

**Syllabus
and
Course Content
for
B.Sc-M.Sc. Integrated
Programme
in
Chemistry
(Choice Based Credit System)**



Department of Chemistry
Faculty of Science
JAMIA HAMDARD
(HAMDARD UNIVERSITY)
Hamdard Nagar, New Delhi-110062

Outline of Scheme:

- **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
- **Elective Course:** Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.
- **Discipline Specific Elective (DSE) Course:** Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective.
- **Dissertation/Project:** An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
- **Generic Elective (GE) Course:** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
 - **Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course:** The Ability Enhancement (AE) are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines.

Scheme of B.Sc. Component of the B.Sc-M.Sc. Integrated Programme as proposed for Jamia Hamdard:

Semester	CORE COURSES (CC) (14) Credits: Th:4, P:2	Ability Enhancement Compulsory Courses (AEC) (2) Credits: Th:2	Skill Enhancement Courses (SEC) (2) Credits: Th:2	Discipline Specific Elective (DSE) (4) Credits: Th:4, P:2	Generic Electives (GE) (4) Credits: Th:4, P:2	Total Credits 140
I	BCH-CC01 TH (4 C) BCH-CC01-TU (2 C)	BCH-AEC01: English Communication (2 C)			BCH-GE01 TH (4C)	20
	BCH-CC02 TH (4 C)	BCH-AEC02: Environment Studies (2 C)			BCH-GE01-TU (2C)	
II	BCH-CC03 TH (4 C)				BCH-GE02 TH(4 C)	20
	BCH-CC04 TH (4 C)					
	BCH-CC05 TH (4 C)					
	BCH-CC06 TH (4 C)					
III	BCH-CC07 TH (4 C)		BCH-SEC (2 C) <i>(Any one from SEC-01 to SEC-06)</i>		BBT-GE03TH(4 C)	26
	BCH-CC08 TH (4 C)					
	BCH-CC09 TH (4 C)					
	BCH-CC10 TH (4 C)					
	BCH-CC11 TH (4 C)					
IV	BCH-CC02 PR (2 C)		BCH-SEC (2C) <i>(Any one from SEC-01 to SEC-06, except one opted in Semester III)</i>		BBC-GE04 TH(4 C)	26
	BCH-CC03 PR (2 C)					
	BCH-CC04 PR (2 C)					
	BCH-CC05 PR (2 C)					
	BCH-CC06 PR (2 C)					
	BCH-CC12 TH (4 C)					
	BCH-CC13 TH (4 C)					
V	BCH-CC14 TH (4 C)			BCH-DSE TH (4) DSE PR (2) <i>(Any three from DSE I-IX)</i>		24
	BCH-CC07 PR (2 C)					
VI	BCH-CC08 PR (2 C)			BCH-DSE TH (4C) BCH-DSE PR (2C) <i>(Any one from DSE I-IX, except those opted in Semester V)</i>	BCH-GE02 PR (2C)	24
	BCH-CC09 PR (2 C)					
	BCH-CC10 PR (2C)					
	BCH-CC11 PR (2C)					
	BCH-CC12 PR (2C)					
	BCH-CC13 PR (2C)					
	BCH-CC14 PR (2C)					
					BBT-GE03 PR (2C)	

TH-Theory; P-Practical; Tu-Tutorial

List of Papers

- **Core Papers (CC): (Credit: 06 each; TH:04, Tu/P:02)** (4 periods/week for theory and practical or 2 periods/week for tutorial)

BCH-CC01.	Basics of computer science and statistics (4 + 2)
BCH-CC02.	Basics of chemistry(4 + 2)
BCH-CC03.	Inorganic Chemistry I: Chemistry of s- and p-block Elements (4 + 2)
BCH-CC04.	Physical Chemistry I: States of Matter & Ionic Equilibrium (4 + 2)
BCH-CC05.	Organic Chemistry I: Hydrocarbons (4 + 2)
BCH-CC06.	Physical Chemistry II: Phase Equilibria and Chemical Kinetics (4 + 2)
BCH-CC07.	Organic Chemistry II: Halogens,Oxygen and Nitrogen Containing Functional Groups(4 + 2)
BCH-CC08.	Inorganic Chemistry II: Coordination Chemistry (4 + 2)
BCH-CC09.	Organic Chemistry III: Heterocyclic and Natural Product Chemistry (4 + 2)

BCH-CC10.	Physical Chemistry III Electrochemistry (4 + 2)
BCH-CC11.	Organic Chemistry IV: Biomolecules (4 + 2)
BCH-CC12.	Physical Chemistry IV: Quantum Chemistry & Spectroscopy (4 + 2)
BCH-CC13.	Inorganic Chemistry IV: Organometallic Chemistry (4 + 2)
BCH-CC14.	Organic Chemistry IV: Spectroscopy and Polymers(4 + 2)

- **Discipline Specific Elective Papers: (Credit-06 each: TH:4, P:2)** (4 periods/week for theory and practical or 2 periods/week for tutorial): **(4 papers to be selected)**

BCH-DSE-01.	Analytical Methods in Chemistry (4) + Lab (2)
BCH-DSE-02.	Molecular Modelling & Drug Design (4) + Lab (2)
BCH-DSE-03.	Novel Inorganic Solids (4) + Lab (2)
BCH-DSE-04.	Polymer Chemistry (4) + Lab (2)
BCH-DSE-05.	Green Chemistry (4) + Lab (2)
BCH-DSE-06.	Industrial Chemicals & Environment (4) + Lab (2)
BCH-DSE-07.	Inorganic Materials of Industrial Importance (4) + Lab (2)
BCH-DSE-08.	Instrumental Methods of Analysis (4) + Lab (2)
BCH-DSE-09.	Dissertation

- **Generic Electives GE 01 to GE 04 (Credit- 06 each: TH:4, P:2)** 4 periods/week for theory and practical or 2 periods/week for tutorial):

Any **one** of the following (GE 01) in Semester I

1. Basics of Physics and Biology
2. Basics of Physics and Maths

Any **three** Generic Elective papers to be chosen from the papers offered by other departments.

BIOLOGICAL SCIENCES (Any Three)	Maths (Any Three)	Computer Science (Any Three)
1. Any three papers to be chosen from the generic elective papers offered by other departments of SCLS	1. Object Oriented Programming in C++ (P) 2. Finite Element Methods 3. Mathematical Finance 4. Econometrics 5. Cryptography and Network Security 6. Information Security 7. Applications of Algebra 8. Combinatorial Mathematics	1. Computer Fundamentals (4) + Lab (2) 2. Introduction to Database Systems (4) + Lab (2) 3. Introduction to Programming (4) + Lab (2) 4. Computer Networks and Internet Technologies (4) + Lab (2) 5. Multimedia and Applications (4) + Lab (2) 6. Programming in Visual Basic / Gambas (4) + Lab (2) 7. Information Security and Cyber Laws (4) + Lab (2) 8. Web and E-Commerce Technologies (4) + Lab (2)

- **Skill Enhancement Courses (02 papers to be selected) (Credit: 02 each: Th:04)**

BCH-SEC01.	Chemoinformatics
BCH-SEC02.	Intellectual Property Rights
BCH-SEC03.	Pharmaceutical Chemistry
BCH-SEC04.	Chemistry of Cosmetics & Perfumes
BCH-SEC05.	Pesticide Chemistry
BCH-SEC06.	Fuel Chemistry

Generic Elective Papers (GE) (Minor-Chemistry) (any four) for other Departments/Disciplines: (Credit: 06 each)

SEMESTER I

Core papers	AECs	Generic Electives
BCH-CC01 TH (4 C) BCH-CC01-TU (2 C)	BCH-AEC01: English Communication (2 C)	BCH-GE01TH (4C)
BCH-CC02 TH (4 C)	BCH-AEC02: Environment Studies (2 C)	BCH-GE01-TU (2C)

Core Paper

PAPER CODE: BCH-CC01TH

PAPER TITLE: BASICS OF COMPUTER SCIENCE AND STATISTICS

SEMESTER I

TOTAL HOURS: 60

CREDITS: 04

SECTION A: BASICS OF COMPUTER SCIENCE (02 credits)

Unit – I: Elements of Computer Systems

Computer: Definition, Characteristics, Hardware & Software, Computer Organization. Operating Systems: Multi-tasking, Multi programming, Multiuser. Types of Operating System: MS-Windows, Unix/Linux, Mac OS. Database Models: Network, Hierarchical, Relational, Object Oriented. MS-Office: MS-Word, MS-Excel, MS-Power Point, MS-Access.

Unit – II: Information Technology

Elements of Computer Network. Network Topologies: Ring, Bus, Star, Mesh, Hybrid. Internet, Intranet, WWW, URL, Email, HTTP, HTML, Website, Portal, Web Browser, E-Commerce, IP Address. Issues and Threats of Cyber & Information Security: Virus, Worms, Trojan, Malware, Ransom ware, Anti-Virus, Basics of Computer Trouble Shooting.

SECTION B: STATISTICS (02 credits)

UNIT I

Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis. Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions.

UNIT II

Confidence level, critical region, testing of hypothesis and standard error, large sample test and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA)) Correlation and Regression. Emphasis on examples from Biological Sciences.

Suggested Reading for section A

1. Rajaraman V., Adabala, Neeharika, "Fundamentals of Computer" 6th ed., PHI, 2014, ISBN 10: 8120350677
2. Sinha & Sinha, "Computer Fundamentals", 6th ed., BPB Publications, 2007, ISBN 10: 8176567523.
3. Kahate A., "Introduction to Database Management System", Pearson's Education, 2004, ISBN: 813170078X
4. Norton P, "Introduction to Computers", Mc Graw Hills, 2010, ISBN 10: 0070671206
5. Online Tutorial, Jone L. & Curtis F., "Microsoft Office 2016: Step by Step", Microsoft Press, 2015, ISBN: 978-0-7356-9923-6.

Suggested Reading for Section B

1. Le CT (2003) Introductory biostatistics. 1st edition, John Wiley, USA
2. Glaser AN (2001) High YieldTM Biostatistics. Lippincott Williams and Wilkins, USA
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.
5. M.V.Ismail (2008)Biostatistics, Ist Edition, Laxmi ublication Pvt. Ltd.

Core Paper

PAPER CODE: BCH-CC02TH
PAPER TITLE: BASICS OF CHEMISTRY
SEMESTER I

TOTAL HOURS: 60

CREDITS: 04

Unit 1 Chemical Bonding and Molecular Structure Ionic Bonding

Lattice energy and solvation energy. Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, Covalent Bonding: VB Approach, Lewis theory, VSEPR theory to explain the shapes of molecules, salient features of the Valence bond (VB) theory and the concept of hybridization, MO Approach: limitations of the VB approach, salient features of the MO theory. Rules for the LCAO method, bonding and anti-bonding MOs and their characteristics for s-s-, s-p and p-p combinations of atomic orbitals, nonbonding combinations of orbitals MO treatment of homonuclear diatomic molecules of 1st period and heteronuclear diatomic molecules such as CO, HF.

Unit 2 Chemical Thermodynamics

Qualitative idea of thermodynamics. First Law of Thermodynamics: Calculation of work (w), heat (q), changes in internal energy (ΔE) and enthalpy (ΔH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w, q, ΔE , and ΔH for processes involving changes in physical states. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature Kirchoff's equation. Second law of thermodynamics, concept of entropy, Gibbs free energy and Helmholtz free energy. Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity, Gibbs Helmholtz equation. Maxwell's relations. Statements of Third Law of thermodynamics: calculation of absolute entropies of substances.

Unit 3 Fundamentals of Organic Chemistry

Hybridization in organic compounds, cleavage of covalent bond, homolysis and heterolysis, Electronic effects: Electronic effects and their applications – inductive, resonance and hyperconjugation effects. Structure and relative stability of reactive carbon species – carbocations, carbanions, free radicals and carbenes, Molecular Forces: types of intermolecular and intra-molecular forces and their characteristics: dipole-dipole, dipole-induced dipole and dispersion (London) forces. Hydrogen bond (both intramolecular and intermolecular), Effect of inter/intramolecular forces on physical properties such as solubility, vapour pressure, melting and boiling points of different compounds, Aromaticity.

Unit 4 Stereochemistry

Stereochemistry and its importance. Geometrical isomerism, cis-trans and E/Z nomenclature Optical isomerism – optical activity, plane polarized light, enantiomerism, chirality, specific molar rotation, Stereoisomerism with two chiral centres: Diastereomers, mesoisomers, Resolution of racemic modification. Projection diagrams of stereoisomers: Fischer, Newman and Sawhorse projections. Relative Configuration: D/L designation. Absolute Configuration: R/S designation of chiral centres, Conformational isomerism – ethane, butane and cyclohexane, diagrams and relative stability of conformers.

Suggested Reading

1. J.D.Lee: A New Concise Inorganic Chemistry, E.L.B.S.
2. P.W. Atkins: Physical Chemistry, Oxford University Press
3. R.T. Morrison & R.N.Boyd: Organic Chemistry, Prentice Hall
4. James E.Huheey et al. : Inorganic Chemistry: Principles of Structure and reactivity

Ability Enhancement Course

PAPER CODE: -BCH-AEC01
PAPER TITLE: ENGLISH COMMUNICATION
SEMESTER I

TOTAL HOURS: 30

CREDITS: 02

Preamble: The purpose of this course is to introduce students to the theory, fundamentals and tools of communication and to develop in them vital communication skills which should be integral to personal, social and professional interactions. One of the critical links among human beings and an important thread that binds society together is the ability to share thoughts, emotions and ideas through various means of communication: both verbal and non-verbal. In the context of rapid globalization and increasing recognition of social and cultural pluralities, the significance of clear and effective communication has substantially enhanced. The present course hopes to address some of these aspects through an interactive mode of teaching-learning process and by focusing on various dimensions of communication skills. Some of these are: Language of communication, various speaking skills such as personal communication, social interactions and communication in professional situations such as interviews, group discussions and office environments, important reading skills as well as writing skills such as report writing, notetaking etc. While, to an extent, the art of communication is natural to all living beings, in today's world of complexities, it has also acquired some elements of science. It is hoped that after studying this course, students will find a difference in their personal and professional interactions. The recommended readings given at the end are only suggestive; the students and teachers have the freedom to consult other materials on various units/topics given below. Similarly, the questions in the examination will be aimed towards assessing the skills learnt by the students rather than the textual content of the recommended books.

Unit I

Introduction: Theory of Communication, Types and modes of Communication

Language of Communication: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication

Speaking Skills: Monologue, Dialogue Group Discussion, Effective Communication/ Mis-Communication Interview, Public Speech

Unit II

Reading and Understanding: Close Reading, Comprehension, Summary Paraphrasing, Analysis and Interpretation, Translation (from Indian language to English and vice-versa) Literary/Knowledge Texts

Writing Skills: Documenting, Report Writing, Making notes, Letter writing

Recommended Readings:

1. Fluency in English - Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brati Biswas

Ability Enhancement Course

PAPER CODE: BCH-AEC02

PAPER TITLE: ENVIRONMENTAL STUDIES

SEMESTER I

TOTAL HOURS: 30

CREDITS: 02

UNIT 1: THE MULTIDISCIPLINARY NATURE OF ENVIRONMENTAL STUDIES

Definition, scope and importance, Need for public awareness.

UNIT 2: NATURAL RESOURCES: RENEWABLE AND NON RENEWABLE RESOURCES:

a) Natural resources and associated problems

- Forest resources: Use and over-exploitation, deforestation, case studies, Timber extraction, mining, dams and their effects on forests, and tribal people.
- Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dam's benefits and problems.
- Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
- Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizers- pesticides problems, water logging, salinity, case studies.
- Energy Resources: Growing energy needs, renewable and nonrenewable energy sources, use of alternate energy sources, case studies
- Land Resources: Land as a resource, land degradation, man induced landslides, soil erosion, and desertification.

b) Role of individual in conservation of natural resources.

c) Equitable use of resources for sustainable life styles.

UNIT 3: ECO SYSTEMS

- Concept of an eco-system
- Structure and function of an eco-system.
- Producers, consumers, decomposers.
- Energy flow in the eco systems.
- Ecological succession.
- Food chains, food webs and ecological pyramids.
- Introduction, types, characteristic features, structure and function of the following eco systems:
- Forest ecosystem
- Grass land ecosystem
- Desert ecosystem.
- Aquatic eco systems (ponds, streams, lakes, rivers, oceans, estuaries)

UNIT 4: BIODIVERSITY AND IT'S CONSERVATION

- Introduction-Definition: genetics, species and ecosystem diversity.
- Biogeographically classification of India.
- Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values
- Biodiversity at global, national and local level.
- India as a mega diversity nation.
- Hot-spots of biodiversity.
- Threats to biodiversity: habitats loss, poaching of wild life, man wildlife conflicts.
- Endangered and endemic spaces of India.

- Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.

UNIT 5: ENVIRONMENTAL POLLUTION

- Definition Causes, effects and control measures of:
 - a. Air pollution
 - b. Water pollution
 - c. Soil pollution
 - d. Marine pollution
 - e. Noise pollution
 - f. Thermal pollution
 - g. Nuclear hazards
- Solid waste Management: Causes, effects and control measures of urban and
- industrial wastes
- Role of an individual in prevention of pollution
- Pollution case studies
- Disaster management: Floods, earth quake, cyclone and land slides

Suggested Readings:

1. Textbook of Environmental studies, Erach Bharucha, UGC
2. Fundamental concepts in Environmental Studies, D D Mishra, S Chand & Co Ltd

Generic Elective

PAPER CODE: BCH-GE01-A
PAPER TITLE: BASICS OF PHYSICS AND BIOLOGY
SEMESTER I

TOTAL HOURS: 60

CREDITS: 04

SECTION A: BASICS OF PHYSICS (02 CREDITS)

UNIT-I

- a) Oscillations: Periodic motion, time period, frequency, Simple Harmonic Motion (SHM) and its equations, phase, restoring force, Kinetic Energy and Potential Energy in SHM.
- b) Electromagnetic waves: Electromagnetic Spectrum, Electromagnetic waves and their characteristics, Maxwell's Equations

UNIT-II

- a) Interference due to division of amplitude and division of wave fronts, Young's double slit Experiment, Principle of Superposition, Theory of Biprism, Newtons' Rings.
- b) LASER: Introduction, Temporal and Spatial Coherence, Principle of LASER, Stimulated and spontaneous emission. Einstein's Coefficients, He-Ne Laser, Ruby Laser, Applications of Lasers.

SECTION B: BASICS OF BIOLOGY (02 CREDITS)

UNIT-I

a) **Animal and Plant Kingdom**

Salient features and classification of plants into major groups - Algae, Bryophyta, Pteridophyta, Gymnospermae and Angiospermae. Salient features and classification of animals, non-chordates up to phyla level and chordates up to class.

b) **Cell-The Unit of Life**

Cell as the basic unit of life: Structure of prokaryotic and eukaryotic cells; Plant cell and animal cell; Cell envelope, cell membrane, cell wall; Cell organelles - structure and function. Elementary idea of cell cycle, mitosis, meiosis and their significance.

c) **Biomolecules**

Chemical constituents of living cells: biomolecules, structure and function of proteins, carbohydrates, lipids, nucleic acids.

UNIT-II

a) **Human and Plant Physiology**

Plant: basic concepts of transport, photosynthesis, respiration and reproduction in higher plants.

Human: Basic concepts of digestion and absorption; respiration, body fluids and circulation; excretion, nervous system, and reproduction.

b) **Basic Principles of Inheritance and Variation**

Mendelian Inheritance; Deviations from Mendelism-Incomplete dominance, Co-dominance, Multiple alleles and Inheritance of blood groups, Pleiotropy; Elementary idea of polygenic inheritance; Chromosome theory of inheritance; Chromosomes and genes;

Suggested Reading

1. Ajoy Ghatak, Optics, TMH
2. D.S.Mathur, Mechanics
3. Griffith, Electrodynamics
4. Brij Lal and Subramaniam, Optics

Generic Elective

PAPER CODE: BCH-GE01-B
PAPER TITLE: BASICS OF PHYSICS AND MATHEMATICS
SEMESTER I

TOTAL HOURS: 60

CREDITS: 04

SECTION A: BASICS OF PHYSICS (02 CREDITS)

UNIT-I

- c) Oscillations: Periodic motion, time period, frequency, Simple Harmonic Motion (SHM) and its equations, phase, restoring force, Kinetic Energy and Potential Energy in SHM.
- d) Electromagnetic waves: Electromagnetic Spectrum, Electromagnetic waves and their characteristics, Maxwell's Equations

UNIT-II

- c) Interference due to division of amplitude and division of wave fronts, Young's double slit Experiment, Principle of Superposition, Theory of Biprism, Newton's Rings.
- d) LASER: Introduction, Temporal and Spatial Coherence, Principle of LASER, Stimulated and spontaneous emission. Einstein's Coefficients, He-Ne Laser, Ruby Laser, Applications of Lasers.

SECTION B: BASICS OF MATHEMATICS (02 CREDITS)

Unit I: Matrices and Determinants

Matrices: Concept, notation, order, equality, types of matrices, zero and identity matrix, transpose of a matrix, symmetric and skew symmetric matrices. Operation on matrices: Addition and multiplication and multiplication with a scalar. Simple properties of addition, multiplication and scalar multiplication.

Determinants: Determinant of a square matrix (up to 3 x 3 matrices), properties of determinants, minors, co-factors and applications of determinants in finding the area of a triangle. Adjoint and inverse of a square matrix.

Unit II: Calculus

Continuity and Differentiability: Continuity and Derivative, derivative of composite functions, chain rule, derivative of implicit functions. Concept of exponential and logarithmic functions.

Derivatives of logarithmic and exponential functions. Logarithmic differentiation, derivative of functions expressed in parametric forms. Second order derivatives.

Integrals: Integration as inverse process of differentiation. Integration of a variety of functions by substitution, by partial fractions and by parts, Evaluation of simple integrals of the following types and problems based on them. Definite integrals as a limit of a sum, Basic properties of definite integrals and evaluation of definite integrals.

Differential Equations: Definition, order and degree, general and particular solutions of a differential equation. Formation of differential equation whose general solution is given.

Suggested Reading

1. Ajoy Ghatak, Optics, TMH
2. D.S.Mathur, Mechanics
3. Griffith, Electrodynamics
4. Brij Lal and Subramaniam, Optics

SEMESTER II

Core Papers	Generic Electives
BCH-CC03 TH (4 C)	BCH-GE02 TH (4 C)
BCH-CC04 TH (4 C)	
BCH-CC05 TH (4 C)	
BCH-CC06 TH (4 C)	

Core paper

PAPER CODE: BCH-CC03 TH
PAPER TITLE: CHEMISTRY OF S AND P-BLOCK ELEMENTS
INORGANIC CHEMISTRY-I
SEMESTER II

TOTAL HOURS: 60

CREDITS: 04

UNIT I: GENERAL PRINCIPLES OF METALLURGY

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, van Arkel-de Boer process and Mond's process, Zone refining.

UNIT II : CHEMISTRY OF S BLOCK ELEMENTS

- General characteristics: melting point, flame colour, reducing nature, diagonal relationships and anomalous behavior of first member of each group.
- Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water.
- Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates.
- Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium.
- Solutions of alkali metals in liquid ammonia and their properties.

UNIT III CHEMISTRY OF P BLOCK ELEMENTS

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.

UNIT IV

A: Structure, bonding and properties: acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat of the following.

- Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH₃ where E N, P, As, Sb, Bi), Group 16 and Group 17.
- Oxides: oxides of phosphorus, sulphur and chlorine
- Oxoacids: oxoacids of phosphorus and chlorine; peroxyacids of sulphur
- Halides: halides of silicon and phosphorus

B: Preparation, properties, structure and uses of the following compounds:

- Borazine
- Silicates, silicones,
- Phosphonitrilic halides {(PNC_l)_n where n = 3 and 4}
- Interhalogen and pseudohalogen compounds
- Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF₂).

Suggested Reading

- Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3 rd Ed.*, John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry 3rd Ed.(adapted)*, Pearson, 2009 Shriver, D.F., Atkins P.

Core paper

PAPER CODE: BCH-CC04 TH
PAPER TITLE: STATES OF MATTER & IONIC EQUILIBRIUM
PHYSICAL CHEMISTRY-I
SEMESTER II

TOTAL HOURS: 60

CREDITS: 04

UNIT 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, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. 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, Dieterici); 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.

UNIT 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.

UNIT III SOLID STATE

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; 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. Glasses and liquid crystals.

UNIT IV 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.

Suggested Reading

- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University 12 Press (2014).
- Ball, D. W. Physical Chemistry Thomson Press, India (2007).
- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).

Core paper

PAPER CODE: BCH-CC05 TH PAPER TITLE: HYDROCARBONS ORGANIC CHEMISTRY-I SEMESTER II

TOTAL HOURS: 60

CREDITS: 04

UNIT I 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.
- 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 their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (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.

UNIT II 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.

UNIT III: 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.

UNIT IV: POLYNUCLEAR HYDROCARBONS

Aromaticity of polynuclear hydrocarbons, structure elucidation of naphthalene; Preparation and properties of naphthalene, phenanthrene and anthracene.

Suggested Reading

- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
- Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

Core paper

PAPER CODE: BCH-CC06 TH
TITLE: PHASE EQUILIBRIA AND CHEMICAL KINETICS
PHYSICAL CHEMISTRY II
SEMESTER III

TOTAL HOURS: 60

CREDITS: 04

UNIT I CHEMICAL EQUILIBRIUM

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration (Le Chatelier Principle, Quantitatively)). Free energy of mixing and spontaneity. equilibrium between ideal gases and a pure condensed phase

UNIT II 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 solid-liquid, 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.

Three component systems, water-chloroform-acetic acid system, triangular plots. *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.

Unit 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 (steady-state approximation in reaction mechanisms) (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.

UNIT IV SOLUTIONS AND COLLIGATIVE PROPERTIES

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. 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.

Suggested Reading:

1. Peter Atkins & Julio De Paula, *Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd. New Delhi (2004).
4. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*. CRC Press: NY (2011).
6. Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
7. Ball, D. W. *Physical Chemistry* Cengage India (2012).
8. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
9. Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill (2011).
10. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill (2009).

SEMESTER III

Core Papers	SEC	Generic electives
BCH-CC07 TH (4 C)	BCH-SEC01 (2 C)	BBT-GE03 TH (4 C)
BCH-CC08 TH (4 C)	BCH-SEC02 (2C)	
BCH-CC09 TH (4 C)		
BCH-CC10 TH (4 C)		
BCH-CC11 TH (4 C)		

Core paper

PAPER CODE: BCH-CC07 TH

TITLE: HALOGENS, OXYGEN AND NITROGEN CONTAINING FUNCTIONAL GROUPS
ORGANIC CHEMISTRY-II
SEMESTER III

TOTAL HOURS: 60

CREDITS: 04

UNIT I: CHEMISTRY OF HALOGENATED HYDROCARBONS:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN_1 , SN_2 and SN_i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SN_{Ar} , 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.

UNIT II: ALCOHOLS, PHENOLS, ETHERS AND EPOXIDES AND CARBONYL COMPOUNDS

Alcohols: preparation, properties and relative reactivity of 1° , 2° , 3° alcohols, Bouvaelt-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 $LiAlH_4$

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-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.

UNIT III: CARBOXYLIC ACIDS AND THEIR DERIVATIVES

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

Sulphur containing compounds:

Preparation and reactions of thiols, thioethers and sulphonic acids.

UNIT IV: NITROGEN CONTAINING FUNCTIONAL GROUPS

Preparation and important reactions of nitro and compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabrielphthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustivemethylation, Hofmann-elimination reaction;

Distinction between 1° , 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications.

Suggested Readings

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume I)*, Dorling Kindersley (India) Pvt. Ltd.=(Pearson Education).
3. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc. □ McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

Core paper

PAPER CODE: BCH-CC08 TH
TITLE: COORDINATION CHEMISTRY
INORGANIC CHEMISTRY II
SEMESTER III

TOTAL HOURS: 60

CREDITS: 04

UNIT I: COORDINATION CHEMISTRY

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of $10 Dq$ (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of $10 Dq$ (Δ_o , Δ_t).

Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

UNIT II: 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 & Bsworth diagrams). Difference between the first, second and third transition series.

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

UNIT III: LANTHANOIDS AND ACTINOIDS

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT IV: 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.

Suggested Reading:

- Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
- Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
- Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
- Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
- Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

Core paper

PAPER CODE: BCH-CC09 TH
TITLE: HETEROCYCLIC AND NATURAL PRODUCT CHEMISTRY
ORGANIC CHEMISTRY III
SEMESTER III

TOTAL HOURS: 60

CREDITS: 04

UNIT I: HETEROCYCLIC COMPOUNDS

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, structure elucidation of indole, fischer indole synthesis and madelung synthesis), structure elucidation of quinoline and isoquinoline, skraup synthesis, friedlander's synthesis, knorr quinoline synthesis, doebner-miller synthesis, bischler-napieralski reaction, pictet-spengler reaction, pomeranz-fritsch reaction derivatives of furan: furfural and furoic acid.

UNIT II: ALKALOIDS

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

UNIT III: TERPENES

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α -terpineol.

UNIT IV: NUCLEIC ACIDS

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

Suggested Reading:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Wiley & Sons (1976).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).

Core paper

PAPER CODE: BCH-CC10 TH
TITLE: ELECTROCHEMISTRY
PHYSICAL CHEMISTRY III
SEMESTER III

TOTAL HOURS: 60

CREDITS: 04

UNIT I: 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.

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.

UNIT II: ELECTROCHEMISTRY

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

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. 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, glass and SbO/Sb₂O₃ electrodes.

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).

UNIT IV: ELECTRICAL & MAGNETIC PROPERTIES OF ATOMS AND MOLECULES

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, Paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

Suggested Reading:

- Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press (2014).
- Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
- Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
- Barrow, G. M., *Physical Chemistry 5th Ed.*, Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
- Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).

Core paper

PAPER CODE: BCH-CC11 TH
TITLE: BIOMOLECULES
ORGANIC CHEMISTRY IV
SEMESTER III

TOTAL HOURS: 60

CREDITS: 04

UNIT I: AMINO ACIDS, PEPTIDES AND PROTEINS

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

UNIT II: ENZYMES

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).

UNIT III: LIPIDS

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.

Concept of Energy in Biosystems

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.

UNIT III: PHARMACEUTICAL COMPOUNDS: STRUCTURE AND IMPORTANCE

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).

Reference Books:

- Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistry*. 6th Ed. W.H. Freeman and Co.
- Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry*. 4th Edition. W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's*
- *Illustrated Biochemistry*. XXVIII edition. Lange Medical Books/ McGraw-Hill.

SEMESTER IV

Core papers	SEC	DSE	GE
BCH-CC12 TH (4 C) BCH-CC13 TH (4 C)	BCH-SEC02 (2C)	BCH-DSE01 TH (4C)	BBC-GE04 TH (4 C)
BCH-CC02 PR (2 C) BCH-CC03 PR (2 C) BCH-CC04 PR (2 C) BCH-CC05 PR (2 C) BCH-CC06 PR (2 C)			BBC-GE04 PR (2 C)

Core paper

PAPER CODE: BCH-CC02 PR
TITLE: BASICS OF CHEMISTRY
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 02

Checking the calibration of the thermometer

- Purification of organic compounds by crystallization using the following solvents:
 - Water
 - Alcohol
 - Alcohol-Water
- Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
- Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
- Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

Suggested Reading:

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

Core paper

PAPER CODE: BCH-CC03 PR
TITLE: S- AND P-BLOCK ELEMENTS
INORGANIC CHEMISTRY I
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 02

(A) Iodo / Iodimetric Titrations

- (i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
- (ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
- (iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

- (i) Cuprous Chloride, Cu_2Cl_2
- (ii) Preparation of Manganese(III) phosphate, $MnPO_4 \cdot H_2O$
- (iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2 \cdot 12H_2O$ (Potash alum) or Chrome alum.

Suggested Reading:

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

Core paper

PAPER CODE: BCH-CC04 PR
TITLE: STATES OF MATTER & IONIC EQUILIBRIUM
PHYSICAL CHEMISTRY I
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 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.

4. 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
- c) Sodium acetate-acetic acid
- d) Ammonium chloride-ammonium hydroxide
- e) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
- f) Determination of dissociation constant of a weak acid.

Suggested Reading

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

Core paper

PAPER CODE: BCH-CC05 PR
TITLE: HYDROCARBONS
ORGANIC CHEMISTRY I
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 02

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
- a) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Identification of simple organic compounds

Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group

Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars

Suggested Reading

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

Core paper

PAPER CODE: BCH-CC06 PR
TITLE: PHASE EQUILIBRIA AND CHEMICAL KINETICS
PHYSICAL CHEMISTRY- II
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 02

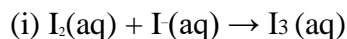
Phase Equilibria:

I. Determination of critical solution temperature and composition at CST of the phenol-water system and to study the effect of impurities of sodium chloride and succinic acid on it.

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

III. Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane.

IV. Study the equilibrium of at least one of the following reactions by the distribution method:



Potentiometry:

V. Perform the following potentiometric titrations: 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

Suggested Reading

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011). 25
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).

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

Core paper

PAPER CODE: BCH-CC12 TH
TITLE: QUANTUM CHEMISTRY AND SPECTROSCOPY
PHYSICAL CHEMISTRY IV
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 04

UNIT I: QUANTUM CHEMISTRY

Postulates of quantum mechanics, quantum mechanical operators and commutation rules, Schrödinger equation and its application to free particle and —particle-in-a-box (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, 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 wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation in Cartesian and spherical polar (Derivation not required). Separation of variables. Spherical harmonics. Discussion of solution (Qualitative).

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).

UNIT II: CHEMICAL BONDING

Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H₂⁺. Bonding and antibonding orbitals. Qualitative extension to H₂. Comparison of LCAO-MO and VB treatments of H₂ (only wave functions, 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).

UNIT 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.

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.

UNIT III: NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales (δ and T), spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

Suggested Readings

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001). • House, J. E.
- Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

Core paper

PAPER CODE: BCH-CC13 TH
TITLE: ORGANOMETALLIC CHEMISTRY
INORGANIC CHEMISTRY IV
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 04

UNIT 1: THEORETICAL PRINCIPLES IN QUALITATIVE ANALYSIS (H₂S SCHEME)

Basic principles involved in analysis of cations and anions. 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.

UNIT 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. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Unit III: 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. Cisplatin as an anti-cancer drug.

Iron and its application in bio-systems, Haemoglobin, Myoglobin; Storage and transfer of iron.

Unit IV: CATALYSIS BY ORGANOMETALLIC COMPOUNDS

Study of the following industrial processes and their mechanism: 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Synthetic gasoline (Fischer Tropsch reaction) 3. Polymerisation of ethene using Ziegler-Natta catalyst

Suggested Reading

- Vogel, A.I. *Qualitative Inorganic Analysis*, Longman, 1972
- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996-03-07.
- Lippard, S.J. & Berg, J.M., *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
- Cotton, F.A., Wilkinson, G., & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.*; Wiley India,
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.*, Harper Collins 1993, Pearson, 2006.
- Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
- Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry 3rd Ed.*, John Wiley and Sons, NY, 1994.
- Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements 2nd Ed*, Elsevier, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
- Lee, J.D. *Concise Inorganic Chemistry 5th Ed.*, John Wiley and sons 2008.
- Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
- Shriver, D.D., Atkins, P. and Langford, C.H., *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.
- Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
- Miessler, G. L. & Tarr, Donald A., *Inorganic Chemistry 4th Ed.*, Pearson, 2010.
- Collman, James P. et al. *Principles and Applications of Organotransition Metal Chemistry*. Mill Valley, CA: University Science Books, 1987.

SEMESTER V

BCH-CC14 TH (4 C)	BCH-DSE01 TH (4C)
	BCH-DSE01 PR (2C)
	BCH-DSE02 TH (4C)
BCH-CC07 PR (2C)	BCH-DSE02 PR (2C)
	BCH-DSE03 TH (4C)
	BCH-DSE03 PR (2C)

Core paper

PAPER CODE: BCH-CC14 TH
TITLE: SPECTROSCOPY AND POLYMERS
ORGANIC CHEMISTRY IV
SEMESTER V

TOTAL HOURS: 60

CREDITS: 04

UNIT I: UV AND IR SPECTROSCOPY

General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λ_{\max} , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward, Rules for calculation of λ_{\max} for the 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. Applications of IR and UV for identification of simple organic molecules.

Unit III: NMR SPECTROSCOPY

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, Interpretation of NMR spectra of simple compounds.

Applications of NMR spectroscopy for identification of simple organic molecules.

UNIT II: CARBOHYDRATES

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.

Unit IV: POLYMERS

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.

Suggested Reading

- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
- Kemp, W. *Organic Spectroscopy*, Palgrave.
- Pavia, D. L. *et al. Introduction to Spectroscopy* 5th Ed. Cengage Learning India Ed. (2015)

Core paper

PAPER CODE: BCH-CC07 PR

TITLE: HALOGEN, OXYGEN AND NITROGEN CONTAINING FUNCTIONAL GROUPS
ORGANIC CHEMISTRY II
SEMESTER IV

TOTAL HOURS: 60

CREDITS: 02

Organic preparations:

- i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method:
 - a. Using conventional method.
 - b. Using green approach
- ii. Benzoylation 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.
- iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).
- iv. Bromination of any one of the following:
 - a. Acetanilide by conventional methods
 - b. Acetanilide using green approach (Bromate-bromide method)
- v. Nitration of any one of the following:
 - a. Acetanilide/nitrobenzene by conventional method
 - b. Salicylic acid by green approach (using ceric ammonium nitrate).
- vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
- vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
- viii. Hydrolysis of amides and esters.
- ix. Semicarbazone of any one of the following compounds: acetone, ethyl methylketone, cyclohexanone, benzaldehyde.
- x. *S*-Benzylisothiuronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
- xi. Aldol condensation using either conventional or green method.
- xii. Benzil-Benzilic acid rearrangement.

The compounds prepared may be used for recrystallization, melting point and TLC.

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press (2000).

SEMESTER VI

Core Papers	DSE	GE
BCH-CC08 PR (2 C)	BCH-DSE	BCH-GE02 PR
BCH-CC09 PR (2 C)	TH(4C)	(2C)
BCH-CC10 PR (2 C)	BCH-DSE PR	
BCH-CC11 PR (2C)	(2C) /	
BCH-CC12 PR (2C)	(Research	BBT-GE03 PR
BCH-CC13 PR (2C)	Project 6C)	(2C)
BCH-CC14 PR (2C)		

Core paper

PAPER CODE: BCH-CC08 PR
TITLE: COORDINATION CHEMISTRY
INORGANIC CHEMISTRY II
SEMESTER VI

TOTAL HOURS: 60

CREDITS: 02

Gravimetric Analysis:

1. Estimation of nickel (II) using Dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN
3. Estimation of iron as Fe₂O₃ by precipitating iron as Fe(OH)₃.
4. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)₃(aluminium oxinate).

Inorganic Preparations:

5. Tetraamminecopper (II) sulphate, [Cu(NH₃)₄]SO₄.H₂O
6. Acetylacetonate complexes of Cu²⁺/Fe³⁺
7. Tetraamminecarbonatocobalt (III) nitrate
8. Potassium tri(oxalato)ferrate(III)

Properties of Complexes

9. Measurement of 10 Dq by spectrophotometric method
10. Verification of spectrochemical series.
11. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g.
12. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Suggested Reading

- Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
- G. Marr and B.W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972

Core paper

PAPER CODE: BCH-CC09 PR
TITLE: HETEROCYCLIC AND NATURAL PRODUCT CHEMISTRY
ORGANIC CHEMISTRY III
SEMESTER VI

TOTAL HOURS: 60

CREDITS: 02

- Detection of extra elements.
- Functional group test for nitro, amine and amide groups.
- Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Suggested Reading

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

Core paper

PAPER CODE: BCH-CC10 PR
TITLE: ELECTROCHEMISTRY
PHYSICAL CHEMISTRY III
SEMESTER VI

TOTAL HOURS: 60

CREDITS: 02

Conductometry

1. Determination of cell constant
2. Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid.
3. 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

Chemical Kinetics:

1. Study the kinetics of the following reactions.
2. Iodide-persulphate reaction (i) Initial rate method; (ii) Integrated rate method
3. Acid hydrolysis of methyl acetate with hydrochloric acid.
4. Saponification of ethyl acetate.
5. Comparison of the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate.

Suggested Reading

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

Core paper

PAPER CODE: BCH-CC11 PR
TITLE: BIOMOLECULES
ORGANIC CHEMISTRY III
SEMESTER VI

TOTAL HOURS: 60

CREDITS: 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.

Suggested Reading

- Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
- Arthur, I. V. Quantitative Organic Analysis, Pearson.

Core paper

PAPER CODE: BCH-CC12 PR
TITLE: QUANTUM CHEMISTRY & SPECTROSCOPY
PHYSICAL CHEMISTRY IV
SEMESTER VI

TOTAL HOURS: 60

CREDITS: 02

Colorimetry

1. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$
2. in a solution of unknown concentration
3. Determine the concentrations of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture.
4. Study the kinetics of iodination of propanone in acidic medium.
5. Determine the amount of iron present in a sample using 1, 10-phenanthroline.
6. Determine the dissociation constant of an indicator (phenolphthalein).
7. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium
8. hydroxide.
9. Analysis of the given vibration-rotation spectrum of $\text{HCl}(\text{g})$

Adsorption

10. VIII. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

UV/Visible spectroscopy

11. Study the 200-500 nm absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1} , kJ mol^{-1} , cm^{-1} , eV).
12. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $\text{K}_2\text{Cr}_2\text{O}_7$.
13. 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.

Suggested Reading

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

Core paper

PAPER CODE: BCH-CC13 PR
TITLE: ORGANOMETALLIC CHEMISTRY
INORGANIC CHEMISTRY IV
SEMESTER VI

:

TOTAL HOURS: 60

CREDITS: 02

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations.

Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-} , $\text{S}_2\text{O}_3^{2-}$, CH_3COO^- , F^- , Cl^- , Br^- , I^- , NO_3^- , BO_3^{3-} , $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-} , NH_4^+ , K^+ , Pb^{2+} , Cu^{2+} , Cd^{2+} , Bi^{3+} , Sn^{2+} , Sb^{3+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Co^{2+} , Ni^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+}

Mixtures should preferably contain one interfering anion, **or** insoluble component (BaSO_4 , SrSO_4 , PbSO_4 , CaF_2 or Al_2O_3) **or** combination of anions e.g. CO_3^{2-} and SO_3^{2-} , NO_2^- and NO_3^- , Cl^- and Br^- , Cl^- and I^- , Br^- and I^- , NO_3^- and Br^- , NO_3^- and I^- .

Spot tests should be done whenever possible.

- (i) Measurement of 10 Dq by spectrophotometric method
- (ii) Verification of spectrochemical series.
- (iii) Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
- (iv) Preparation of acetylacetonato complexes of $\text{Cu}^{2+}/\text{Fe}^{3+}$. Find the λ_{max} of the complex.
- (v) Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetonone, DMG, glycine) by substitution method.

Suggested Reading

- Vogel's *Qualitative Inorganic Analysis*, Revised by G. Svehla. Pearson Education, 2002.
- Marr & Rockett *Practical Inorganic Chemistry*. John Wiley & Sons 1972.

Core paper

PAPER CODE: BCH-CC14 PR
TITLE: SPECTROSCOPY AND POLYMERS
ORGANIC CHEMISTRY IV
SEMESTER V

TOTAL HOURS: 60

CREDITS: 02

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. 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.

Suggested Reading

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

DSE I-IX (ELECTIVES)
(BCH-DSE01-09)

PAPER CODE: BCH-DSE01 TH
TITLE: ANALYTICAL METHODS IN CHEMISTRY

TOTAL HOURS: 60

CREDITS: 04

UNIT I: QUALITATIVE AND QUANTITATIVE ASPECTS OF ANALYSIS

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

UNIT II: 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;

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotopesubstitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, 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.

UNIT III: THERMAL AND ELECTROANALYTICAL METHODS OF ANALYSIS

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

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.

UNIT IV: SEPARATION TECHNIQUES

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Role of computers in instrumental methods of analysis.

Suggested Reading

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
- Willard, H.H. *et al.: Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles
- Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. *Analytical Chemistry; Methods of separation*, van Nostrand, 1974.

PAPER CODE: BCH-DSE01 PR
TITLE: ANALYTICAL METHODS IN CHEMISTRY

TOTAL HOURS: 60

CREDITS: 02

1. Separation Techniques: Chromatography:

- Separation of mixtures
- Paper chromatographic separation of Fe³⁺, Al³⁺, and Cr³⁺.
- Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.
- Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.
- Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

2. Solvent Extractions:

- To separate a mixture of Ni²⁺ & Fe²⁺ by complexation with DMG and extracting the Ni²⁺-DMG complex in chloroform, and determine its concentration by spectrophotometry.
- Solvent extraction of zirconium with amberlite LA-1, separation from a mixture of iron and gallium.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

5. Analysis of soil:

- Determination of pH of soil.
- Total soluble salt
- Estimation of calcium, magnesium, phosphate, nitrate

6. Ion exchange:

- Determination of exchange capacity of cation exchange resins and anion exchange resins.
- Separation of metal ions from their binary mixture.
- Separation of amino acids from organic acids by ion exchange chromatography.

7. Spectrophotometry

- Determination of pK_a values of indicator using spectrophotometry.
- Structural characterization of compounds by infrared spectroscopy.
- Determination of dissolved oxygen in water.
- Determination of chemical oxygen demand (COD).
- Determination of Biological oxygen demand (BOD).
- Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Suggested Reading:

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

PAPER CODE: BCH-DSE02 TH
TITLE: MOLECULAR MODELLING & DRUG DESIGN

TOTAL HOURS: 60

CREDITS: 04

Unit I: INTRODUCTION TO MOLECULAR MODELLING

Introduction. Useful Concepts in Molecular Modelling: Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

Unit II: FORCE FIELDS

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force Field Models for the Simulation of Liquid Water.

Unit III: ENERGY MINIMIZATION AND COMPUTER SIMULATION MOLECULAR DYNAMICS & MONTE CARLO SIMULATION

Minimization and related methods for exploring the energy surface. Non-derivative method, First and second order minimization methods. Computer simulation methods. Simple thermodynamic properties and Phase Space. Boundaries. Analyzing the results of a simulation and estimating errors. Molecular Dynamics Simulation Methods. Molecular Dynamics using simple models. Molecular Dynamics with continuous potentials. Molecular Dynamics at constant temperature and pressure. Metropolis method. Monte Carlo simulation of molecules. Models used in Monte Carlo simulations of polymers.

UNIT IV: STRUCTURE PREDICTION AND DRUG DESIGN

Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by 'Threading', Molecular docking. Structure based de novo ligand design.

Drug Discovery – Chemoinformatics – QSAR.

Suggested Reading:

- A.R. Leach, *Molecular Modelling Principles and Application*, Longman, 2001.
 - J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons, 1997.
 - Satya Prakash Gupta, *QSAR and Molecular Modeling*, Springer – Anamaya Publishers, 2008.
-

PAPER CODE: BCH-DSE02 PR
TITLE: MOLECULAR MODELLING & DRUG DESIGN

TOTAL HOURS: 60

CREDITS: 02

1. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds.
2. Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans* 2-butene.
3. Visualize the electron density and electrostatic potential maps for LiH, HF, N₂, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules.
4. Relate the charge on the hydrogen atom in hydrogen halides with their acid character.
5. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine.
6. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 °C, 100 °C, 108 °C, 82 °C, respectively).
7. Build and minimize organic compounds of your choice containing the following functional groups. Note the dipole moment of each compound: (a) alkyl halide (b) aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester (j) amide.
8. (a) Determine the heat of hydration of ethylene. (b) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
9. Arrange 1-hexene, 2-methyl-2-pentene, (*E*)-3-methyl-2-pentene, (*Z*)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.
10. (a) Compare the optimized bond angles H₂O, H₂S, H₂Se. (b) Compare the HAH bond angles for the second row dihydrides and compare with the results from qualitative MO theory.

Note: Software: ChemSketch, ArgusLab (www.planaria-software.com), (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similar software.

Suggested Reading

- A.R. Leach, *Molecular Modelling Principles and Application*, Longman, 2001.
- J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons, 1997.
- Gupta, S.P. *QSAR and Molecular Modeling*, Springer - Anamaya Publishers, 2008.

PAPER CODE: BCH-DSE03 TH
TITLE: NOVEL INORGANIC SOLIDS

TOTAL HOURS: 60

CREDITS: 04

Unit 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. Inorganic solids of technological importance: Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments. Molecular material and fullerenes, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.

Unit II: 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.

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.

Unit IV: Introduction to engineering materials for mechanical construction:

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

Speciality polymers: Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers, Ion-exchangeresins and their applications. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

Suggested Reading:

- Shriver & Atkins. *Inorganic Chemistry*, Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
- Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. John Wiley & Sons, 1974.
- Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley & Sons, 2003.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

DSE

PAPER CODE: BCH-DSE03 PR
TITLE: NOVEL INORGANIC SOLIDS

TOTAL HOURS: 60

CREDITS: 02

1. Determination of cation exchange method
2. Determination of total difference of solids.
3. Synthesis of hydrogel by co-precipitation method.
4. Synthesis of silver and gold metal nanoparticles.

Suggested Reading

- Fahlman, B.D. *Materials Chemistry*, Springer, 2004.
-

PAPER CODE: BCH-DSE04 TH
TITLE: POLYMER CHEMISTRY

TOTAL HOURS: 60

CREDITS: 04

Unit I: INTRODUCTION AND HISTORY OF POLYMERIC MATERIALS:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems.

Unit II: Kinetics of Polymerization:

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques. Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships.

Unit III: Determination of molecular weight of polymers (M_n , M_w , etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. **Glass transition temperature (T_g) and determination of T_g , Free volume theory, WLF equation, Factors affecting glass transition temperature (T_g).**

Polymer Solution – Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymer solutions, Flory-Huggins theory, Lower and Upper critical solution temperatures.

Unit IV: Properties of Polymers (Physical, thermal, Flow & Mechanical Properties). Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting polymers, [polyacetylene, polyaniline, poly(p-phenylenesulphide polypyrrole, polythiophene)].

Suggested Reading:

- R.B. Seymour & C.E. Carraher: *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.
- G. Odian: *Principles of Polymerization*, 4th Ed. Wiley, 2004.
- F.W. Billmeyer: *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
- P. Ghosh: *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
- R.W. Lenz: *Organic Chemistry of Synthetic High Polymers*. Interscience Publishers, New York, 1967.

Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) /Methyl Acrylate (MA) / Acrylic acid (AA).
 - a. Purification of monomer
 - b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutyronitrile =(AIBN)
2. Preparation of nylon 66/6
3. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC)and phenolphthalein
4. Redox polymerization of acrylamide
5. Precipitation polymerization of acrylonitrile
6. Preparation of urea-formaldehyde resin
7. Preparations of novalac resin/ resold resin.
8. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
 - (a) Polyacrylamide-aq.NaNO₂ solution
 - (b) (Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol)(PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG)(OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

Suggested Reading:

- M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press,1999.
- H.R. Allcock, F.W. Lampe & J.E. Mark, *Contemporary Polymer Chemistry*, 3rd ed.Prentice-Hall (2003)
- F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed. Wiley-Interscience (1984)
- J.R. Fried, *Polymer Science and Technology*, 2nd ed. Prentice-Hall (2003)
- P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. JohnWiley & Sons (2002)
- L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons(2005)
- M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press(2005).
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Unit I: INTRODUCTION TO GREEN CHEMISTRY: What is Green Chemistry? Need for Green Chemistry; Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry. Principles of Green Chemistry and Designing a Chemical synthesis: Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following: Designing a Green Synthesis using these principles; Prevention of Waste/byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/ minimization of hazardous/ toxic products reducing toxicity. $\text{risk} = (\text{function}) \text{hazard} \times \text{exposure}$; waste or pollution prevention hierarchy.

Unit II: GREEN SOLVENTS: supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorinated biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents; Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy; Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.; Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route to carbonyl) and Flixborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.: Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Unit III: EXAMPLES OF GREEN SYNTHESIS/ REACTIONS AND SOME REAL WORLD CASES:

Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis); Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction; Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasound alternative to Iodine); Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments; Designing of Environmentally safe marine antifoulant; Right fit pigment: synthetic azo pigments to replace toxic organic and inorganic pigments.; An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn. 8 Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils; Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

Unit IV: FUTURE TRENDS IN GREEN CHEMISTRY

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C₂S₃); Green chemistry in sustainable development.

Suggested Reading:

- Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
- Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
- Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
- Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
- Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
- Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.

Safer starting materials

1. Preparation and characterization of nanoparticles of gold using tea leaves.
2. **Using renewable resources:** Preparation of biodiesel from vegetable/ waste cooking oil.
3. **Avoiding waste:** Principle of atom economy: Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
4. Preparation of propene by two methods can be studied
 - Triethylamine ion + OH⁻ → propene + trimethylpropene + water
 - 1-propanol/H₂SO₄/
 - Propene + water
5. Other types of reactions, like addition, elimination, substitution and rearrangements should also be studied for the calculation of atom economy.
6. **Use of enzymes as catalysts:** Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.
7. **Alternative Green solvents:** Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice.
8. Mechanochemical solvent free synthesis of azomethines
9. **Alternative sources of energy:**
 - Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper.
 - Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Suggested Reading:

- Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
- Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
- Ryan, M.A. *Introduction to Green Chemistry*, Tinneland; (Ed), American Chemical Society, Washington DC (2002).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore ISBN 978-93-81141-55-7 (2013).
- Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).
- Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry*, American Chemical Society (2008).
- Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.
- Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach*, W.B. Saunders, 1995.

PAPER CODE: BCH-DSE06 TH
TITLE: INDUSTRIAL CHEMICALS AND ENVIRONMENT

TOTAL HOURS: 60

CREDITS: 04

UNIT I: INDUSTRIAL GASES AND INORGANIC CHEMICALS: Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene. *Inorganic Chemicals:* Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate; **Industrial Metallurgy:** Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

UNIT II: ENVIRONMENT AND ITS SEGMENTS:

Ecosystems. Biogeochemical cycles of carbon, nitrogen and Sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.

Pollution by SO₂, CO₂, CO, NO_x, H₂S and other foul smelling gases. Methods of estimation of CO, NO_x, SO_x and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

UNIT III: WATER POLLUTION: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc.

Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

UNIT IV: ENERGY & ENVIRONMENT: Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management. Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

Suggested Reading:

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
- K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
- S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
- G.T. Miller, *Environmental Science* 11th edition. Brooks/ Cole (2006).
- A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).

DSE

PAPER CODE: BCH-DSE06 PR
TITLE: INDUSTRIAL CHEMICALS AND ENVIRONMENT

TOTAL HOURS: 60

CREDITS: 02

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration
6. method (AgNO₃ and potassium chromate).
7. Estimation of total alkalinity of water samples (CO₃²⁻, HCO₃⁻) using double titration method.
8. Measurement of dissolved CO₂.
9. Study of some of the common bio-indicators of pollution.
10. Estimation of SPM in air samples.
11. Preparation of borax/ boric acid.

Suggested Reading:

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
 - R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
 - J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
 - S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
 - K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
 - S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
-

PAPER CODE: BCH-DSE07 TH
TITLE: INDUSTRIAL CHEMICALS AND ENVIRONMENT

TOTAL HOURS: 60

CREDITS: 04

UNIT 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, colored glass, photosensitive glass. *Ceramics:* Important clays and feldspar, ceramic, their types and manufacture. Hightechnology 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 thermosetting process, quick setting cements.

UNIT II: Fertilizers: Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammoniumnitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate; **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, Plasticpaint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolyticand electroless), metal spraying and anodizing.

UNIT 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; **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.

UNIT IV: 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. **CHEMICAL EXPLOSIVES:** Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

Suggested Reading:

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, Wiley Publishers, New Delhi.
- J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, Vikas Publications, New Delhi.
- Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

DSE

PAPER CODE: BCH-DSE07 PR
TITLE: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

TOTAL HOURS: 60

CREDITS: 02

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. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

Suggested Reading:

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
 - R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.60
 - W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, WileyPublishers, New Delhi.
 - J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
 - P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
 - R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, VikasPublications, New Delhi.
 - Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).
-

UNIT 1: INTRODUCTION TO SPECTROSCOPIC METHODS OF ANALYSIS: Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation; Molecular spectroscopy: *Infrared spectroscopy*: Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

UNIT II: UV-Visible/ Near IR – emission, absorption, fluorescence and photoacoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags).

Mass spectrometry (electrical discharges): Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

NMR spectroscopy: Principle, Instrumentation, Factors affecting chemical shift, Spin coupling,

UNIT III: Separation techniques *Chromatography:* Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

UNIT IV: Elemental analysis: Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

Electroanalytical Methods: Potentiometry & Voltammetry, Radiochemical Methods, X-ray analysis and electron spectroscopy (surface analysis)

Suggested Reading:

- D.A. Skoog, F.J. Holler & S. Crouch (ISBN 0-495-01201-7) *Principles of Instrumental Analysis*, Cengage Learning India Edition, 2007.
- Willard, Merritt, Dean, Settle, *Instrumental Methods of Analysis*, 7th ed, IBH Book House, New Delhi.
- Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press (2014).
- Kakkar, R. *Atomic and Molecular Spectroscopy: Concepts and Applications*. Cambridge University Press, 2015.
- Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
- Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Smith, B.C. *Infrared Spectral Interpretations: A Systematic Approach*. CRC Press, 1998.
- Moore, W.J., *Physical Chemistry* Orient Blackswan, 1999.

DSE

PAPER CODE: BCH-DS08 PR

TITLE: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

TOTAL HOURS: 60

CREDITS: 02

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/ Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids.
16. Use of "presumptive tests" for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

Suggested Reading

- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.

DSE

PAPER CODE: BCH-DSE09

TITLE: DISSERTATION

TOTAL HOURS: 60

CREDITS: 06

- (a) A project/thesis work of 06 credits could be undertaken in the Sixth semester.
- (b) The thesis work shall include the experimental work on a specified topic and submission of the thesis towards the end of the Semester VI. The project work/thesis shall be evaluated as per the guidelines proposed by the Board of Studies and specified in the syllabus.
- (c) The evaluation of the dissertation, project presentation and viva-voce will be conducted by external examiner. The project shall comprise of the three components namely **Part A, Part B and Part C**. Part A will be assigned 50 marks and will comprise of submission of a project report after completion of the project. Part B will be assigned 50 marks and will comprise of a presentation on the topic of student's project work carried out in department/industry/institute/research Centre. Part C will be assigned 50 marks and will include a viva-voce examination

Skill Enhancement Courses

SEC

(BCH-SEC01 to BCH-SEC06)

SEC

PAPER CODE: BCH-SEC01
TITLE: CHEMOINFORMATICS

TOTAL HOURS: 30

CREDITS: 02

UNIT I: Introduction to Chemoinformatics: History and evolution of chemoinformatics, Use of chemoinformatics, Prospects of chemoinformatics, Molecular Modelling and Structure elucidation.

UNIT II: Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

UNIT III: Searching chemical structures: Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

UNIT IV: Applications: Prediction of Properties of Compounds; Linear Free Energy relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling Toxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and Structure Based Drug design; Application of Chemoinformatics in Drug Design.

Hands-on Exercises

Suggested Reading:

- Andrew R. Leach & Valerie, J. Gillet (2007) *An introduction to Chemoinformatics*. Springer: The Netherlands.
- Gasteiger, J. & Engel, T. (2003) *Chemoinformatics: A text-book*. Wiley-VCH.
- Gupta, S. P. (2011) *QSAR & Molecular Modeling*. Anamaya Pub.: New Delhi.

TOTAL HOURS: 30

CREDITS: 02

UNIT I: INTRODUCTION TO INTELLECTUAL PROPERTY: Historical Perspective, Different Types of IP, Importance of protecting IP. Copyrights: Introduction, How to obtain, Differences from Patents: Trade Marks, Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs.; Patents: Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.

UNIT II: GEOGRAPHICAL INDICATIONS: Definition, rules for registration, prevention of illegal exploitation, importance to India. Industrial Designs: Definition, How to obtain, features, International design registration.: Layout design of integrated circuits: Circuit Boards, Integrated Chips, Importance for electronic industry.

UNIT III: TRADE SECRETS: Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection. Different International agreements (a) World Trade Organization (WTO): General Agreement on Tariffs & Trade (GATT), Trade-Related Intellectual Property Rights (TRIPS) agreement; General Agreement on Trade-related Services (GATS); Madrid Protocol; Berne Convention; Budapest Treaty; Paris Convention

UNIT IV: WIPO AND TRIPS: IPR and Plant Breeders Rights, IPR and Biodiversity, IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement, agencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assets, and their valuation, Intellectual Property in the Indian Context – Various laws in India, Licensing and technology transfer.

Suggested Reading:

- Acharya, N.K. *Textbook on intellectual property rights*, Asia Law House (2001).
 - Guru, M. & Rao, M.B. *Understanding Trips: Managing Knowledge in Developing Countries*, Sage Publications (2003).
 - Ganguli, P. *Intellectual Property Rights: Unleashing the Knowledge Economy*, TataMcGraw-Hill (2001).
 - Miller, A.R. & Davis, M.H. *Intellectual Property: Patents, Trademarks and Copyright in a Nutshell*, West Group Publishers (2000).
 - Watal, J. *Intellectual property rights in the WTO and developing countries*, Oxford University Press, New Delhi.
-

SEC

PAPER CODE: BCH-SEC03
TITLE: PHARMACEUTICAL CHEMISTRY

TOTAL HOURS: 30

CREDITS: 02

UNIT I: DRUGS & PHARMACEUTICALS

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of therepresentative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen)

UNIT II:SYNTHESIS OF ANTI INFECTIOUS AGENTS: Synthesis of therepresentative drugs of the following classes:antibiotics (Chloramphenicol);antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide,Trimethoprim); antiviral agents (Acyclovir), HIV-AIDS relateddrugs (AZT- Zidovudine)

UNIT III: SYNTHESIS OF CNS AND CARDIOVASCULAR AGENTS: Synthesis of therepresentative drugs of the following classes:Central Nervous System agents (Phenobarbital,Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone)

UNIT IV: FERMENTATION

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii)Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine,Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Suggested Reading

- Patrick, G. L. *Introduction to Medicinal Chemistry*, Oxford University Press, UK, 2013.
- Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, VallabhPrakashan, Pitampura, New Delhi, 2012.
- Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4thed., B.I. Waverly Pvt. Ltd. New Delhi.

SEC

PAPER CODE: BCH-SEC04
TITLE: CHEMISTRY OF COSMETICS & PERFUMES

TOTAL HOURS: 30

CREDITS: 02

UNIT I: A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder,

UNIT II: A general study including preparation and uses of the following: lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours.

UNIT III: A general study including preparation and uses of the following: Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

UNIT IV: Preparation of talcum powder, shampoo, Preparation of enamels, Preparation of hair remover, face cream, nail polish and nail polish remover.

Suggested Reading

- Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
 - Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
 - Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).
-

PAPER CODE: BCH-SEC05
TITLE: PESTICIDE CHEMISTRY

TOTAL HOURS: 30

CREDITS: 02

UNIT I: General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship,

UNIT II: synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion)

Unit III: synthesis and technical manufacture and uses of Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Unit IV: To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications; Preparation of simple organophosphates, phosphonates and thiophosphates

Suggested Reading

- Cremllyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, New York, 1978.
-

PAPER CODE: BCH-SEC06**TITLE: FUEL CHEMISTRY****TOTAL HOURS: 30****CREDITS: 02**

UNIT I: Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

UNIT II: COAL: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

UNIT III: PETROLEUM AND PETROCHEMICAL INDUSTRY: Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

UNIT IV: LUBRICANTS: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pour point) and their determination.

Suggested Reading

- Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
- Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi. 75
- Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

**Generic Elective Papers (GE)
(Minor-Chemistry) (any four)
for other Departments/
Disciplines: (Credit: 06 each)**

PAPER CODE: BCH-GE01 TH
TITLE: ATOMIC STRUCTURE, BONDING, TRANSITION ELEMENTS AND COORDINATION CHEMISTRY
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit I: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2 , Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s . Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations. (14 Lectures)

Unit II: Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO⁺. Comparison of VB and MO approaches. (16 Lectures)

Unit III: Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only). (12 Lectures)

Unit IV: Coordination Chemistry

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature. (8 Lectures)
Crystal Field Theory Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination. (10 Lectures)

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.

PAPER CODE: BCH-GE01 PR

TITLE: ATOMIC STRUCTURE, BONDING TRANSITION ELEMENTS AND COORDINATION CHEMISTRY

Credits: 02

Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO_4 .
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .
4. Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$.

Semi-micro qualitative analysis (using H_2S or other methods) of mixtures - not more than four ionic species (two anions and two cations, excluding insoluble salts) out of the following:

Cations : NH_4^+ , Pb^{2+} , Bi^{3+} , Cu^{2+} , Cd^{2+} , Fe^{3+} , Al^{3+} , Co^{2+} , Ni^{2+} , Mn^{2+} , Zn^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , K^+ Anions : CO_3^{2-} , S^{2-} , SO_3^{2-} , $\text{S}_2\text{O}_3^{2-}$, NO_3^- , CH_3COO^- , Cl^- , Br^- , I^- , NO_2^- , SO_4^{2-} , PO_4^{3-} , BO_3^{3-} , $\text{C}_2\text{O}_4^{2-}$, F(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximate) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.

Reference Books:

- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

PAPER CODE: BCH-GE02 TH
Title: ORGANIC CHEMISTRY
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles.

Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values.

Aromaticity: Benzenoids and Hückel's rule.

(8 Lectures)

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms).

Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

(10 Lectures)

UNIT II: Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation. Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO₄) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC₂ and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO₄, ozonolysis and oxidation with hot alk. KMnO₄.

(12 Lectures)

UNIT III: Functional group approach (preparations & reactions)

Aromatic hydrocarbons Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

(8 Lectures)

Alkyl and Aryl Halides Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN₁, SN₂ and SN_i) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent. Benzyne Mechanism: KNH₂/NH₃ (or NaNH₂/NH₃). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(8 Lectures)

UNIT IV: Alcohols, Phenols and Ethers (Upto 5 Carbons) Alcohols

Preparation: Preparation of 1° , 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO₄, acidic dichromate, conc. HNO₃).

Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer- 81 Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction. Ethers (aliphatic and aromatic): Cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from nitriles. Reactions – Reaction with HCN, ROH, NaHSO₃, NH₂-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf Verley reduction. (14 Lectures)

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988). • Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
- Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
- Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

PAPER CODE: BCH-GE02 PR
TITLE: ORGANIC CHEMISTRY
(02 credits)

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)
3. Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
4. Identify and separate the sugars present in the given mixture by paper chromatography.
5. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
6. Criteria of Purity: Determination of melting and boiling points.
7. Preparations: Mechanism of various reactions involved to be discussed.
8. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
 - (a) Bromination of Phenol/Aniline
 - (b) Benzoylation of amines/phenols
 - (c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Reference Books

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

PAPER CODE: BCH-GE03 TH
TITLE: PHYSICAL CHEMISTRY
(04 credits)

Theory: 60 Lectures

Unit I: Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances. (10 Lectures)

Unit II: Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG° , Le Chatelier's principle. Relationships between K_p , K_c and K_x for reactions involving ideal gases. (8 Lectures) 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. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. (12 Lectures)

Unit III: Solutions and Phase Equilibria

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. (8 Lectures)

Phase Equilibria Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $\text{FeCl}_3\text{-H}_2\text{O}$ and Na-K only). (8 Lectures)

Unit IV: Conductance and Electrochemistry

Conductance Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acidbase). (6 Lectures)

Electrochemistry Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG , ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only). (8 Lectures)

Reference Books:

- Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998). • Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).

PAPER CODE: BCH-GE03 PR
TITLE: PHYSICAL CHEMISTRY
(02 credits)

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
 2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
 3. Determination of enthalpy of ionization of acetic acid.
 4. Determination of integral enthalpy of solution of salts (KNO₃, NH₄Cl).
 5. Determination of enthalpy of hydration of copper sulphate.
 6. Study of the solubility of benzoic acid in water and determination of ΔH .
 7. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
 8. Preparation of buffer solutions: (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
 9. Study of the equilibrium of one of the following reactions by the distribution method: $I_2(aq) + I(aq) \rightleftharpoons I_3^-(aq)$ $Cu^{2+}(aq) + xNH_3(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$
 10. Phase equilibria
 - a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
 - b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
 - c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.
 11. Determination of cell constant
 12. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
 13. Perform the following conductometric titrations
 - a) Strong acid vs. strong base
 - b. Weak acid vs. strong base
 14. Perform the following potentiometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Potassium dichromate vs. Mohr's salt Section

Reference Books:

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

PAPER CODE: BCH-GE04 TH
TITLE: STATES OF MATTER & CHEMICAL KINETICS, TRANSITION METALS AND
BIORGANIC CHEMISTRY
(04 credits)

Theory: 60 Lectures

Unit I: Chemistry of 3d metals and Organometallic Compounds

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$. (6 Lectures)

Organometallic Compounds Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). (12 Lectures)

Unit II: Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+ , K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones). (12 Lectures)

Kinetic Theory of Gases Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2 . Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, 88 collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only). (8 Lectures)

Unit III: Liquids and solids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only). (6 Lectures)

Solids Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Structures of $NaCl$, KCl and $CsCl$ (qualitative treatment only). Defects in crystals. Glasses and liquid crystals. (8 Lectures)

Unit IV: Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and

second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).
(8 Lectures)

Reference Books:

- Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
- Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
- Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
- Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
- Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
- Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008. 89

PAPER CODE: BCH-GE04 PR
TITLE: STATES OF MATTER & CHEMICAL KINETICS, TRANSITION METALS AND
BIORGANIC CHEMISTRY
(02 credits)

- (I) Surface tension measurement (use of organic solvents excluded).
- a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
 - b) Study of the variation of surface tension of a detergent solution with concentration.
- (II) Viscosity measurement (use of organic solvents excluded).
- a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
 - b) Study of the variation of viscosity of an aqueous solution with concentration of solute.
- (III) Chemical Kinetics Study the kinetics of the following reactions.
3. Iodide-persulphate reaction
 4. Acid hydrolysis of methyl acetate with hydrochloric acid.
 5. Saponification of ethyl acetate.
 6. Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate

Reference Books:

- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

PAPER CODE: BCH-GE05 TH
TITLE: FUNCTIONAL ORGANIC GROUP CHEMISTRY, POLYNUCLEAR
HYDROCARBONS AND UV, IR SPECTROSCOPY
(04 credits)

Theory: 60 Lectures

Unit I Functional group approach

The following reactions (preparations & reactions) to be studied in context to the structure.

Carboxylic acids and their derivatives Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation. (6 Lectures)

Amines and Diazonium Salts Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO₂, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes (6 Lectures)

Unit II: Amino Acids, Peptides, Proteins and carbohydrates

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of –COOH group, acetylation of –NH₂ group, complexation with Cu²⁺ ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (Nterminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butylloxycarbonyl and phthaloyl) & Cactivating groups and Merrifield solid-phase synthesis. (10 Lectures)

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation. (8 Lectures)

Unit III: Polynuclear and heteronuclear aromatic compounds:

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine. (6 Lectures) Active methylene compounds: Preparation: Claisen ester condensation. Keto-enol tautomerism. Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon). (12 Lectures)

Unit IV: Application of Spectroscopy to Simple OrganicMolecules

Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λ_{max} & ϵ_{max} , chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and α,β – unsaturated compounds. Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids

and their derivatives (effect of substitution on $>C=O$ stretching absorptions).
(18 Lectures)

Reference books

- I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.
- John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall.
- R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons. • R.T. Morrison & R.N. Boyd: Organic Chemistry, Prentice Hall.
- Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

PAPER CODE: BCH-GE05 PR
TITLE: FUNCTIONAL ORGANIC GROUP CHEMISTRY, POLYNUCLEAR
HYDROCARBONS AND UV, IR SPECTROSCOPY
(02 credits)

1. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
2. Separation of amino acids by paper chromatography
3. Determination of the concentration of glycine solution by formylation method.
4. Titration curve of glycine
5. Action of salivary amylase on starch
6. Effect of temperature on the action of salivary amylase on starch.
7. Differentiation between a reducing and a nonreducing sugar.

Reference Books:

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
 - A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
 - Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
 - Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
-