 Lectures]**

Module II

Chemistry of s and p Block Elements I:
Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements.
Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. **[12 Lectures]**

Module III

Chemistry of s and p Block Elements II:
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, silanes, oxides and oxoacids of nitrogen, phosphorus and chlorine.
Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens. **[18 Lectures]**

Module IV

Noble Gases:
Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF2). Molecular shapes of noble gas compounds (VSEPR theory). **[10 Lectures]**

Module V

Inorganic Polymers:
Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Silicates – clays and zeolites, polyphosphazenes, metal-organic framework compounds (MOFs). **[10 Lectures]**

Recommended 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, 3rd 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
Inorganic Chemistry Lab II
SUBJECT CODE: CH10405A

(Credits: Practical-02)

(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, $MnPO_4.H_2O$
(iii) Preparation of aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.

Recommended Books:

1. Mendham, J. et al.: Vogel's Text Book 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 III
Organic Chemistry II
SUBJECT CODE: CH10107A

(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, analyze and design transformations between different functional groups.

Learning Outcome: Students will be able to describe and classify organic compounds in terms of their functional groups and reactivity.

Module I

CHEMISTRY OF HALOGENATED HYDROCARBONS (16 HRS)
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. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Module II

ALCOHOLS, PHENOLS, ETHERS, AND EPOXIDES: ALCOHOLS (16 HRS)
preparation, properties, and relative reactivity of 1°, 2°, 3° 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 effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism; Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4.

Module III

CARBOXYLIC ACIDS AND THEIR DERIVATIVES (10 HRS)
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 sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

Module IV

CARBONYL COMPOUNDS 1 (10 HRS)
Preparation, properties, structure and reactivity; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Module V

CARBONYL COMPOUNDS 2 (4 HRS)

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

SULPHUR CONTAINING COMPOUNDS (4 HRS)

Preparation and reactions of thiols, thioethers and sulphonic acids.

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
Organic Chemistry Lab II
SUBJECT CODE:CH10406A

(Credits: Practical-02)

ORGANIC PREPARATIONS:

1. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (a) Using conventional method. (b) Using green approach.
2. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β-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-Benzylisothiouronium 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.

Recommended 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 III
Physical Chemistry III
SUBJECT CODE: CH10108A

(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.

Learning Outcome: By the end of the course, students will be able to: Understand phase equilibrium, criteria, CST, Gibbs-Duhem-Margules equation. Learn the working of electrochemical cells, galvanic cell, corrosion and happenings in surroundings related to electrochemistry.

Module I

Phase Equilibria: Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solidliquid,liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. (14 Lectures)

Module II

Binary solutions: 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. (14 Lectures)

Module III

Chemical Kinetics Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, 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. Reaction mechanism- steady-state approximation and rate determining step approximation methods. (18 Lectures)

Module IV

Catalysis: 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. (8 Lectures)

Module V

Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms, nature of adsorbed state. (6 Lectures)

Recommended Books:

1. Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Pres s (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 III
Physical Chemistry Lab III
SUBJECT CODE: CH10407A

(Credits: Practical-02)

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

2. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems.

3. Distribution of acetic/ benzoic acid between water and cyclohexane.

4. Study the equilibrium of at least one of the following reactions by the distribution method: (i) I2(aq) + I→ I3(aq)2+ (ii) Cu2+(aq) + nNH3 → Cu(NH3)n

5. Study the kinetics of the following reactions.
   (i) Initial rate method: Iodide-persulphate reaction.
   (ii) Integrated rate method: a. Acid hydrolysis of methyl acetate with hydrochloric acid. b. Saponification of ethyl acetate.
   (iii) Compare the strengths of HCl and H2SO4 by studying kinetics of hydrolysis of methyl acetate.

6. Adsorption I. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Recommended 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).

B.Sc. CHEMISTRY – SEMESTER III
Analytical Tools in Chemistry
(Skill Enhancement Course)
SUBJECT CODE: CH10301A

(Credits: Theory-03)

Course Objective: This is an elective 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. Experiments included aim at giving students a hands on experience using different chemical as well as physical techniques of separation, characterization and quantitative chemical analysis of samples.

Learning outcome: On successful completion students will be have theoretical understanding about choice of various analytical techniques used for qualitative and quantitative separation, characterization and analysis of samples. At the same time through the experiments students will gain hands on experience of the discussed techniques. This will enable students to take judicious decisions while analysing different samples.

Module I

Errors and sampling

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.
Sampling: Sampling techniques for solids, liquids and gases, sampling statistics and statistical criteria of good sampling, variability in the sample, hazards of sampling.

(12 Lectures)

Module II

Solvent extraction

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

(12 Lectures)

Module III

III Partition and Electro Chromatography

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, electrodialysis. capillary electrophoresis and its applications.

(12 Lectures)

Module IV

Optical methods of analysis

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. Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

(12 Lectures)

Module V

Electroanalytical & Thermal methods:

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.
Theory of thermogravimetry (TG), basic principle of instrumentation.
Techniques for quantitative estimation of Ca and Mg from their mixture, analysis of alloys.

(12 Lectures)

Recommended Books:

1. Mendham, J. et al.: Vogel's Text Book 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 III
Project Based Seminar
SUBJECT CODE: CH10601A

(Credits: 01)

B.Sc. CHEMISTRY – SEMESTER IV
Inorganic Chemistry III
SUBJECT CODE: CH10109A

(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. Through the accompanying lab course, experiments related to gravimetric analysis, synthesis of coordination compounds and separation of metal ions using chromatography is included. This will broaden the experimental skills of the students where students will learn about various aspects of experiment design depending upon the requirements like synthesis, estimation or separation.

Learning Outcome: On successful completion, students will be able name coordination compounds according to IUPAC, explain bonding in this class of compounds, understand their various properties in terms of CFSE and predict reactivity. Students will be able to appreciate the general trends in the properties of transition elements in the periodic table and identify differences among the rows. Through the experiments students not only will be able to prepare, estimate or separate metal complexes/compounds but also will be able to design experiments independently which they should be able to apply if and when required.

Module I

Coordination Chemistry:
Coordination compounds, types of ligands, Werner's theory, IUPAC nomenclature and isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. **[10h]**

Module II

Coordination Chemistry:
Valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspects of ligand field and MO Theory. Chelate effect, polynuclear complexes, labile and inert complexes. **[16h]**

Module III

Transition Elements:
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. **[14h]**

Module IV

Lanthanoids and Actinoids:
Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). **[8h]**

Module V

Bioinorganic Chemistry:
Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. 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; Storage and transfer of iron. **[12h]**

Recommended 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.
3. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry, Panima Publishing Company, 1994.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH, 2007.
5. Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
6. Greenwood, N.N. & Earnshaw, A., Chemistry of the Elements, 2nd Ed., Elsevier India,2010.

B.Sc. CHEMISTRY – SEMESTER IV
Inorganic Chemistry Lab III
SUBJECT CODE: CH10408A

(Credits: Practical-02)

Gravimetric Analysis
i. Estimation of nickel(II) using dimethylglyoxime (DMG).
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe2O3 by precipitating iron as Fe(OH)3.
iv. Estimation of Al (III) by precipitating with oxine and weighing as Al(oxine)3 (aluminium oxinate).
v. Estimation of Ba as $BaSO_4$

Inorganic Preparations:
i. Tetraamminecopper(II) sulphate, [Cu(NH3)4] SO4.H2O
ii. Cis and trans K[Cr(C2O4)2. (H2O)2] Potassium dioxalatodiaquachromate (III)
iii. Tetraamminecarbonatocobalt (III) ion
iv. Potassium tris(oxalato)ferrate(III)

Chromatography of metal ions Principles involved in chromatographic separations. Paper chromatographic separation of
following metal ions:
i. Ni(II) and Co(II)
ii. Fe(III) and Al(III)

Recommended Book:
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 NostrandReinhold. 1972.
3. Inorganic Syntheses, Vol. 1-10.

B.Sc. CHEMISTRY – SEMESTER IV
Organic Chemistry III
SUBJECT CODE: CH10110A

(Credits: Theory-04)

Course Objectives: The course intrudes 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.

Learning Outcome: Students shall demonstrate the ability to identify and classify different types of N-based derivatives, alkaloids and heterocyclic compounds/explain their structure mechanism and reactivity/critically examine their synthesis and reactions mechanism.

Module I

NITROGEN CONTAINING FUNCTIONAL GROUPS (18 HRS)
Preparation and important reactions of nitro and 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 HRS)
Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

Module III

HETEROCYCLIC COMPOUNDS 1 (12 HRS)
Classification and nomenclature, Structure, aromaticity in 5-numbered 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

HETEROCYCLIC COMPOUNDS 2 (10 HRS)
Quinoline and isoquinoline: Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction

Module V

ALKALOIDS (6 HRS)
Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

TERPENES (6 HRS)
Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α-terpineol.

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 IV
Organic Chemistry Lab III
SUBJECT CODE: CH10409A

(Credits: Practical-02)

1. Detection (i) N, (ii) S and (iii) halogens in organic compounds.
2. Functional group test for (i) nitro, (ii) amine and (iii) amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (i) alcohols, (ii) carboxylic acids, (iii) phenols and (iv) carbonyl compounds.

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).

B.Sc. CHEMISTRY – SEMESTER IV
Physical Chemistry IV
SUBJECT CODE: CH10111A

(Credits: Theory-04)

Course Objective: This course aims to make the students understand conductance, anomaly of strong electrolytes, laws governing migration of ions in solutions and application of conductance measurement for titration methods and have understanding of kinetics of chemical reaction, catalysis and photochemical reactions.

Learning Outcome: By the end of the course, students will be able to: Explain the chemistry of conductance and its variation with dilution, migration of ions in solutions. Learn the applications of conductance measurements. Have understanding of rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatic. Have knowledge of the laws of absorption of light energy by molecules and the subsequent photochemical lreactions.

Module I

Electrode potential, half reactions, origin of electrode potential – measurement of electrode potential, Nernst equation and its applications, electrochemical series & its applications, electrochemical cell and its classifications (galvanic cell, electrolytic cell), types of electrodes (reference electrodes- standard hydrogen electrode, calomel electrode, silver-silver chloride electrode and indicator electrodes- hydrogen electrode, quinhydrone electrode), electromotive force. (10 Lectures)

Module II

Conductance: 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. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. (15 Lectures)

Module III

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. (20 Lectures)

Module IV

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. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. (6 Lectures)

Module V

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; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Applications of electrolysis in metallurgy and industry. (9 Lectures)

Recommended 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 IV
Physical Chemistry Lab IV
SUBJECT CODE: CH10410A

(Credits: Practical-02)

Conductometry:

I. Determination of cell constant

II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

III. Perform the following conductometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Mixture of strong acid and weak acid vs. strong base iv. Strong acid vs. weak base Potentiometry I Perform the following potentiometric titrations: 31 i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Dibasic acid vs. strong base

iv. Potassium dichromate vs. Mohr's salt

Recommended 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).

B.Sc. CHEMISTRY – SEMESTER IV
Fundamentals of Molecular Spectroscopy
(Skill Enhancement Course – II)
SUBJECT CODE: CH10302A

(Credits: Theory-03)

Course Objective: The aim of this course is to introduce the students to fundamentals of different molecular spectroscopy such as rotational, vibrational, Raman, electronic, electronic spectroscopy. It will also be introduced how quantum mechanical ideas in some simple systems such as particle in a box, rigid rotor, simple harmonic oscillator etc are applied in spectroscopic techniques.

Learning Outcome: After completion of this course, students are expected to learn about the different spectroscopic techniques and to understand the basics of various kinds of spectroscopic techniques and basics of how to use spectroscopic data in determination of molecular properties.

Module I

Origin of spectra, interaction of radiation with matter, Spectroscopy and its importance in chemistry. Absorption and Emission Spectrometry, Difference between atomic and molecular spectra, Link between spectroscopy and quantum chemistry, Fundamental laws of spectroscopy and selection rules, Born-Oppenheimer approximation. [**12 Lectures]**

Module II

Rotation spectroscopy: Schrödinger equation of a rigid rotator and brief discussion of its results (Solution not required). Quantization of rotational energy levels. Microwave (pure rotational) spectra of diatomic molecules. Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. [**12 Lectures]**

Module III

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels, Selection rules, Amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, Diatomic vibrating rotator, P, Q, R branches, IR spectra of diatomic molecules.

Raman spectroscopy: Classical Treatment. Rotational Raman Effect; Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. **[12 Lectures]**

Module IV

Electronic Spectroscopy: Potential energy curves (diatomic molecules), Frank-Condon principle and vibrational structure of electronic spectra; Frank Condon factor. **[12 Lectures]**

Module V

Electronic Spectroscopy: Bond dissociation and principle of determination of dissociation energy (ground state); Decay of excited states by radiative and non-radiative paths; Pre-dissociation; Fluorescence and phosphorescence. **[12 Lectures]**

References:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. Hollas J. Modern Spectroscopy. Wiley.
4. Kapoor K.L. A Text Book of Physical Chemistry, McGraw Hill India.
5. Barrow, G. M. Molecular Spectroscopy, McGraw-Hill.
6. McHale, J. L. Molecular Spectroscopy, Pearson Education.

B.Sc. CHEMISTRY – SEMESTER IV
Project Based Seminar
SUBJECT CODE: CH10602A

(Credits: 01)

B.Sc. CHEMISTRY – SEMESTER V
Organic Chemistry IV
(Biomolecules)
SUBJECT CODE: CH10112A

(Credits: Theory-04)

Course Objectives: 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.

Learning Outcome: Students will be able to explain/describe the important features of nucleic acids, amino acids, enzymes, lipids and carbohydrate. Students will able to examine their properties and applications after doing this course.

Module I

Nucleic Acids **(9 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 **(16 Lectures)**
Amino acids, Peptides and their classification.
α-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 active site of enzymes. Mechanism of enzyme action (taking trypsin as 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, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Module IV

Lipids **(8 Lectures)**
Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Module V

Carbohydrates **(17 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.
Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

Reference Books:

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) Biochemistry. VIth 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 V
Organic Chemistry Lab IV
SUBJECT CODE: CH10411A

(Credits: Practical-02)

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

Reference Books:

1. Arthur, I. V. Quantitative Organic Analysis, Pearson.
2. Plummer, D. T. An Introduction to Practical Biochemistry, 3rd Edition, McGraw Hill.
3. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.

B.Sc. CHEMISTRY – SEMESTER V
PHYSICAL CHEMISTRY V
SUBJECT CODE: CH10113A

(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.

Learning Outcome: By the end of the course, students will be able to: Learn about limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems. Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle and application of quantization to spectroscopy. Interpret various types of spectra and know about their application in structure elucidation

MODULE I

Quantum Chemistry: Postulates of quantum mechanics, quantum mechanical operators, 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. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. **(12 Lectures)**

MODULE II

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution. Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom). Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules. **(12 Lectures)**

MODULE III

Molecular Spectroscopy: Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

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. Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear

spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. **(12 Lectures)**

MODULE IV

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. **(12 Lectures)**

MODULE V

Photochemistry Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence. **(12 Lectures)**

Recommended Books:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
4. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 4) McGraw Hill Education; 5th edition (2017)

PHYSICAL CHEMISTRY LAB V
SUBJECT CODE: CH10412A

(Credits: 02)

UV/Visible spectroscopy I.

Study the 200-500 nm absorbance spectra of KMnO4 and K2Cr2O7 (in 0.1 M H2SO4) and determine the λmax values. Calculate the energies of the two transitions in different units (J molecule-1, kJ mol-1, cm-1, eV).

II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of K2Cr2O7.

III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

I. Verify Lambert-Beer's law and determine the concentration of CuSO4/KMnO4/K2Cr2O7 in a solution of unknown concentration

II. Determine the concentrations of KMnO4 and K2Cr2O7 in a mixture.

III. Study the kinetics of iodination of propanone in acidic medium.

IV. Determine the amount of iron present in a sample using 1,10-phenathroline.

V. Determine the dissociation constant of an indicator (phenolphthalein).

VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

VII. Analysis of the given vibration-rotation spectrum of HCl(g)

Recommended 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).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

B.Sc. CHEMISTRY – SEMESTER V
Applications of Computers in Chemistry
(DSC – I) (Discipline Specific Elective Paper)
SUBJECT CODE: CH10303A

(Credits: Theory-04)

Theory: 60 Lectures

Course Objective: This course intends to make learners familiar with basics of C language, computer programming using C and numerical methods, handling of experimental data, curve fitting etc to analyse experimental results. This basic knowledge will help the students to perform and interpret results of various chemistry practicals.

Learning Outcome: After the completion of this course the students will be able to write simple programs in C. They will be able to write programs for numerical methods which will enable them to compute, interpret and present results based on data obtained from experiments. The learners will also be able to use software commonly used by chemists like Chem Draw, origin etc.

Module I

Basics of C
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. **(12 Lectures)**

Module II

Loops in C
Conditional statements, while, do while and for loops, logical operators. Typical programs using these loops. **(12 Lectures)**

Module III

Arrays and Functions
1 Dimensional and 2 Dimensional arrays, Matrix addition and multiplication, Functions/ sub routines in C and related programs. **(12 Lectures)**

Module IV

Numerical methods I:
Roots of equations: Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi. **(12 Lectures)**

Module IV

Numerical methods II
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. **(12 Lectures)**

Recommended 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
Applications of Computers in Chemistry Lab
(DSC – I) (Discipline Specific Elective Paper Lab)
SUBJECT CODE: CH10413A

(Credits: 02)

1. Computer programs illustrating the use of conditional statements, loops, arrays and functions. At least 12 programs.
2. Computer programs based on numerical methods for the following.

a. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
b. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
c. Numerical integration (e.g. entropy/ enthalpy changes from heat capacity data), probability distributions (gas kinetic theory) and mean values.
d. Correlation and regression, curve fitting
e. Simple exercises using molecular visualization software and other software commonly used in Chemistry like Chem Draw, Origin etc.

Recommended Books:

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
5. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007)
6. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001)
7. Rajaraman, V. Computer programming in C. Prentice-Hall of India
8. Balaguruswamy, E. Numerical Methods Tata McGraw Hill publication

B.Sc. CHEMISTRY – SEMESTER V
Renewable Energy
(DSC – II) (Discipline Specific Elective Paper)
SUBJECT CODE: CH10304A

(Credits: Theory-03)

Course Objective:
To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of solar wind and Alternative Sources of Energy. 2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding solar wind and Alternative Sources of Energy

Learning Outcome:
CO1. Conceptual knowledge of the technology, economics and regulation related issues associated with solar wind and alternative sources of energy CO2. Ability to analyse the viability of wind and alternative energy projects CO3. Capability to integrate various options and assess the business and policy environment regarding wind and alternative energy projects CO4. Advocacy of strategic and policy recommendations on usage of wind and alternative energy

Module I

Definition of renewable energy.
Solar Energy: Direct and indirect uses of solar energy. Solar radiation and its spectral characteristics. Solar Thermal Energy: rooftop solar water heater, domestic water heating. Solar collectors. Solar ponds. Ocean Thermal Energy Conversion (OTEC). Environmental impact of solar thermal heating system. Solar photovoltaics: A brief history of PV. PV in silicon: basic principles. Costs of energy from PV. Environmental impact and safety. **(15 Lectures)**

Module II

Bioenergy: Biomass as fuel. Biomass as a solar energy store. Conversion efficiencies. Bioenergy sources I – Energy crops, woody crops, agricultural crops. Bioenergy sources II – wood residues, temperate crop wastes, tropical crop wastes, animal wastes, municipal solid wastes, landfill gas and commercial and industrial wastes. Combustion: Wood and crop residues, charcoal, combustion of municipal solid wastes. Production of gaseous fuels from biomass: Anaerobic digestion, gasification. Fermentation to produce ethanol. Vegetable oils to biodiesel. Environmental benefits and impacts of bioenergy. **(15 Lectures)**

Module III

Hydroelectricity: The scheme. The turbines. Hydro resource. Stored energy and available power. Types of hydroelectric plant. The Francis turbine. Impulse turbines. Turgo and cross flow turbines. Small-scale hydroelectricity. Environmental considerations. **(10 Lectures)**

Module IV

Wind Energy: The wind. Wind turbines. Wind turbine types. Aerodynamics of wind turbine. Power and energy from wind turbines. Environmental impacts of wind turbines. **(10 Lectures)**

Module V

Geothermal Energy: Introduction. The source of heat. The physics of geothermal resources. Volcano-related heat sources and fluids. The heat source in sedimentary basins. Geothermal waters. Technologies for geothermal resource exploitation. Environmental implications. **(10 Lectures)**

Recommended Books:

1. Fundamentals and applications of renewable energy by Kanoglu and Cengel
2. Renewable Energy Technology, Economics and Environment by Martin Kaltschmitt and Wolfgang Streicher
3. Introduction to renewable energy for engineers by Kirk Hagen
4. Renewable energy systems by David Buchla and Thomas Kissell.

B.Sc. CHEMISTRY – SEMESTER V
Renewable Energy Lab
(DSC – II) (Discipline Specific Elective Paper Lab)
SUBJECT CODE: CH10414A

(Credits: 02)

Course Objective:

To gain the practical knowledge on various renewable energy gadgets.

Learning Outcome:

On completion of the lab course, the students will be exposed to renewable energy sources and their applications.

List of Experiments

1. Characterization of biomass – proximate analysis
2. Determination of caloric value of fuels – solids and gases
3. Design of KVIC / Deenbandhu model biogas plant
4. Study of UASB biomethanation plant
5. Purification of biogas – CO2 and H2S removal
6. Performance evaluation of agro based gasifier
7. Study on pyrolysis unit – Biochar, Charcoal and Tar making process
8. Automatic weather station – Analysis of wind data and prediction
9. Testing of solar water heater
10. Testing of natural convection solar dryer
11. Study on Solar power and I-V Characteristics
12. Testing of solar photovoltaic water pumping system

Recommended Books:

1. Khandelwal, K.C. and Mahdi, S.S. Biogas Technology. Tata Mc Graw Hill Pub. Co. Ltd., New Delhi, 1986.
2. Nijaguna, B. T. Biogas Technology New Age International Pvt. Ltd., New Delhi, 2006.
3. Rao. S and B.B. Parulekar. Energy Technology – Non conventional, Renewable and Conventional. Khanna Publishers, New Delhi, 2000.
4. Solanki, C.S. Solar Photovotaics – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., New Delhi, 2011.

B.Sc. CHEMISTRY – SEMESTER V
Project Based Learning
SUBJECT CODE: CH10603A

(Credits: 01)

B.Sc. CHEMISTRY – SEMESTER VI
Inorganic Chemistry IV
SUBJECT CODE: CH10114A

(Credits: Theory-04)

Course Objectives: The course aims to introduce the learners to the synthetic process, properties and the utility of the industrially important inorganic materials (such as silicates, ceramics, cements, fertilizers, paints, batteries, alloys and explosives). The course also provides an opportunity to the students to learn about some of the industrial process such as surface coating and catalysis relevant to industry where heterogeneous catalysis dominates. Experiments are aimed at helping learners acquire hands on experience in qualitative and quantitative analysis of the inorganic materials which are basically manufactured in chemical industries. To learn some industrial techniques such as surface coating etc.

Learning Outcome: At the end of this course the students will be able to understand the basic foundation of industrial inorganic chemistry. This will be helpful for pursuing further studies of industrial chemistry in future. Experiments will help the students to gather the experience of qualitative and quantitative chemical analysis. Students will be capable of doing analysis of the inorganic materials which are used in our daily life.

Module I

Silicate Industries

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides,fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements. **[12h]**

Module II

Surface Coatings:

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels,emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing. **[12h]**

Module III

Batteries:

Primary and secondary batteries, battery components and their role, Characteristics of battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell. **[12h]**

Module IV

Alloys:

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels. **[12h]**

Module V

Catalysis:
General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.
Phase transfer catalysts, application of zeolites as catalysts. **[12h]**

Recommended Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. Karl Heinz Büchel, Hans-Heinrich Moretto Peter, Woditsch; Industrial Inorganic Chemistry, Wiley-VCH.
5. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
6. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
7. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
8. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut

B.Sc. CHEMISTRY – SEMESTER VI
Inorganic Chemistry Lab IV
SUBJECT CODE: CH10415A

(Credits: Practical-02)

60 Lectures

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Determination of composition of dolomite (by complexometric titration).
5. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
6. Analysis of Cement.
7. Preparation of pigment (zinc oxide).

Recommended Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut

B.Sc. CHEMISTRY – SEMESTER VI
Organic Chemistry V
SUBJECT CODE: CH10115A

(Credits: Theory-04)

Course Objectives: This course introduces students to a brief about Spectroscopy, Concept of Energy in Bio System, Pharmaceuticals molecules, Polymers and Dyes.
Students will be familiarized with the importance of Spectroscopy in organic chemistry, The functionality of Bio molecules in Human physiology, The various drug molecules etc.

Learning Outcome: Students will be able to explain/describe the important features of Spectroscopy, Bio molecules and various Drug molecules

Module I

Organic Spectroscopy (24 Lectures)

General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward, Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpetation of NMR spectra of simple compounds.
Applications of IR, UV and NMR for identification of simple organic molecules.

Module II

Concept of Energy in Biosystems (7 Lectures)

Cells obtain energy by the oxidation of foodstuff (organic molecules).
Introduction to metabolism (catabolism, anabolism).
ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change.
Agents for transfer of electrons in biological redox systems: NAD+, FAD.
Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle.
Overview of catabolic pathways of fat and protein.
Interrelationship in the metabolic pathways of protein, fat and carbohydrate.

Caloric value of food, standard caloric content of food types.

Module III

Pharmaceutical Compounds: Structure and Importance (12 Lectures)
Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis),
Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Module IV

Dyes **(8 Lectures)**

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of:

Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet;

Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Module V

Polymers **(9 Lectures)**

Introduction and classification including di-block, tri-block and amphiphilic polymers;

Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);

Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives;

Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

Reference Books:

1. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
4. Nelson, D.L., Cox, M.M. and Lehninger, A. L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
5. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
8. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan (2010).
9. Kemp, W. Organic Spectroscopy, Palgrave
10. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
11. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.

B.Sc. CHEMISTRY – SEMESTER VI
Organic Chemistry Lab V
SUBJECT CODE: CH10416A

(Credits: Practical-02)

(Any Five Experiment)

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

Recommended Books:

1. Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

B.Sc. CHEMISTRY – SEMESTER VI
(DSE – III, Discipline Specific Elective Paper)
Inorganic Materials of Industrial Importance
SUBJECT CODE: CH10305A

(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.

Learning Outcome: By studying this course the students will learn about how ligand substitution and redox reactions take place in coordination complexes. Students will also learn about organometallic compounds, comprehend their bonding, stability, reactivity and uses. They will be familiar with the variety of catalysts based on transition metals and their application in industry. On successful completion, students in general will be able to appreciate the use of concepts like solubility product, common ion effect, pH etc. in analysis of ions and how a clever design of reactions, it is possible to identify the components in a mixture. With the experiments related to coordination compound synthesis, calculation of 10Dq, controlling factors etc. will make the students appreciate the concepts of theory in experiments.

Module I

Mechanism of Inorganic Reactions

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, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes. Electron transfer reactions. **[8h]**

Module II

Organometallic Compounds

Definition and classification of organometallic compounds on the basis of 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. π-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. **[10h]**

Module III

Organometallic Compounds

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. **[10h]**

Module IV

Transition Metals in Catalysis

Study of the following industrial processes and their mechanism:
1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation (Co catalysts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes **[6h]**

Module V

Theoretical Principles in Qualitative Inorganic Analysis (H_2S Scheme)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II. **[6h]**

Recommended Books:

1. Vogel, A.I. Qualitative Inorganic Analysis, Longman, 1972.
2. Svehla, G. & Sivasankar, B., Vogel's Qualitative Inorganic Analysis, 7th Ed., Prentice Hall, 2012.
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. 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.
6. Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
7. Douglas, B.E. and Mc Daniel, D.H., Concepts and Models of Inorganic Chemistry, 3rd Ed. Wiley India, 2006.
8. Greenwood, N.N. & Earnshaw, A., Chemistry of the Elements, 2nd Ed., Elsevier India, 2010.
9. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
10. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
11. Shriver, D.D. & Atkins, P., Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
12. Basolo, F. & Person, R. Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed.., John Wiley & Sons Inc; NY.
13. Purcell, K.F. & Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co. 1977
14. Miessler, G. L. & Tarr, D. A., Inorganic Chemistry 4th Ed., Pearson, 2010.
15. Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals. J New York, NY: John Wiley, 2000.
16. Spessard, Gary O., &Gary L. Miessler. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.

B.Sc. CHEMISTRY – SEMESTER VI
Inorganic Materials of Industrial Importance Lab
SUBJECT CODE: CH10417A

(Credits: Practical-02)

• Qualitative semimicro analysis of mixtures containing at 3 or 4 acid, basic and interfering acid radicals. Emphasis should be given to the understanding of the chemistry of different reactions.
• Spot tests should be done whenever possible.
• Synthesis of ammine complexes of Ni (II) and their ligand exchange reactions involving bidentate ligands like acetylacetone, dimethylglyoxime, glycine, etc.
• Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}.
• Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs. thermodynamic factors.
• Determination of ε_{max} value from UV-visible spectra of complexes.
• Measurement of 10 Dq by spectrophotometric method, verification of spectrochemical series.

Recommended Books

1. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
2. Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold.1972.

B.Sc. CHEMISTRY – SEMESTER VI
(DSE – III, Discipline Specific Elective Paper)
Novel Inorganic Solids
SUBJECT CODE: CH10306A

Credit: 4

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.

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.

Module I

Synthesis and modification of inorganic solids:
Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods. **(12 Lectures)**

Module II

Inorganic solids of technological importance:
Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments. Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, metal containing liquid crystals. **(12 Lectures)**

Module III

Nanomaterials:
Overview of nanostructures and nanomaterials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and artificial nanomaterials, bionano composites. **(12 Lectures)**

Module IV

Composite materials:
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. **(12 Lectures)**

Module V

Speciality polymers:
Ceramics & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications. **(12 Lectures)**

Recommended Books:

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

B.Sc. CHEMISTRY – SEMESTER VI
Novel Inorganic Solids Lab
SUBJECT CODE: CH10418A

(Credits: Practical-02)

1. Sol-gel synthesis (Pechini method) of Metal oxide.
2. Precipitation/Co-precipitation method of metal oxide/hydroxide synthesis
3. Layer by layer deposition of film by successive ionic layer adsorption and reaction (SILAR) on glass substrate.
4. Hydrothermal technique for deposition of film on substrate.
5. Synthesis of metal nanoparticles.

B.Sc. CHEMISTRY – SEMESTER VI
Project Based Learning
SUBJECT CODE: CH10604A

(Credits: 04)

B.Sc. CHEMISTRY – SEMESTER VII
Research Ethics
SUBJECT CODE:

(Credits: Theory-02)

Course Objectives: To understand the philosophy of science and ethics, research integrity and publication ethics. To identify research misconduct and predatory publications.

Learning Outcome: At the end of the course the student will have awareness about the publication ethics and publication misconducts.

Module I

PHILOSOPHY AND ETHICS (7 HRS)
Introduction to philosophy: definition, nature and scope, concept, branches. Ethics: definition, moral philosophy, nature of moral judgements and reactions.

Module II

SCIENTIFIC CONDUCT 1 (5 HRS)
Ethics with respect to science and research. Intellectual honest and research integrity. Scientific misconducts: falsification, fabrication, and plagiarism.

Module III

SCIENTIFIC CONDUCT 2 (5 HRS)
Redundant publications: duplicate and overlapping publications, salami slicing. Selective reporting and misrepresentation of data.

Module IV

PUBLICATION ETHICS 1 (7 HRS)
Publication ethics: definition, introduction, and importance. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types.

Module V

PUBLICATION ETHICS 2 (6 HRS)
Violation of publication ethics, authorship, and contributor ship. Identification of publication misconduct, complaints and appeals. Predatory publishers and journals.

Reference Books:

1. The Ethics of Teaching and Scientific Research. By Miro Todorovich; Paul Kurtz; Sidney Hook.
2. Research Ethics: A Psychological Approach. By Barbara H. Stanley; Joan E. Sieber; Gary B. Melton.
3. Research Methods in Applied Settings: An Integrated Approach to Design and Analysis. By Jeffrey A. Gliner; George A. Morgan Lawrence Erlbaum Associates, 2000.
4. Ethics and Values in Industrial-Organizational Psychology. By Joel Lefkowitz Lawrence Erlbaum Associates, 2003.

B.Sc. CHEMISTRY – SEMESTER VII
Research Methodology
SUBJECT CODE:

(Credits: Theory-04)

Course Objectives: This course is introduced to impart knowledge about the basic concepts of research and to provide a road map for conducting research.

Learning Outcome: After completing this course, students should be able to construct a rational research proposal to generate fruitful output in terms of publications and patents in the field of chemical sciences.

Module I

LITERATURE SURVEY 1 (6 Lectures)

Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, textbooks, current contents,

Module II

LITERATURE SURVEY 2 (8 Lectures)

Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities.

Module III

LITERATURE SURVEY 3 (6 Lectures)

Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus. Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Module IV

CHEMICAL SAFETY AND ETHICAL HANDLING OF CHEMICALS 1 (5 Lectures)

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards.

Module V

CHEMICAL SAFETY AND ETHICAL HANDLING OF CHEMICALS 2 (5 Lectures)

Procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

REFERENCE BOOKS:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
4. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.

B.Sc. CHEMISTRY – SEMESTER VII
Research Project
SUBJECT CODE: CH10605A

(Credits: 14)

B.Sc. CHEMISTRY – SEMESTER VIII
Research Project
SUBJECT CODE:CH10606A

(Credits: Theory-20)