Rev: 04

SYLLABUS

For

3 YEARS BSC IN CHEMISTRY PROGRAMME

(Revised Syllabus Approved by Academic Council)

Unveiling Excellence

Dept. of

Chemistry

JUNE, 2018

UNIVERSITY OF SCIENCE &TECHNOLOGY, MEGHALAYA

Techno City, 9th Mile, Baridua, Ri-Bhoi, Meghalaya, 793101

Syllabus Contents

Course: Bachelor of Science in Chemistry

Department: Chemistry

School: SOAS

About the Department:

Established in the year 2012, the Department of Chemistry has been providing higher education in chemistry by training students through its ongoing B.Sc., M.Sc. and Ph.D programmes. The academic curriculum of the department has been framed to enable the students to achieve a good understanding of the subject. The Department already has developed a strong association with the leading research institutes of the region to collaborate on research grounds. The research activities are currently centered at environmental chemistry, synthetic methodologies and catalysis.

Academic Focus:

The Department focuses on the areas which reflect the technical know-how of current research and we aim to develop teaching and research in these fields of chemistry. We collaborate with different stake holders and organizations to create new inputs and materials into our teaching and research.

Career Scope:

The curriculum of the department of chemistry, USTM is framed to provide both basic and applied knowledge in the field of chemistry. The employment opportunities for chemical professionals can be divided into five main sectors: industry, academia, government, non-profit, and entrepreneurship.

Programme Details:

The Department of Chemistry provides 3 (three) years Bachelor of Science (B.Sc.) program with 6 (six semesters). The program is designed specifically to provide both basic and applied knowledge in the field. Additionally it trains students from time to time, in certain areas of chemistry which have direct employment oppurtunities. The program is fully made into Choice Based Credit System to enable students to opt different courses according to their choice and interests.

Eligibility Criteria: Higher Secondary School leaving certificate in Science stream with 50 % marks.

Programme Objectives (PO)

The programme provides scienctific skills and knowledge essential for success in the field. The Programme aims to train proper laboratory techniques and safety protocols so as to enable the students persue career in higher education and in R&D sector. It also equips students with effective scientific skills and commitment towards ethical and social responsibilities.

Programme Specific Outcomes (PSO)

Programme Name: Master of Science

Programme Code: M.Sc.

PSO1: Sound knowledge about the fundamentals of theories concerning behind formation of new substances.

PSO2: To appropriately apply techniques for the qualitative and quantitative analysis of chemicals in laboratories and industries.

PSO3: To develop analytical skills and problem solving skills requiring application of chemical principles.

PSO4: To become familiar with the different branches of chemistry like analytical, organic, inorganic, physical, environmental, polymer, biochemistry etc.

PSO5: To Acquire the ability to undertake independent research**.**

PSO6: To understand the different issues of environmental concern and sustainable solution.

Programme Structure:

The B.Sc. programme is a three year program divided into six semesters. The programme is of 140 credits and for the award of degree a student will be required to complete the credits as per the University norm.

SEMESTER-I						
Course Code	**Title**	**Credit**	**Nature of course (T/P)**	**Marks Allotted**		
				Internal	**End Semester**	**Total**
BSC 101	Inorganic Chemistry-I **(CC-1)**	4	T	30	70	100
BSC 102	Physical Chemistry-I **(CC-2)**	4	T	30	70	100
BSC 103	Inorganic Chemistry-I Lab **(CC-3)**	2	P	15	35	50
BSC 104	Physical Chemistry-I Lab (**CC-4)**	2	P	15	35	50
BEN-711	Communicative English **(AECC-1)**	4	T	30	70	100
BSC 711	Organic, Inorganic and Physical Chemistry I **(GE-1)**	4	T	30	70	100
BSC 712	Organic Chemistry Lab **(GE-Lab)**	2	P	15	35	50
Total		**22**		**165**	**385**	**550**

SEMESTER-II						
Course Code	**Title**	**Credit**	**Nature of course (T/P)**	**Marks Allotted**		
				Internal	**End Semester**	**Total**
BSC 201	Organic Chemistry-I **(CC-4)**	4	T	30	70	100
BSC 202	Physical Chemistry-II **(CC-5)**	4	T	30	70	100
BSC 203	Organic Chemistry-I Lab **(CC-6)**	2	P	15	35	50
BSC 204	Physical Chemistry-II Lab **(CC-7)**	2	P	15	35	50
BEV-720	Environmental Science **(AECC-2)**	4	T	30	70	100
BSC 721	Organic, Inorganic and Physical Chemistry II **(GE-2)**	4	T	30	70	100
BSC 722	Inorganic Chemistry Lab **(GE-Lab)**	2	P	15	35	50
Total		**22**		**165**	**385**	**550**

SEMESTER-III						
Course Code	**Title**	**Credit**	**Nature of course (T/P)**	**Marks Allotted**		
				Internal	**End Semester**	**Total**
BSC 301	Inorganic Chemistry-II **(CC-7)**	4	T	30	70	100
BSC 302	Organic Chemistry-II **(CC-8)**	4	T	30	70	100
BSC-303	Physical Chemistry-III **(CC-9)**	4	T	30	70	100
BSC-304	Inorganic Chemistry-II Lab	2	P	15	35	50
BSC-305	Organic Chemistry-II Lab	2	P	15	35	50
BSC-306 A / BSC-306 B	Pharmaceutical Chemistry / Chemical Technology for Society **(SEC-1)**	2	T	15	35	50
BSC 731	Organic, Inorganic and Physical Chemistry I **(GE-1)**	4	T	30	70	100
BSC 732	Organic Chemistry Lab **(GE-Lab)**	2	P/T	15	35	50
Total		**24**		**180**	**420**	**600**

SEMESTER-IV						
Course Code	**Title**	**Credit**	**Nature of course (T/P)**	**Marks Allotted**		
				Internal	**End Semester**	**Total**
BSC 401	Inorganic Chemistry-III **(C-10)**	4	T	30	70	100
BSC 402	Organic Chemistry III **(C-11)**	4	T	30	70	100
BSC 403	Physical Chemistry-IV **(C-12)**	4	T	30	70	100
BSC 404	Inorganic Chemistry-III Lab	2	P	15	35	50
BSC-405	Organic Chemistry-III Lab	2	P	15	35	50
BSC-406 A/BSC-406 B	Petroleum & Petrochemicals / Pesticide Chemistry **(SEC-2)**	2	T	15	35	50
BSC 721	Organic, Inorganic and Physical Chemistry II **(GE-2)**	4	T	30	70	100
BSC 722	Inorganic Chemistry Lab **(GE-Lab)**	2	P/T	15	35	50
Total		**24**		**180**	**420**	**600**

SEMESTER-V						
Course Code	**Title**	**Credit**	**Nature of course (T/P)**	**Marks Allotted**		
				Internal	**End Semester**	**Total**
BSC 501	Organic Chemistry-IV **(C-13)**	4	T	30	70	100
BSC 502	Physical Chemistry-V **(C-14)**	4	T	30	70	100
BSC 503	Organic Chemistry-IV Lab **(C-15)**	2	P	15	35	50
BSC-504	Physical Chemistry III Lab	2	P	15	35	50
BSC-505A / BSC-505B	Green Chemistry / Novel Inorganic Solids **(DSE-1)**	4	T	30	70	100
BSC-506	DSE I Lab	2	P	15	35	50
BSC-507A BSC-507B	Analytical Methods in Chemistry Industrial Chemicals and environment **(DSE-2)**	4	T	30	70	100
BSC-508	DSE II Lab	2	P	15	35	50
Total		**24**		**180**	**420**	**600**

SEMESTER-VI						
Course Code	**Title**	**Credit**	**Nature of course (T/P)**	**Marks Allotted**		
				Internal	**End Semester**	**Total**
BSC 601	Inorganic Chemistry-IV **(C-16)**	4	T	30	70	100
BSC 602	Organic Chemistry-V **(C-17)**	4	T	30	70	100
BSC 603	Inorganic Chemistry-IV Lab **(C-18)**	2	P	15	35	50
BSC 604	Physical Chemistry-IV Lab	2	P	15	35	50
BSC-605A/BSC-605B	Research Methodology for Chemistry / Instrumental Methods of Analysis **(DSE-3)**	4	T	30	70	100
BSC-606A/BSC-606B	Polymer Chemistry / Inorganic materials of Industrial importance **(DSE-4)**	4	T	30	70	100
BSC-607A / BSC-607B	IT Fundamentals / IT Skills for Chemists **(SEC-3)**	2	T	15	35	50
BSC-608	Dissertation	2	P	15	35	50
Total		**24**		**180**	**420**	**600**

Semester	Core Courses (15)	Ability Enhancement Compulsory Courses [AECC] (2)	Skill Enhancement Course [SEC] (3)	Discipline Specific Elective [DSE] (4)	Generic Elective [GE] (2)
I	Inorganic Chemistry-I	Communicative English			Organic, Inorganic and Physical Chemistry I
	Physical Chemistry-I				Organic Chemistry Lab
	Inorganic Chemistry-I Lab				
	Physical Chemistry-I Lab				
II	Organic Chemistry-I	Environmental Science			Organic, Inorganic and Physical Chemistry II
	Physical Chemistry-II				Inorganic Chemistry Lab
	Organic Chemistry-I Lab				
	Physical Chemistry-II Lab				
III	Inorganic Chemistry-II		Pharmaceutical Chemistry / Chemical Technology for Society (SEC 1)		Organic, Inorganic and Physical Chemistry I
	Organic Chemistry-II				Organic Chemistry Lab
	Physical Chemistry-III				
	Inorganic Chemistry-II Lab				
	Organic Chemistry-II Lab				
IV	Inorganic Chemistry-III		Petroleum & Petrochemicals / Pesticide Chemistry (SEC 2)		Organic, Inorganic and Physical Chemistry II
	Organic Chemistry III				Inorganic Chemistry Lab
	Physical Chemistry-IV				
	Inorganic Chemistry-III Lab				

	Organic Chemistry-III Lab				
V	Organic Chemistry-IV			Green Chemistry / Novel Inorganic Solids (DSE I)	
	Physical Chemistry-V			DSE I LAB	
	Organic Chemistry-IV Lab			Analytical Methods in Chemistry / Industrial Chemicals and environment (DSE II)	
				DSE II LAB	
VI	Inorganic Chemistry-IV		IT Fundamentals / IT Skills for Chemists **(SEC-3)**	Research Methodology for Chemistry / Instrumental Methods of Analysis **(DSE-III)**	
	Organic Chemistry-V			Polymer Chemistry / Inorganic materials of Industrial importance **(DSE-IV)**	
	Inorganic Chemistry-IV Lab				
	Physical Chemistry-IV Lab				
	Dissertation				

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF SCIENCE & TECHNOLOGY, MEGHALAYA

Course Wise Content for Bachelor of Science in Chemistry Programme
SEMESTER I

Course Code	Title	Credit	Total Marks
BSC-101	Inorganic Chemistry-I	4	100
BSC-102	Physical Chemistry-I	4	100
BSC-103	Inorganic Chemistry-I Lab	2	50
BSC-104	Physical Chemistry-I Lab	2	50
BEN-711	Communicative English **(AECC-1)**	4	100
BSC 711	Organic, Inorganic and Physical Chemistry I **(GE-1)**	4	100
BSC 712	Organic Chemistry Lab **(GE-Lab)**	2	50

BSC 101: INORGANIC CHEMISTRY-I

Marks: 30+70=100
Total Credits: 4

***Objective*: Introduction to fundamentals of Atomic structure, periodicity of elements and chemical bonding**

***Course Outcome*: To develop knowledge among students in various branches of inorganic chemistry. To impart essential theoretical knowledge on atomic structure, periodic properties and chemical bonding.**

CO1: To give the basic knowledge of Atomic Structure
CO2: To give the basic knowledge of wave functions and quantum numbers
CO3: To give the basic knowledge of Periodicity of Elements
CO4: To give the basic knowledge of Chemical Bonding
CO5: To give the basic knowledge of Oxidation-Reduction

Contents:

Atomic Structure:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and $\psi 2$. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum

multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Periodicity of Elements:

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

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

Chemical Bonding:

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

(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N2, O2, C2, B2, F2, CO, NO, and their ions; HCl, BeF2, CO2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing

lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

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

(iii) *Metallic Bond:* Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

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

process.

Oxidation-Reduction:

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

Suggested Readings

BSC 101: INORGANIC CHEMISTRY-I

Text Books / Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.

2. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry,

Oxford, 1970

3. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.

4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

BSC 102: PHYSICAL CHEMISTRY I

Marks: 30+70=100
Total Credits: 4

Objective: To understand the general characteristics of different states of matter and ionic equilibrium. To impart knowledge to the students about the intermolecular forces in gases and liquids, the structure of solids, Defects in solids.

Course Outcome: Basic knowledge and interpretation of states of matter and solution chemistry of ionic equilibrium.

CO1: To give the basic knowledge of nature of forces within gas molecules, kinetics and laws.
CO2: To give the basic knowledge of nature of forces within liquid state.
CO3: To study the arrangement of atoms in the solid state and their determination.
CO4: To give the basic knowledge of thermodynamics of electrolytes. salts, acid and bases and indicators.
CO5: To give the basic knowledge of measurement of few properties associated with fluids

Contents:

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. vander Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

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.

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.

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 Readings

BSC 102: PHYSICAL CHEMISTRY I

Text Books/Reference Books:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press

2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).

3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).

4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

BSC 103: INORGANIC CHEMISTRY I LAB

Marks: 15+35=50
Total Credits: 2

Objective: To impart basic training in quantitative analysis in laboratory.

Course Outcome: Students will be able to perform quantitative analysis of various metals.

CO1: Practical knowledge of acid-base titration

CO2: Practical knowledge of oxidation-reduction

CO3: calibration of laboratory apparatus

CO4: Expertise in solution preparation

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

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

(B) Acid-Base Titrations

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

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

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

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized KMnO4 solution.

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

(iii) Estimation of Fe(II) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) and external indicator.

Suggested Readings

Text Book / Reference Book:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

BSC: 104 Physical Chemistry-I LAB

Marks: 15+35=50

Total Credits: 2

Objective: The objective of the course is to introduce experiments on Surface tension, viscometry, pH-metry etc.

Course Outcome: Students will learn and handle surface tension apparatus, viscometer apparatus, pH-meter and analysis of experimental data.

CO1: Practical knowledge of handling viscosity and surface tension appartus.
CO2: Analysis of surface tension and viscosity data
CO3: analysis of acid-base reactions using pH metric titration
CO4: to learns to prepare buffer solutions for various pratical uses.

Contents:

1. **Surface tension measurements.**

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

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

2. **Viscosity measurement using Ostwald's viscometer**.

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

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

3. Indexing of a given powder diffraction pattern of a cubic crystalline system.

4. pH metry

a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

b. Preparation of buffer solutions of different pH

i. Sodium acetate-acetic acid

ii. Ammonium chloride-ammonium hydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

d. Determination of dissociation constant of a weak acid.

Any other experiment carried out in the class.

Suggested Readings:

Text Books / Reference Books

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

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed*.; McGraw-Hill: New York (2003).

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

BSC- 711: Organic, Inorganic and Physical Chemistry I

Marks: 30+70=100

Total Credits=4

Objective: The objective of the generic elective course is to introduce selected important topics from organic, Inorganic and Physical Chemistry sections.

Course Outcome: Students will have basic understanding of general chemistry covering topics like hydrocarbons, structure of Atom and states of Matter.

CO1: To give basic knowledge on the organic compounds and some typical properties.
CO2: To give basic knowledge on Hydrocarbons and properties.
CO3: To give basic knowledge on structure of Atom and related parameters
CO4: To give basic knowledge on the gasesous state and its thermodynamics
CO5: To give basic knowledge on the liquid state and its thermodynamics

Contents:

Section A: Organic Chemistry

Introduction to Organic Compounds

Hybridisation of orbitals, implications of hybridisation on the concept of bond length, bond energy, bond angles, shape of the molecules with following different examples. Nature of covalent bond, Introduction to stereochemistry.

Bronsted-Lowry and Lewis concepts of acids and bases, electronegativity, polarity of bonds and dipole moment, inductive effect, effect of H-bonding on boiling point and solubility of organic compounds.

Conjugation, resonance, hyper-conjugation, tautomerism, electrophiles and nucleophiles. Reactive intermediates: carbocatons, carbonions, free radicals, carbenes - stability and examples.

Hydrocarbons

Alkanes and cycloalkanes

Nomenclature, methods of formation (with special reference to mechanism of Kolbe**,** Corey-House and Wurtz reactions), chemical reactivity. Reaction profile, activation energy, transition state, mechanism of chlorination, relative reactivity of halogens towards different types of alkanes.

General method of preparation of cycloalkanes (upto cyclohexane) and their reaction with halogens and HX. Baeyer's strain theory- its limitations and modifications.

Alkenes

Nomenclature, methods of formation, chemical reactivity with mechanism.

Alkynes

Nomenclature, structure and bonding in alkynes, methods of formation, chemical reactivity with mechanism.

Aromatic Hydrocarbons and Aromaticity

Structure of benzene, molecular orbital picture of benzene, stability of benzene ring, resonance energy, aromaticity, Huckel's (4n+2) rule and its application to simple molecules and ions, electrophilic substitution reactions in aromatic hydrocarbons.

Section B: Inorganic Chemistry

Structure of Atom

Bohr's theory of H-atom – atomic spectra of hydrogen. Qualitative treatment of dual nature of matter (de Broglie equation), Heisenberg's uncertainty principle, quantum numbers, orbital, Radial function and angular function, effective nuclear charge, energy of the orbitals. Electron spin and spin quantum number.

Many electron atoms – electronic configuration – aufbau principle, Pauli's principle,

Hund's rule.

Chemical Periodicity

Long form of periodic table, modern periodic law, types of elements on the basis of electronic configuration; periodic variation in properties – atomic and ionic radii, ionization enthalpy, electro gain enthalpy, and electro negativity; diagonal relationship.

Section C: Physical Chemistry

Gaseous state

Ideal gas equation, derivation of gas laws, Maxwell's speed and energy distributions (derivation excluded); distribution curves; different types of speeds and their significance, concept of equipartition principle, van der Waals equation, Virial equation, continuity of state, Boyle temperature, critical constants, specific heats and specific ratios, laws of partial pressure, vapour density and density method of determination of molecular weights, frequency of binary collisions, mean free path.

Liquid state and Solid state

Structure of liquids. Properties of liquids – surface tension, viscosity, vapour pressure and their determination.

Classification of solids, Laws of crystallography – (i) Law of constancy of interfacial angles (ii) Law of rationality of indices (iii) Law of symmetry. Symmetry elements of crystals. Definition of unit cell & space lattice. Bravais lattices, crystal system. Xray diffraction by crystals. Derivation of Braggs equation. Determination of crystal structure of NaCl.

Suggested Readings

BSC- 711: Organic, Inorganic and Physical Chemistry I

Organic Chemistry

1. Organic Chemistry by T.W. Graham Solomons and Craig B. Fryhle (10th Edition), Willy Student Edition (2012)
2. Advanced General Organic Chemistry by S. K. Ghosh, New Central Book Agency Ltd., 2009.
3. A text book of organic chemistry by R. K. Bansal, New Age International Pvt. Ltd. 5th edition (2007)
4. Organic Chemistry by R.T Morrison and R.N. Boyd, (6th edn), Prentice Hall of India Pvt Ltd. (2009).

Inorganic Chemistry

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia
2. Advanced Inorganic Chemistry by Tuli, Prakash and Basu
3. Concise inorganic chemistry by J.D. Lee
4. Inorganic chemistry by Cotton and Wilkinson, John Willey, Sixth Edition.

Physical Chemistry

1. Advanced Physical Chemistry, Gurdeep Raj, Krishna Prakashan Media (p) Ltd, 2011.
2. Physical Chemistry (Vol. 1 & 2), K.L. Kapoor, Macmillan, 2001.
3. A text book of Physical Chemistry by A. S. Negi and S. C. Anand, New Age International, 2007.
4. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma, Madan S. Pathania, Vishal Publishing Company, 2008.

BSC: 712 Organic Chemistry Practical **Marks: 15+35=50**

Credit: 2

Objective: To give hands on practice on the qualitative test of Organic compounds

Course Outcome: Students will be able to characterize and identify a given organic compound.

CO1: To give knowledge on the preliminary test for detection of organic compound

CO2: To give knowledge on test for elemental detection

CO3: To give knowledge on the detection of functional groups

CO4: To give knowledge on the prepration of derivatives and characterization

Contents:

Part I: Qualitative analysis of organic sample (35 marks)

(i) Detection of elements (N, Cl, Br, I, S), solubility test, unsaturation and aromaticity.

(ii) Systematic analysis to detect the functional groups: alcoholic/phenolic OH, carboxylic, aldehyde, ketone, ester, nitro, amido.

(iii) Preparation of crystalline derivatives/ suitable derivatives to identify the compound. Melting point determination and identification of compounds.

Suggested Readings

BSC: 712 Organic Chemistry Practical

Practical Books

1. Inorganic chemistry practical by S. Baruah.
2. Practical Chemistry by S. Giri, D. N. Bajpai, O. P. Pandey, S. Chand and Co., Seventh Edition, 1990.
3. Advanced Practical Physical Chemistry by J.B. Yadav, KRISHNA Prakashan Media (P) Ltd, 2012.

SEMESTER II

Course Code	Title	Credit	Total Marks
BSC-201	Organic Chemistry-I	4	100
BSC-202	Physical Chemistry-II	4	100
BSC-203	Organic Chemistry-I Lab	2	50
BSC-204	Physical Chemistry-II Lab	2	50
BEV-720	Environmental Science **(AECC-2)**	4	100
BSC 721	Organic, Inorganic and Physical Chemistry II **(GE-2)**	4	100
BSC 722	Inorganic Chemistry Lab **(GE-Lab)**	2	50

BSC 201: ORGANIC CHEMISTRY I **Marks: 30+70=100**

Total Credits: 4

Objective: To impart the students a thorough knowledge about the chemistry of some selected functional groups with a view to develop proper aptitude towards the study of organic compounds and their reactions. To enable the students to understand and study Organic reaction mechanisms.

Course Outcome: Students will be able to understand the basic fundamentals of organic reaction through mechanism, reaction intermediates and stereochemistry.

CO1: To give the basic knowledge of Organic Compounds

CO2: To give the basic knowledge of Stereochemistry

CO3: To give the basic knowledge of Aliphatic Hydrocarbons

CO4: To give the basic knowledge of Aromatic Hydrocarbons

CO5: To give the basic knowledge of types of organic reactions

Contents:

Basics of Organic Chemistry

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

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; H-bonding and its effect on the properties of organic molecules; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative

stability of Carbocations, Carbanions, Free radicals and Carbenes.

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

Stereochemistry:

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

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

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 E^1, E^2, E^{1cb} reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions and their mechanisms (Markownikoff / Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and 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.

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

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.

Suggested Readings

BSC

Text Books / Reference Books:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.

5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

6. Peter Sykes, A Guidebook to Mechanism In Organic Chemistry; 6th Edition, Pearson Education.

BSC 202: PHYSICAL CHEMISTRY II **Marks: 30+70=100**

Total Credits: 4

Objective: Students will be introduced to fundamentals of chemical thermodynamics, equilibrium and colligative properties.

Course Outcome: Students will have an insight into the thermodynamic aspects of chemical reaction and colligavtive properties of solutions. Thermochemical equations can be derived.

CO1: To give the basic knowledge of thermodynamics

CO2: To give the basic knowledge of thermochemistry

CO3: To give the basic knowledge of chemical equilibrium

CO4: To give the basic knowledge of solutions and colligative properties

CO5: To give the basic knowledge of thermodynamic systems of variable composition

Contents:

Chemical Thermodynamics:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

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

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

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

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Systems of Variable Composition:

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Chemical Equilibrium:

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

Solutions and Colligative Properties:

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

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Suggested Readings:

Text Books / Reference Books

1. Peter, A. & Paula, J. de. *Physical Chemistry 9th Ed.,* Oxford University Press (2011).

2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).

3. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).

4. McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).

5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).

BSC 203: ORGANIC CHEMISTRY I LAB **Marks: 15+35=50**

Total Credits: 2

Objective: To introduce common laboratory practices, techniques/apparatus for carrying out a synthesis of organic compounds

Course Outcome: Students will be able to perform identification of organic compounds

CO1: To determine the physical properties of organic compounds

CO2: Separation of mixture of organic compounds by TLC and paper chromatography

CO3: To learn purification techniques

CO4: to handle melting point apparatus.

Contents:

1. Checking the calibration of the thermometer

2. Purification of organic compounds by crystallization using the various solvents.

3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds

5. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation method)

6. Chromatography

a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

b. Separation of a mixture of two sugars by ascending paper chromatography

c. Separation of a mixture of i. naphthalene and o- or p-nitrophenol OR

ii. Naphthalene and o- or p-aminophenol by thin layer chromatography (TLC)

Suggested Readings

Text Books / Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

3. Vogels, A Textbook of Practical Organic Chemistry.

BSC 204: Physical Chemistry II LAB

Marks: 15+35=50
Total Credits: 2

Objective:

Course Outcome:

CO1: To give the practical knowledge of determination of thermo-chemical properties

CO2: To get the practical knowledge on the construction of a Caloriemeter

CO3: To study the thermochemical properties using Caloriemeter

CO4: To study the solubility of liquid in liquids

Contents

Thermochemistry

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

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

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

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

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

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

(g) Study of the solubility of benzoic acid in water and determination of ΔH.

Any other experiment carried out in the class

Suggested Readings

BSC 204: Physical Chemistry II LAB

Text Books / Reference Books

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

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

BSC 721: Organic, Inorganic and Physical Chemistry II

Marks: 100

Credits: 4

Objective: The objective of the generic elective course is to introduce selected important topics from organic, Inorganic and Physical Chemistry sections.

Course Outcome: Students will have basic understanding of general chemistry covering topics like types of reaction mechanisms, chemical bonding and chemical thermodynamics

CO1: To give basic knowledge on nucleophillic and eletrophillic reactions

CO2: To give basic knowledge on alcohols, phenols and their preparation routes

CO3: To give basic knowledge on chemical bonding and acid-base concept

CO4: To give basic knowledge on chemical thermodynamics and equilibrium

CO5: To give basic knowledge on chemical kinetics

Contents:

Section A: Organic Chemistry

Nucleophilic Substitution and Elimination Reactions

Nucleophilic Substitution Reactions

Nucleophile, ambident nucleophile, S_N^1, S_N^2, S_N^i, mechanism and stereochemistry of substitution reactions.

Elimination reactions

E^1, E^2, E^1cB mechanisms, orientation in elimination reactions (Saytzeff's and Hoffmann's rules).

Aliphatic halo compounds Preparation and reactions

Organic Compounds-I

Alcohols

Classification and nomenclature, method of preparation including hydration and industrial prepration of ethyl alcohol (from molasses), reaction of alcohols, distinction between primary, secondary and tertiary alcohols (Victor Meyer's test, Lucas test), preparation and chemical reactions of glycol and glycerol.

Phenols

Nomenclature, structure and bonding. Preparation, industrial preparation from Cumene, physical properties and acidic character, chemical reactions, nitration, halogenation, sulphonation, Kolbe's reaction, Reimer-Tiemann reaction.

Aldehydes and Ketones

Nomenclature and structure of the carbonyl group, method of preparation of aldehydes and ketones (both aliphatic and aromatic), chemical reactivity of carbonyl group, mechanism of nucleophilic additions and addition-elimination reactions with HCN, $NaHSO_3$, NH_2OH, NH_2-NH_2, $C_6H_5NHNH_2$, $NH_2CONHNH_2$) and Cannizzaro reaction; acidity of α-hydrogen in carbonyl compounds and formation of enolates, aldol condensation, benzoin condensation.

Section B: Inorganic Chemistry

Chemical Bonding

Ionic bond, lattice energy, Born Haber Cycle, Calculation of lattice enthalpy, size effect, Efficiency of packing and crystal lattices, radius ratio, covalent character in ionic bond, The octet rule, resonance, VSEPR model, LCAO-MO theory and its application to homonuclear & heteronuclear diatomic molecules (H_2, N_2, O_2, O_2^{-2}, O_2^{-}, O_2^{+}, HF) and bond length, bond order, bond strength.

Acid-Base and redox concept

Arrehenius and Bronsted-Lowry concept, Lewis concept, effect of solvent on relative strengths of acids and bases – leveling effect, HSAB principle

Concepts of oxidation and reduction, oxidation number, common oxidants and reductants, balancing of redox reactions by ion electron method and oxidation number method.

Section C: Physical Chemistry

Chemical thermodynamics and Chemical equilibria

Thermal equilibrium and zeroth law, First law, reversible and irreversible work, isothermal and adiabatic expansions, Joule-Thomson effect (derivation excluded); Thermochemistry: Hess's law and its application, Second law and its elementary interpretation, Carnot's cycle and theorems, Clausius inequality, criteria of spontaneity, free energy and entropy

Conditions of spontaneity and equilibrium, degree of advancement and Le Chatelier principle; Van't Hoff isotherm, isobar and isochore. Equilibrium constant and standard Gibbs free energy change. Definitions of K_P, K_C and K_x ; van't Hoff's reaction.

Chemical kinetics

Introduction of reaction rate in terms of extent of reaction; rate constants, order and molecularity of reactions. Reactions of zero order, first order, second order. Pseudo first order reactions (example using acid catalyzed hydrolysis of methyl acetate). Determination of order of a reaction. Rate-determining and steady-state approximation – explanation with suitable examples. Temperature dependence of rate constant: Arrhenius equation, energy of activation.

Suggested Readings

BSC 721: Organic, Inorganic and Physical Chemistry II

Organic Chemistry

1. Organic Chemistry by T.W. Graham Solomons and Craig B. Fryhle (10^{th} Edition), Willy Student Edition (2012)
2. Advanced General Organic Chemistry by S. K. Ghosh, New Central Book Agency Ltd., 2009.
3. A text book of organic chemistry by R. K. Bansal, New Age International Pvt. Ltd. 5^{th} edition (2007)
4. Organic Chemistry by R.T Morrison and R.N. Boyd, (6^{th} edn), Prentice Hall of India Pvt Ltd. (2009).

Inorganic Chemistry

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia
2. Advanced Inorganic Chemistry by Tuli, Prakash and Basu
3. Concise inorganic chemistry by J.D. Lee
4. Inorganic chemistry by Cotton and Wilkinson, John Willey, Sixth Edition.

Physical Chemistry

1. Advanced Physical Chemistry, Gurdeep Raj, Krishna Prakashan Media (p) Ltd, 2011.
2. Physical Chemistry (Vol. 1 & 2), K.L. Kapoor, Macmillan, 2001.
3. A text book of Physical Chemistry by A. S. Negi and S. C. Anand, New Age International, 2007.
4. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma, Madan S. Pathania, Vishal Publishing Company, 2008.

BSC 722: Inorganic Practical **Total Marks: 15+35=50**

Credits: 2

Objective: To give hands on practice on the qualitative test of Inorganic compounds

Course Outcome: Students will be able to characterize and identify a given Inorganic compound.

CO1: To give knowledge on the qualitative analysis of single ion in a given compound

CO2: To give knowledge on qualitative analysis of mixture of ions in a given compound

CO3: To give knowledge on the quantitative estimation of metal ions

CO4: To give knowledge quantitative estimation of metal ions using different quantitative methods

Contents:

Part I: Qualitative Analysis

Inorganic Mixtures containing three radicals/ions to be analyzed – one of the radicals /ions may be interfering (borate, phosphate). Following ions/radicals to be included:

Pb^{2+}, Hg_2^{2+}, Hg^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Sn^{4+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+}.

Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, NO_3^{-}, BO_3^{3-}, PO_4^{3-}.

Part II: Inorganic Quantitative Analysis

Estimation of inorganic ions by volumetric, complexometric, gravimetric, redox method.

The following one-component systems should be estimated Cu^{2+}, Fe^{2+}, Ca^{2+}, Mg^{2+}, Zn^{2+}, Ni^{2+}, Cl^{-} and SO_4^{2-}**.**

Suggested Readings

BSC 722: Inorganic Chemistry Practical

Practical Books

1. Inorganic chemistry practical by S. Baruah.

2. Practical Chemistry by S. Giri, D. N. Bajpai, O. P. Pandey, S. Chand and Co., Seventh Edition, 1990.

Advanced Practical Physical Chemistry by J.B. Yadav, KRISHNA Prakashan Media (P) Ltd, 2012.

SEMESTER III

Course Code	Title	Credit	Total Marks
BSC 301	Inorganic Chemistry-II **(CC-7)**	4	100
BSC 302	Organic Chemistry-II **(CC-8)**	4	100
BSC-303	Physical Chemistry-III **(CC-9)**	4	100
BSC-304	Inorganic Chemistry-II Lab	2	50
BSC-305	Organic Chemistry-II Lab	2	50
BSC-306 A / BSC-306 B	Pharmaceutical Chemistry / Chemical Technology for Society **(SEC-1)**	2	50
BSC 731	Organic, Inorganic and Physical Chemistry I **(GE-1)**	4	100
BSC 732	Organic Chemistry Lab **(GE-Lab)**	2	50

BSC 301: INORGANIC CHEMISTRY-II **Marks: 30+70=100**

Total Credits: 4

Objective: To impart the basic foundation in metallurgy, detail acid-base concept, s and p block elements and inorganic polymers

Course Outcome: Students will be acquinted with the techniques involved in metallurgy, application of acid-base concept, chemistry of s and p block elements and inorganic polymers.

CO1: To give the basic knowledge of Metallurgy
CO2: To give the basic knowledge of Acids and Bases
CO3: To give the basic knowledge of Chemistry of s and p Block Elements
CO4: To give the basic knowledge of Inorganic Polymers
CO5: To give the basic knowledge of Noble elements based compounds

Contents

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. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

Acids and Bases

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of

Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

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

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements.

Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.

Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Noble Gases:

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

Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

Suggested Readings

BSC 301: INORGANIC CHEMISTRY-II

Text Books/ Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.

2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.

3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.

4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.

5. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry 4th Ed.*, Pearson, 2010.

6. Shriver & Atkins, *Inorganic Chemistry 5th Ed.*

BSC 302: ORGANIC CHEMISTRY-II **Marks: 30+70=100**

Total Credits: 4

Objective: To impart the knowledge in organic chemistry with special emphasis on synthesis and properties of halogenated alcoholic, phenolic and carbonyl groups.

Course Outcome: Students will be able to understand and design synthesis of organic compounds involving different functional groups.

CO1: To give the basic knowledge of Halogenated Hydrocarbons
CO2: To give the basic knowledge of Alcohols and Phenols.
CO3: To give the basic knowledge of Aldehydes and ketones
CO4: To give the basic knowledge of Sulphur compounds

CO5: To give the basic knowledge on selected name reactions

Contents

Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_{N1}, S_{N2} and S_{Ni} mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; S_{NAr}, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Alcohols, Phenols, Ethers and Epoxides:

Alcohols: preparation, properties and relative reactivity of 1º, 2º, 3º 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 $LiAlH_4$

Carbonyl Compounds:

Structure, reactivity and preparation;

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

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

Carboxylic Acids and their Derivatives:

Organic acids and their relative strengths.

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

Sulphur containing compounds:

Preparation and reactions of thiols, thioethers and sulphonic acids.

Suggested Readings

BSC 302: ORGANIC CHEMISTRY-II

Text Books / Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.

BSC 303: PHYSICAL CHEMISTRY-III **Marks: 30+70=100**

Total Credits: 4

Objective: The course is designed to provide fundamental study on phase equilibrium, Kinetics and catalysis

Course Outcome:

CO1: To give the basic knowledge of phase diagram and their equilibrium study
CO2: To give the basic knowledge of chemical kinetics
CO3: To give the basic knowledge of catalysis
CO4: To give the basic knowledge of adsorption
CO5: To give the basic knowledge of thermodynamics of binary Solutions

Contents:

Phase Equilibria:

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

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

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.

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.

Catalysis:

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

Surface chemistry:
Physical adsorption, chemisorption, adsorption isotherms, nature of adsorbed state.

Suggested Readings:

BSC 303: PHYSICAL CHEMISTRY-III

Text Books / Reference Books:

1. Peter Atkins & Julio De Paula, *Physical Chemistry 9th Ed.*, Oxford University Press (2010).

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).

BSC 304: Inorganic Chemistry II LAB **Marks: 15+35=50**

Total Credits: 2

Objective: The course aims to give expertise with the principles of basic analytical chemistry mainly volumetric analysis and synthesis.

Course Outcome: Students will be able to estimate quantitatively iodo/iodimetric titrations and synthesis of selected inorganic compounds.

CO1: To give the practical knowledge of iodometric titration

CO2: To give the practical knowledge of preparation of double salt

CO3: estimation of toxic ions like Arsenic.

CO4: estimation of halogens.

Contents

(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, $MnPO_4.H_2O$

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

Suggested Readings

BSC 304: Inorganic Chemistry II LAB

Reference Books:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

BSC 305: Organic Chemistry II-LAB **Marks: 15+35=50**

Total Credits: 2

Objective: The course aims to train students with the basic analytical chemistry for organic compounds.

Course Outcome: Students will be able to confirm presence of functional groups in organic compounds.

CO1: To detect elements other than carbon.

CO2: Determination of functional groups of organic compounds.

CO3: Preparation of derivative

CO4: Measurement of melting points of organic compounds

Contents:

1. Detection of extra elements and (N, S, Cl, Br and I)

2. Functional group tests for alcohols, phenols, carbonyl, carboxylic acid group, nitro, amine and amide groups.

3. Preparation of a suitable crystalline derivative. Determination of Melting point of the compound the derivative.

4. Identification of an organic compound using the above data.

Suggested Readings

BSC 305: Organic Chemistry II-LAB

Text Books / Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000)

BSC 306A: SEC-I PHARMACEUTICAL CHEMISTRY **Marks: 15+35=50**

Total Credits: 2

Objective: to learn the background of pharmaceutical drugs with emphasis on synthesis and application.

Course Outcome: Upon completion students will be familiar with the different classes of pharmaceutical drugs.

CO1: To give the basic knowledge of drugs
CO2: To give the basic knowledge of fermentation
CO3: Synthesis of several common drugs
CO4: Intoduction of several classes of drugs

Contents

Drugs & Pharmaceuticals

Definition of Drugs and Permaceuticals. Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

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 B_2, Vitamin B_{12} and Vitamin C.

Suggested Books

BSC 306A: SEC-I PHARMACEUTICAL CHEMISTRY

Text Books / Reference Books:

1. G.L. Patrick: Introduction to *Medicinal Chemistry, Oxford University* Press, UK.
2. Hakishan, V.K. Kapoor: *Medicinal and Pharmaceutical Chemistry,* Vallabh Prakashan, Pitampura, New Delhi.
3. William O. Foye, Thomas L., Lemke, David A. William: *Principles of Medicinal Chemistry*, B.I. Waverly Pvt. Ltd. New Delhi.

BSC 306B: SEC-I CHEMICAL TECHNOLOGY & SOCIETY **Marks: 15+35=50**

Total Credits: 2

Objective: The course will will develop scienctific solutions for societal needs

Course Outcome: This course will help students to connect chemical technology for societal benefits.

CO1: To impart the basic knowledge of Chemical Technology

CO2: To give the basic knowledge of effect of chemicals, plastic, nuclear materials, fossil fuel, genetic engineering on society.

CO3: To impart training on extraction, leaching, adsorption and adsorption methods.

CO4: To create knowledge about societal issues on chemical industry.

CONTENTS

Chemical Technology

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.

Society

Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants); energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission; materials like plastics and polymers and their natural analogues, proteins and nucleic acids, and molecular reactivity and interconversions from simple examples like combustion to complex instances like genetic engineering and the manufacture of drugs.

Suggested Readings

BSC 306B: SEC-I CHEMICAL TECHNOLOGY & SOCIETY

Text Book / Reference Book:

John W. Hill, Terry W. McCreary & Doris K. Kolb, *Chemistry for changing times* 13th Ed.

BSC- 731: Organic, Inorganic and Physical Chemistry I

Marks: 30+70=100

Total Credits=4

Objective: The objective of the generic elective course is to introduce selected important topics from organic, Inorganic and Physical Chemistry sections.

Course Outcome: Students will have basic understanding of general chemistry covering topics like hydrocarbons, structure of Atom and states of Matter.

CO1: To give basic knowledge on the organic compounds and some typical properties.
CO2: To give basic knowledge on Hydrocarbons and properties.
CO3: To give basic knowledge on structure of Atom and related parameters
CO4: To give basic knowledge on the gasesous state and its thermodynamics
CO5: To give basic knowledge on the liquid state and its thermodynamics

Contents:

Section A: Organic Chemistry

Introduction to Organic Compounds

Hybridisation of orbitals, implications of hybridisation on the concept of bond length, bond energy, bond angles, shape of the molecules with following different examples. Nature of covalent bond, Introduction to stereochemistry.

Bronsted-Lowry and Lewis concepts of acids and bases, electronegativity, polarity of bonds and dipole moment, inductive effect, effect of H-bonding on boiling point and solubility of organic compounds.

Conjugation, resonance, hyper-conjugation, tautomerism, electrophiles and nucleophiles. Reactive intermediates: carbocatons, carbonions, free radicals, carbenes - stability and examples.

Hydrocarbons

Alkanes and cycloalkanes

Nomenclature, methods of formation (with special reference to mechanism of Kolbe**,** Corey-House and Wurtz reactions), chemical reactivity. Reaction profile, activation energy, transition state, mechanism of chlorination, relative reactivity of halogens towards different types of alkanes.

General method of preparation of cycloalkanes (upto cyclohexane) and their reaction with halogens and HX. Baeyer's strain theory- its limitations and modifications.

Alkenes

Nomenclature, methods of formation, chemical reactivity with mechanism.

Alkynes

Nomenclature, structure and bonding in alkynes, methods of formation, chemical reactivity with mechanism.

Aromatic Hydrocarbons and Aromaticity

Structure of benzene, molecular orbital picture of benzene, stability of benzene ring, resonance energy, aromaticity, Huckel's (4n+2) rule and its application to simple molecules and ions, electrophilic substitution reactions in aromatic hydrocarbons.

Section B: Inorganic Chemistry

UNIT I: Structure of Atom

Bohr's theory of H-atom – atomic spectra of hydrogen. Qualitative treatment of dual nature of matter (de Broglie equation), Heisenberg's uncertainty principle, quantum numbers, orbital, Radial function and angular function, effective nuclear charge, energy of the orbitals. Electron spin and spin quantum number.

Many electron atoms – electronic configuration – aufbau principle, Pauli's principle,

Hund's rule.

Unit II: Chemical Periodicity

Long form of periodic table, modern periodic law, types of elements on the basis of electronic configuration; periodic variation in properties – atomic and ionic radii, ionization enthalpy, electro gain enthalpy, and electro negativity; diagonal relationship.

Section C: Physical Chemistry

Gaseous state

Ideal gas equation, derivation of gas laws, Maxwell's speed and energy distributions (derivation excluded); distribution curves; different types of speeds and their significance, concept of equipartition principle, van der Waals equation, Virial equation, continuity of state, Boyle temperature, critical constants, specific heats and specific ratios, laws of partial pressure, vapour density and density method of determination of molecular weights, frequency of binary collisions, mean free path.

Liquid state and Solid state

Structure of liquids. Properties of liquids – surface tension, viscosity, vapour pressure and their determination.

Classification of solids, Laws of crystallography – (i) Law of constancy of interfacial angles (ii) Law of rationality of indices (iii) Law of symmetry. Symmetry elements of crystals. Definition of unit cell & space lattice. Bravais lattices, crystal system. Xray diffraction by crystals. Derivation of Braggs equation. Determination of crystal structure of NaCl.

Suggested Readings

BSC 731: Organic, Inorganic and Physical Chemistry I

Organic Chemistry

5. Organic Chemistry by T.W. Graham Solomons and Craig B. Fryhle (10th Edition), Willy Student Edition (2012)
6. Advanced General Organic Chemistry by S. K. Ghosh, New Central Book Agency Ltd., 2009.
7. A text book of organic chemistry by R. K. Bansal, New Age International Pvt. Ltd. 5th edition (2007)
8. Organic Chemistry by R.T Morrison and R.N. Boyd, (6th edn), Prentice Hall of India Pvt Ltd. (2009).

Inorganic Chemistry

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia
2. Advanced Inorganic Chemistry by Tuli, Prakash and Basu
3. Concise inorganic chemistry by J.D. Lee
4. Inorganic chemistry by Cotton and Wilkinson, John Willey, Sixth Edition.

Physical Chemistry

5. Advanced Physical Chemistry, Gurdeep Raj, Krishna Prakashan Media (p) Ltd, 2011.
6. Physical Chemistry (Vol. 1 & 2), K.L. Kapoor, Macmillan, 2001.
7. A text book of Physical Chemistry by A. S. Negi and S. C. Anand, New Age International, 2007.
8. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma, Madan S. Pathania, Vishal Publishing Company, 2008.

BSC 732: Organic Chemistry Practical **Marks: 15+35=50**

Credit: 2

Objective: To give hands on practice on the qualitative test of Organic compounds

Course Outcome: Students will be able to characterize and identify a given organic compound.

CO1: To give knowledge on the preliminary test for detection of organic compound

CO2: To give knowledge on test for elemental detection

CO3: To give knowledge on the detection of functional groups

CO4: To give knowledge on the prepration of derivatives and characterization

Contents:

Part I: Qualitative analysis of organic sample (35 marks)

(i) Detection of elements (N, Cl, Br, I, S), solubility test, unsaturation and aromaticity.

(ii) Systematic analysis to detect the functional groups: alcoholic/phenolic OH, carboxylic, aldehyde, ketone, ester, nitro, amido.

(iii) Preparation of crystalline derivatives/ suitable derivatives to identify the compound. Melting point determination and identification of compounds.

Suggested Readings

BSC 732: Organic Chemistry Practical

Practical Books

1. Inorganic chemistry practical by S. Baruah.
2. Practical Chemistry by S. Giri, D. N. Bajpai, O. P. Pandey, S. Chand and Co., Seventh Edition, 1990.
3. Advanced Practical Physical Chemistry by J.B. Yadav, KRISHNA Prakashan Media (P) Ltd, 2012.

SEMESTER IV

Course Code	Title	Credit	Total Marks
BSC-401	Inorganic Chemistry-III	4	100
BSC-402	Organic Chemistry III	4	100
BSC-403	Physical Chemistry-IV	4	100
BSC-404	Inorganic Chemistry-III Lab	2	50
BSC-405	Organic Chemistry-III Lab	2	50
BSC-406 A/BSC-406 B	Petroleum & Petrochemicals / Pesticide Chemistry	2	50
BSC 721	Organic, Inorganic and Physical Chemistry II **(GE-2)**	4	100
BSC 722	Inorganic Chemistry Lab **(GE-Lab)**	2	50

BSC 401: INORGANIC CHEMISTRY-III **Marks: 30+70=100**

Total Credits: 4

Objective: To acquire the knowledge of coordination compounds, transition elements and bioinorganic chemistry

Course Outcome: Students will be able to get insight into the basic fundamentals of coordination, transition elements and bioinorganic chemistry

CO1: To give the basic knowledge of complex compounds
CO2: To give the basic knowledge of d- block elements
CO3: To give the basic knowledge of f- block elements
CO4: To give the basic knowledge of Lanthanides
CO5: To give the basic knowledge of Bioinorganic Chemistry

Contents:

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 (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative 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.

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)

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

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 Readings

BSC 401: INORGANIC CHEMISTRY-III

Text Books / Reference Books:

1. Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.

2. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.

3. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.

4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. Wiley-VCH, 1999

5. Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.

6. Greenwood, N.N. & Earnshaw A., Chemistry of the Elements, Butterworth- Heinemann,1997.

BSC 402: ORGANIC CHEMISTRY III **Marks: 30+70=100**

Total Credits: 4

Objective: To understand the synthetic approach of some selected class of organic compounds

Course Outcome: Students will be familiar with varieties of organic name reactions concerning different functional groups.

CO1: synthetic approach for Nitrogen containing organic compounds

CO2: synthetic approach for polynuclear hydrocarbons

CO3: synthetic approach for Alkaloids

CO4: synthetic approach for Terpenoids

CO5: Medicial importance of Alkaloids and Terpenoids

Contents:

Nitrogen Containing Functional Groups

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

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

Polynuclear Hydrocarbons

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

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.

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.

Terpenes

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

Suggested Readings

BSC 402: ORGANIC CHEMISTRY III

Text Books / Reference Books:

1.Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* John Welly & Sons (1976).

5. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.

6. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.

7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.

8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).

BSC 403: PHYSICAL CHEMISTRY-IV **Marks: 30+70=100**

Total Credits: 4

Objective: To provide the knowledge of applied chemistry in the field of electrochemistry
Course Outcome: Students will be able to understand the fundaments of electrochemistry

CO1: Understand the basic concepts of electrochemistry.

CO2: Understand the basic theories of electrical conductance

CO3: Understand the basic concepts of electrochemistry.

CO4: Application of conductance and emf measurments

CO5: Understand the different types of magnetism and measurement.

Contents:

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.

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).

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 Readings

BSC 403: PHYSICAL CHEMISTRY-IV

Text Books / Reference Books:

1. Atkins, P.W & Paula, J.D. *Physical Chemistry*, 9th Ed., Oxford University Press (2011).
2. Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
3. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
4. Barrow, G. M., *Physical Chemistry 5th Ed.*, Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
6. Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).

BSC 404: Inorganic Chemistry III-LAB **Marks: 15+35=50**

Total Credits: 2

Objective: To impart the training in the quantitative analysis and separation of ions.

Course Outcome: Students will be able to estimate and separate ions invoving inorganic compounds.

CO1: Techniques of Gravimetric estimation.

CO2: Gravimetric estimation of ions in metal complexes

CO3: Separation of ions using Chromatography

CO4: Preparation of some important metal complexes

Contents:

Gravimetric Analysis:

i. Estimation of nickel (II) using Dimethylglyoxime (DMG).

ii. Estimation of copper as CuSCN

iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

iv. Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

Inorganic Preparations:

i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$

ii. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III)

iii. Tetraamminecarbonatocobalt (III) ion

iv. Potassium tris(oxalate)ferrate(III)

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni (II) and Co (II)

ii. Fe (III) and Al (III)

Suggested Readings

BSC 404: Inorganic Chemistry III-LAB

Text Book / Reference Book:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

BSC 405: Organic Chemistry III-LAB **Marks: 15+35=50**

Total Credits: 2

Objective: To impart hands on training in the synthesis of organic compounds with different approaches

Course Outcome: Students will have experience in synthesis of organic compounds involving different reaction conditions

CO1: To give the practical knowledge of organic preparations

CO2: To give the practical knowledge of green chemistry in organic synthesis

CO3: To perform selected name reactions

CO4: To perform selected organic reaction using green methodology

Contents:

Organic preparations: (Minimum Six preparation)

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. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, pcresol) 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 methyl ketone, cyclohexanone, benzaldehyde.

x. *S*-Benzylisothiouronium 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 prepration should be done using 0.5-1 g of the organic compound. The solid samples must be collected and recrystallized, and melting point to be recorded.

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Suggested Readings

BSC 405: Organic Chemistry III-LAB

Text Books / Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

5. Vogels, A Textbook of Practical Organic Chemistry.

BSC 406 A: SEC-II Petroleum & Petrochemicals **Marks: 15+35=50**

Total Credits: 2

Objective: To familiarize the students on fuels and their uses.

Course Outcome: Students will be aware of different fuels, their purification methods and detail properties.

CO1: To give the basic knowledge of Petroleum & Petrochemicals

CO2: To give the basic knowledge of Lubricants

CO3: To give the basic knowledge of Coal Chemistry

CO4: Purification of petroleum products

Contents:

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

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.

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants.

Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

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.

Suggested Readings

BSC 406 A: SEC-II Petroleum & Petrochemicals

Text Books / Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol -I, Ellis Horwood Ltd. UK.

2. P.C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.

3. B.K. Sharma: *Industrial Chemistry*, Goel Publishing House, Meerut**.**

BSC 406 B: SEC-II PESTICIDE CHEMISTRY **Marks: 15+35=50**

Total Credits: 2

Objective: To make awareness among the students on pesticide chemicals and their applications.

Course Outcome:

CO1: To give the basic knowledge of synthesis and manufacture of pesticides

CO2: To give the basic knowledge of good and bad effect of pesticides on environment

CO3: To analyze pesticides.

CO4: To know the chemistry of Pesticides

Contents:

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Suggested Readings

Text Book / Reference Book:

1. R. Cremlyn: *Pesticides*, John Wiley.

BSC 741: Organic, Inorganic and Physical Chemistry II

Marks: 30+70=100

Credits: 4

Objective: The objective of the generic elective course is to introduce selected important topics from organic, Inorganic and Physical Chemistry sections.

Course Outcome: Students will have basic understanding of general chemistry covering topics like types of reaction mechanisms, chemical bonding and chemical thermodynamics

CO1: To give basic knowledge on nucleophillic and eletrophillic reactions

CO2: To give basic knowledge on alcohols, phenols and their preparation routes

CO3: To give basic knowledge on chemical bonding and acid-base concept

CO4: To give basic knowledge on chemical thermodynamics and equilibrium

CO5: To give basic knowledge on chemical kinetics

Contents:

Section A: Organic Chemistry

Nucleophilic Substitution and Elimination Reactions

Nucleophilic Substitution Reactions

Nucleophile, ambident nucleophile, S_N^1, S_N^2, S_N^i, mechanism and stereochemistry of substitution reactions.

Elimination reactions

E^1, E^2, E^1cB mechanisms, orientation in elimination reactions (Saytzeff's and Hoffmann's rules).

Aliphatic halo compounds Preparation and reactions

Organic Compounds-I

Alcohols

Classification and nomenclature, method of preparation including hydration and industrial prepration of ethyl alcohol (from molasses), reaction of alcohols, distinction between primary,

secondary and tertiary alcohols (Victor Meyer's test, Lucas test), preparation and chemical reactions of glycol and glycerol.

Phenols

Nomenclature, structure and bonding. Preparation, industrial preparation from Cumene, physical properties and acidic character, chemical reactions, nitration, halogenation, sulphonation, Kolbe's reaction, Reimer-Tiemann reaction.

Aldehydes and Ketones

Nomenclature and structure of the carbonyl group, method of preparation of aldehydes and ketones (both aliphatic and aromatic), chemical reactivity of carbonyl group, mechanism of nucleophilic additions and addition-elimination reactions with HCN, $NaHSO_3$, NH_2OH, NH_2-NH_2, $C_6H_5NHNH_2$, $NH_2CONHNH_2$) and Cannizzaro reaction; acidity of α-hydrogen in carbonyl compounds and formation of enolates, aldol condensation, benzoin condensation.

Section B: Inorganic Chemistry

Chemical Bonding

Ionic bond, lattice energy, Born Haber Cycle, Calculation of lattice enthalpy, size effect, Efficiency of packing and crystal lattices, radius ratio, covalent character in ionic bond, The octet rule, resonance, VSEPR model, LCAO-MO theory and its application to homonuclear & heteronuclear diatomic molecules (H_2, N_2, O_2, O_2^{-2}, O_2^{-}, O_2^{+}, HF) and bond length, bond order, bond strength.

Acid-Base and redox concept

Arrehenius and Bronsted-Lowry concept, Lewis concept, effect of solvent on relative strengths of acids and bases – leveling effect, HSAB principle

Concepts of oxidation and reduction, oxidation number, common oxidants and reductants, balancing of redox reactions by ion electron method and oxidation number method.

Section C: Physical Chemistry

Chemical thermodynamics and Chemical equilibria

Thermal equilibrium and zeroth law, First law, reversible and irreversible work, isothermal and adiabatic expansions, Joule-Thomson effect (derivation excluded); Thermochemistry: Hess's law and its application, Second law and its elementary interpretation, Carnot's cycle and theorems, Clausius inequality, criteria of spontaneity, free energy and entropy

Conditions of spontaneity and equilibrium, degree of advancement and Le Chatelier principle; Van't Hoff isotherm, isobar and isochore. Equilibrium constant and standard Gibbs free energy change. Definitions of K_P, K_C and K_x ; van't Hoff's reaction.

Chemical kinetics

Introduction of reaction rate in terms of extent of reaction; rate constants, order and molecularity of reactions. Reactions of zero order, first order, second order. Pseudo first order reactions (example using acid catalyzed hydrolysis of methyl acetate). Determination of order of a reaction. Rate-determining and steady-state approximation – explanation with suitable examples. Temperature dependence of rate constant: Arrhenius equation, energy of activation.

Suggested Readings

BSC 741: Organic, Inorganic and Physical Chemistry I

Organic Chemistry

1. Organic Chemistry by T.W. Graham Solomons and Craig B. Fryhle (10^{th} Edition), Willy Student Edition (2012)

2. Advanced General Organic Chemistry by S. K. Ghosh, New Central Book Agency Ltd., 2009.

3. A text book of organic chemistry by R. K. Bansal, New Age International Pvt. Ltd. 5^{th} edition (2007)

4. Organic Chemistry by R.T Morrison and R.N. Boyd, (6^{th} edn), Prentice Hall of India Pvt Ltd. (2009).

Inorganic Chemistry

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia

2. Advanced Inorganic Chemistry by Tuli, Prakash and Basu

3. Concise inorganic chemistry by J.D. Lee

4. Inorganic chemistry by Cotton and Wilkinson, John Willey, Sixth Edition.

Physical Chemistry

1. Advanced Physical Chemistry, Gurdeep Raj, Krishna Prakashan Media (p) Ltd, 2011.

2. Physical Chemistry (Vol. 1 & 2), K.L. Kapoor, Macmillan, 2001.

3. A text book of Physical Chemistry by A. S. Negi and S. C. Anand, New Age International, 2007.

4. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma, Madan S. Pathania, Vishal Publishing Company, 2008.

BSC 742: Inorganic Practical **Total Marks: 15+35=50**

Credits: 2

Objective: To give hands on practice on the qualitative test of Inorganic compounds

Course Outcome: Students will be able to characterize and identify a given Inorganic compound.

CO1: To give knowledge on the qualitative analysis of single ion in a given compound

CO2: To give knowledge on qualitative analysis of mixture of ions in a given compound

CO3: To give knowledge on the quantitative estimation of metal ions

CO4: To give knowledge quantitative estimation of metal ions using different quantitative methods

Contents:

Part I: Qualitative Analysis

Inorganic Mixtures containing three radicals/ions to be analyzed – one of the radicals /ions may be interfering (borate, phosphate). Following ions/radicals to be included:

Pb^{2+}, Hg_2^{2+}, Hg^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Sn^{4+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+}.

Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, NO_3^{-}, BO_3^{3-}, PO_4^{3-}.

Part II: Inorganic Quantitative Analysis

Estimation of inorganic ions by volumetric, complexometric, gravimetric, redox method.

The following one-component systems should be estimated Cu^{2+}, Fe^{2+}, Ca^{2+}, Mg^{2+}, Zn^{2+}, Ni^{2+}, Cl^{-} and SO_4^{2-}**.**

Suggested Readings

BSC 742: Inorganic Practical

1. Inorganic chemistry practical by S. Baruah.

2. Practical Chemistry by S. Giri, D. N. Bajpai, O. P. Pandey, S. Chand and Co., Seventh Edition, 1990.

3. Advanced Practical Physical Chemistry by J.B. Yadav, KRISHNA Prakashan Media (P) Ltd, 2012.

Semester IV

Course Code	Title	Credit	Total Marks
BSC-501	Organic Chemistry-IV	4	100
BSC-502	Physical Chemistry-V	4	100
BSC-503	Organic Chemistry-IV Lab	2	50
BSC-504	Physical Chemistry III Lab	2	50
BSC-505A / BSC-505B	Green Chemistry / Novel Inorganic Solids	4	100
BSC-506	DSE I Lab	2	50
BSC-507A BSC-507B	Analytical Methods in Chemistry Industrial Chemicals and environment	4	100
BSC-508	DSE II Lab	2	50

BSC 501: ORGANIC CHEMISTRY-IV **Marks: 30+70=100**

Total Credits: 4

Objective: To provide the importance of biomolecules and energy conversion reactions.

Course Outcome: Students will be able to understand the structure, classification and reaction of different biomolcules

CO1: To Study the classification, structures and properties of carbohydrates.

CO2: To study the classification and synthetic methods of amino acids, peptides and proteins.
CO3: To analyze the mechanisms of enzyme and drug actions and study the structure-activity relationships of some drug molecules.
CO4: To classify the components of nucleic acids and lipids and understand the roles of DNA, RNA, triglycerides, phospholipids, glycolipids, and steroids in biological systems.
CO5: To understand the concept of energy conversion in biological systems

Contents:

Carbohydrates:

Classification and nomenclature, interrelationship among monosachharides. Reaction of glucose and fructose with Br_2, HCN, Tollen's reagent, Fehling's solution, hydroxylamine, phenylhydrazine, HNO_3 and osazone formation. Elucidation of pyranose and furanose structures. Determination of ring size. Haworth projection formula, configuration of glucose and fructose. Epimerization, inter-conversion of aldoses and ketoses. Ascending and descending series.

Disaccharides: Maltose and sucrose – their reactions and structure, structure of cellulose and starch (detailed study not required).

Amino Acids, Peptides and Proteins

Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a values, isoelectric point and electrophoresis;

Study of peptides: Nomenclature and structure of mono, di and polypeptides, 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

Lipids

Lipids: definition and classification of 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.

Biological Chemistry

Enzymes – Introduction, nomenclature and characteristics. Mechanism of enzyme action (a general picture); mechanism of action of the enzyme chymotripsin as a peptidase.; co-enzyme, co-enzymes derived from niacin and thiamine, lipoic acid, co-enzyme A, energy production in biological system (role of ATP and ATP-ADP cycle), glycolysis and tricarboxylic acid cycle. Oxidative phosphorylation and ATP synthesis.

Nucleic acids: Structure of purine and pyrimidine bases in nucleic acid (adenine, guanine, cytosine, uracil and thiamine) [no synthesis]. Structure of nucleosides, nucleotides and DNA, replication of DNA.

Pharmaceutical Compounds: Structure and Importance

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

Suggested Readings:

BSC 501: ORGANIC CHEMISTRY-IV

Text Books / Reference Books:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.

2. Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.

3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.

BSC 502: PHYSICAL CHEMISTRY V **Marks: 30+70=100**

Total Credits: 4

Objective: To Provide fundamental knowledge in the basic principles, and applications of quantum chemistry, spectroscopy and photochemistry.

Course Outcome: Students will be able to relate and apply quantum chemistry in spectroscopy

CO1: To understand the basic concept of quantum chemistry and its applications.

CO2: To Apply the Schrodinger equation in simple model systems.
CO3: To understand the basic knowledge of spectroscopy and its application.
CO4: To Understand the principle, application of Electronic, NMR, ESR spectroscopy.
CO5: To acquire knowledge about photochemistry and its applications.

Contents

Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, 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 wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

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

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

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.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, 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.

Photochemistry

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

Suggested Readings

BSC 502: PHYSICAL CHEMISTRY V

Text Books / Reference Books:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).

2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).

3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).

4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).

5. Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015)

BSC 503: Organic Chemistry IV-LAB **Marks: 15+35=50**

Total Credits: 2

Objective: To learn qualitative and quantitative tests of proteins etc.

Course Outcome: Students will gain practical knowledge in the estimation and analysis of amino acids, proteins and Oil.

CO1: To give the basic knowledge of organic estimation

CO2: To give the practical knowledge of saponification

CO3: To give training in estimation of amino acids and proteins

CO4: To determine action of salivary amylase

Contents

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.

Suggested Readings

BSC 503: Organic Chemistry IV-LAB

Text Books / Reference Books:

1. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.

2. Arthur, I. V. *Quantitative Organic Analysis*, Pearson.

BSC: 504 Physical Chemistry-III LAB

Marks: 15+35=50
Total Credits: 2

Objective: To study adsorption, equilibrium reactions and kinetics.

Course Outcome: Students will be able to learn some selected phase equilibria reactions and parameters, kinetics of reactions and adsorption

CO1: To give the practical knowledge of kinetic study

CO2: To give the practical knowledge of adsorption study

CO3: To give the practical knowledge of equilibrium study

CO4: To give the practical knowledge of phase study

Contents:

I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities 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 Cyclohexane.

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

(i) $I_2(aq) + I \rightarrow I_3(aq)^{2+}$

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

V. Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction

2. Integrated rate method:

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

VI. Adsorption

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

Suggested Readings

BSC: 504 Physical Chemistry-III LAB

Text Books / Reference Books:

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

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).

BSC 505A: GREEN CHEMISTRY (DSE I)

Marks: 30+70=100
Total Credits: 4

Objective: To impart the knowledge of green chemistry and ensure the establishment of the principles of green chemistry

Course Outcome: Understanding and applying the principles of green chemistry

CO1: To give the knowledge of Introduction to Green Chemistry

CO2: T**o** Know the importance of employing green chemistry principles

CO3: To know the Importance of catalyst to achieve the principles of green chemistry

CO4: Acquiring knowledge of greener synthetic methods in real world cases

CO5: To Ensuring the future trends and importance of greener synthetic methods

Contents

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; 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); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions - use of microwaves, 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; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Examples of Green Synthesis/ Reactions

1. Green Synthesis of the following compounds (atleast two): adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide,

acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis), citral, ibuprofen, paracetamol, furfural.

2. Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzole acid), Oxidation (of toluene, alcohols). Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement,

Orthoester Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation.Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2- dihydrotriazine derivatives; benzimidazoles.

3. Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.

4. Selective methylation of active methylene group using dimethylcarbonate: Solid-state polymerization of amorphous polymers using diphenylcarbonate; Use of "Clayan", a nonmetallic oxidative reagent for various reactions;

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry in sustainable development.

Suggested Readings

BSC 505A: GREEN CHEMISTRY (DSE I)

Text Books / Reference Books

1. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).

2. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998).

3. A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).

4. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).

5. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

BSC 505B: NOVEL INORGANIC SOLIDS (DSE I)

Marks: 30+70=100
Total Credits: 4

Objective: To impart the importance and applications of functional and composite materials and to know the application of polymers in industries.

Course Outcome: Students will be able to know the synthesis and technical importance of different functional materials

CO1: To give the knowledge of Synthesis and modification of Inorganic solids.

CO2: To give the knowledge of application of Inorganic solids.

CO3: To give the knowledge of Introduction to Nanomaterials.

CO4: To give the knowledge of alloys, composite materials and polymers.

CO5: To give the knowledge on the application of engineering materials for construction purposes

Contents

Synthesis and modification of inorganic solids:

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

(10 Lectures)

Inorganic solids of technological importance:

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments.

Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.

(10 Lectures)

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, bio-nano composites.

(10 Lectures)

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.

(10 Lectures)

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.

(10 Lectures)

Speciality polymers:

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

(10 Lectures)

Suggested Readings

BSC 505B: NOVEL INORGANIC SOLIDS (DSE I)

Text Books / Reference Books:

1. Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)

2. Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry.

3. Frank J. Ovens, Introduction to Nanotechnology

BSC 506A: (DSE I LAB) GREEN CHEMISTRY

Marks: 15+35=50
Total Credits: 2

Objective: To perform some selected Green Methodology based synthesis.

Course Outcome: Students will be able to understand the principles of green chemistry through some reactions.

CO1: To give the practical knowledge of Green Synthesis

CO2: To give the practical knowledge of solvent free synthesis

CO3: To learn microwave based synthesis

CO4: To prepare biodiesel in laboratory scale.

Contents

The following experiments are to be performed

1. Synthesis of Paracetamol
2. Diels Alder reaction in water
3. Preparation of biodiesel from vegetable oil.
4. Solvent free, microwave assisted one pot synthesis of Phthalocyanine complex of copper (II)
5. Any other experiments carried out in the class.

Suggested Readings

BSC 506A: (DSE I LAB) GREEN CHEMISTRY

Text Books / Reference Books:

1. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

2. P. T. Anastas and J. C. Warner, Green Chemistry: Theory and Practice, Oxford University Press (1998)

BSC 506B: (DSE I LAB) NOVEL INORGANIC SOLIDS

Marks: 15+35=50
Total Credits: 2

Objective: To learn the synthesis of some selected Novel inorganic solids

Course Outcome: Students will be able to synthesis novel inorganic solids at laboratory scale.

CO1: To give the practical knowledge of Determination of exchange capacity

CO2: To give the practical knowledge of Synthesis of nanomaterials.

CO3: To determine TDS

CO4: To characterize nanoparticles

Contents

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 Readings

BSC 506B: (DSE I LAB) NOVEL INORGANIC SOLIDS

Reference Book:

1.Fahan, *Materials Chemistry*, Springer (2004).

BSC 507A: DSE II: ANALYTICAL METHODS IN CHEMISTRY **Marks: 30+70=100**
Total Credits: 4

Objective: To apply the various analytical and spectroscopic methods in in estimating identifying and separation of ions and compounds respectively.

Course Outcome: Students will be able to understand the quantitative and qualitative aspects of analysis.

CO1: To give the knowledge of sampling, error, and statistical methods

CO2: To give the knowledge of use of UV-Vis, IR, absorption and emission spectroscopy

CO3: To give the knowledge of Thermal methods and Electroanalytical methods

CO4: To give the knowledge of Separation techniques

CO5: To analyze data obtained from different methods as mentioned.

Contents

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.

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 isotope substitution.

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.

Thermal methods of analysis:

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

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

Electroanalytical methods:

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

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.

Suggested Readings

Text Books / Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman.

2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.

3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.

7. Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.

8. Ditts, R.V. Analytical Chemistry – Methods of separation.

BSC 507B: DSE II INDUSTRIAL CHEMICALS AND ENVIRONMENT

Marks: 30+70=100
Total Credits: 4

Objective: To provide environmental awareness of handling hazardous chemicals and ensure the environmental safety.

Course Outcome: Students will be able to know chemicals causing environmental hazards and their proper handling

CO1: To give the knowledge of manufacture of inorganic chemicals and metals

CO2: To give the knowledge of air pollution with reference to particles in air

CO3: To give the knowledge of water pollution with special reference to effluents

CO4: To give the knowledge of fossil and nuclear fuels and its hazards

CO5: Understanding the industrial preparation and purification of metals

Contents

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.

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, NOx, H2S and other foul smelling gases. Methods of estimation of CO, NOx, SOx 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.

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.

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.

Biocatalysis

Introduction to biocatalysis: Importance in “Green Chemistry” and Chemical Industry.

Suggested Readings

BSC 507B: DSE II INDUSTRIAL CHEMICALS AND ENVIRONMENT

Text Books / Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.

2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.

3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.

4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.

5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.

6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

7. S.E. Manahan, Environmental Chemistry, CRC Press (2005).

8 G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).

9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

BSC 508A: DSE II LAB: ANALYTICAL METHODS IN CHEMISTRY

Marks: 15+35=50
Total Credits: 2

Objective: To impart training at laboratory scale on the use of separation, spectroscopic Techniques

Course Outcome: Students will be able to perform different separation and spectroscopic methods to analyse and characterize a compound.

CO1: To give the practical knowledge of Separation technique

CO2: To give the practical knowledge of spectroscopic technique

CO3: To give the practical knowledge of Solvent Extractions

CO4: To give the practice knowledge on the use of Ion exchange resins

Contents:

I. Separation Techniques

1. Chromatography:

(a) Separation of mixtures

(i) Paper chromatographic separation of Fe3+, Al3+, and Cr3+.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

(i) 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.

(ii) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons 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 fame photometric techniques.

5. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

6. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

III Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry.

2 Structural characterization of compounds by infrared spectroscopy.

3 Determination of dissolved oxygen in water.

4 Determination of chemical oxygen demand (COD).

5 Determination of Biological oxygen demand (BOD).

6 Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Suggested Readings

BSC 508A: DSE II LAB: ANALYTICAL METHODS IN CHEMISTRY

Text Books / Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman.

2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.

3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.

7. Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.

8. Ditts, R.V. Analytical Chemistry – Methods of separation.

BSC 508B: DSE II LAB: INDUSTRIAL CHEMICALS & ENVIRONMENT

Marks: 15+35=50
Total Credits: 2

Objective: To impart hands on training on the quantitative analysis of environmentally concerned chemicals.

Course Outcome: Students will be able to determine quantitatively the amount of various hazardous chemicals by different methods.

CO1: To give the practical knowledge of Determination of DO, BOD and COD

CO2: To give the practical knowledge of Determination of air pollutants

CO3: To give the practical knowledge of Determination of water pollutants

CO4: To measure the amount of dissolved gases.

Contents

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 method (AgNO3 and potassium chromate).

6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3) using double titration method.

7. Measurement of dissolved CO_2.

8. Study of some of the common bio-indicators of pollution.

9. Estimation of SPM in air samples.

10. Preparation of borax/ boric acid.

Suggested Readings

BSC 508B: DSE II LAB: INDUSTRIAL CHEMICALS & ENVIRONMENT

Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.

2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.

3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.

4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.

5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.

6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi

SEMESTR VI

Course Code	Title	Credit	Total Marks
BSC-601	Inorganic Chemistry-IV	4	100
BSC-602	Organic Chemistry-V	4	100
BSC-603	Inorganic Chemistry-IV Lab	2	50
BSC-604	Physical Chemistry-IV Lab	2	50
BSC-605A/BSC-605B	Research Methodology for Chemistry / Instrumental Methods of Analysis	4	100
BSC-606A/BSC-606B	Polymer Chemistry / Inorganic materials of Industrial importance	4	100
BSC-607A / BSC-607B	IT Fundamentals / IT Skills for Chemists	2	50
BSC-608	Dissertation	2	50

BSC 601: INORGANIC CHEMISTRY-IV **Marks: 30+70=100**

Total Credits: 4

Objective: To acquire the detail knowledge on principles of Qualitative analysis, reaction mechanism in inorganic compounds and chemistry of Organometallic compounds

Course Outcome: Students will able to perform the qualitative analysis of inorganic compounds and gain insight into the organometallic chemistry

CO1: To give the knowledge of Theory of Qualitative Analysis

CO2: To give the knowledge of Organometallic Compounds

CO3: To give the knowledge on the structural features of organometallic compounds

CO4: To give the knowledge of inorganic reaction mechanism

CO5: To give the knowledge of Catalysis by Organometallic Compounds

Contents

Theoretical Principles in Qualitative Analysis (H2S Scheme)

Basic principles involved in analysis of cations and anions and solubility products, common

ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type. Concept of apticity 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. -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. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)

3. Wacker Process

4. Synthetic gasoline (Fischer Tropsch reaction)

5. Synthesis gas by metal carbonyl complexes

Suggested Readings

BSC 601: INORGANIC CHEMISTRY-IV

Text Books / Reference Books:

1. Vogel, A.I. *Qualitative Inorganic Analysis*, Longman, 1972

2. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996-03-07.

3. Cotton, F.A. G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;* Wiley India,

4. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.,* Harper Collins 1993, Pearson,2006.

5. Sharpe, A.G. *Inorganic Chemistry,* 4th Indian Reprint (Pearson Education) 2005

6. Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry3rd Ed.,* John Wiley and Sons, NY, 1994.

7. Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements*, *Elsevier 2nd Ed*, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).

8. Lee, J.D. *Concise Inorganic Chemistry 5th Ed.*, John Wiley and sons 2008.

9. Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.

10. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.

11. Basolo, F. & Person, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed.*, John Wiley & Sons Inc; NY.

12. Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977

13. Miessler, G. L. & Donald, A. Tarr, *Inorganic Chemistry 4th Ed.*, Pearson, 2010.

14. Collman, James P. et al. *Principles and Applications of Organotransition Metal Chemistry*. Mill Valley, CA: University Science Books, 1987.

BSC 602: ORGANIC CHEMISTRY-V

Marks: 30+70=100
Total Credits: 4

Objective: To impart the principles of Spectroscopy in structural elucidation of organic compounds. Additionally the chemistry of dyes and organic polymers.

Course Outcome: Students will be able to elucidate organic compounds with combined use of different spectroscopic techniques.

CO1: To give the knowledge of Application of spectroscopy – UV, IR, NMR in organic chemistry

CO2: To give the knowledge of Application of Mass spectroscopy in organic compounds

CO3: To analyze compounds using combined data

CO4: To give the knowledge of organic dyes

CO5: To give the knowledge of organic polymers

Contents

Organic Spectroscopy

General principles Introduction to absorption and emission spectroscopy.

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

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

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

Mass Spectrometry – Basic principles, types of ions produced in mass spectrometer, molecular ion peak, base peak and metastable ion, determination of molecular mass of organic compounds.

Applications of IR, UV, NMR spectroscopy and mass spectrometry for identification of simple organic molecules.

Dyes

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

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 Readings

BSC 602: ORGANIC CHEMISTRY-V

Text Books / Reference Books:

1. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.

2. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.

4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.

5. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

6. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.

7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.

8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).

BSC: 603 INORGANIC CHEMISTRY IV-LAB **Marks: 15+35=50**
Total Credits: 2

Objective: The course aims to give hands on training in qualitative analysis in a mixture , some selected inorganic complexes preparation and spectrophotometric analysis

Course Outcome: The students will be able to handle and detect the precence of ions in a mixture of compounds and their analysis

CO1: To give the practical knowledge of qualitative analysis of cations and anions

CO2: To give the practical knowledge of qualitative analysis of cations and anions in mixtures

CO3: To give the practical knowledge of preparations of inorganic compounds

CO4: To give the hands on practice on the analysis by spectrophotometry.

Contents:

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-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, 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 acetylacetanato complexes of Cu^{2+}/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 acetylacetone, DMG, glycine) by substitution method.

Suggested Readings

BSC: 603 INORGANIC CHEMISTRY IV-LAB

Text Books / Reference Books

1. Vogel's *Qualitative Inorganic Analysis,* Revised by G. Svehla.

2. Marr & Rockett *Inorganic Preparations.*

BSC 604: Physical Chemistry IV-LAB **Marks: 15+35=50**

Total Credits: 2

Objective: The course aims to provide instrumentation based analysis of acid-base reactions using conductance and EMF measurement

Course Outcome: The students will be able to know the handling of instruments mentioned in the course and analysis of data

CO1: To know the Calibration of Instruments viz., Conductance and pH meter.

CO2: To know the handling of electrodes involved

CO3: To analyse the acid-base reactions using conductance data

CO4: **To analyse the acid-base reactions using pH data**

Contents:

Conductometry

I. Determination of cell constant

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

III. Perform the following conductometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Mixture of strong acid and weak acid vs. strong base

iv. Strong acid vs. weak base

Potentiometry

I Perform the following potentiometric titrations:

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 Readings

BSC 604: Physical Chemistry IV-LAB

Text Books / Reference Books:

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

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).

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

BSC 605A: DSE III RESEARCH METHODOLOGY FOR CHEMISTRY

Marks: 30+70=100
Total Credits: 4

Objective: To introduce the concept of scientific research and the methods of conducting scientific enquiries.

Course Outcome: The students will be able to understand the different methods of conducting scientific research

CO1: To give the knowledge of Literature Survey

CO2: To give the knowledge of Writing Scientific Papers

CO3: To give the knowledge of Safety and Handling of Chemicals

CO4: To give the knowledge of Data Analysis and fundamentals of electronics

CO5: To give the knowledge on manuscript writting

Contents

Literature Survey:

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Methods of Scientific Research and Writing Scientific Papers:

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation.

Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

Chemical Safety and Ethical Handling of Chemicals:

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Data Analysis

The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.

Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

Electronics

Basic fundamentals of electronic circuits and their components used in circuits of common instruments like spectrophotometers, typical circuits involving operational amplifiers for electrochemical instruments. Elementary aspects of digital electronics.

Suggested Readings

BSC 605A: DSE III RESEARCH METHODOLOGY FOR CHEMISTRY

Text Books / Reference Books

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) *Practical skills in chemistry*. 2nd Ed. Prentice-Hall, Harlow.

2. Hibbert, D. B. & Gooding, J. J. (2006) *Data analysis for chemistry*. Oxford University Press.

3. Topping, J. (1984) *Errors of observation and their treatment.* Fourth Ed., Chapman Hall, London.

4. Harris, D. C. *Quantitative chemical analysis*. 6th Ed., Freeman (2007) Chapters 3-5.

5. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis.* Cambridge Univ. Press (2001) 487 pages.

6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.

7. OSU safety manual 1.01.

BSC 605B: DSE III INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

Marks: 30+70=100
Total Credits: 4

Objective: To learn the analysis of data of different instrumention methods

Course Outcome: The students will be able to interpret the data obtained from spectroscopic and non spectroscopic methods and identify composition of compounds.

CO1: To give the knowledge of spectroscopic instrumentation viz., IR, UV etc.

CO2: To give the knowledge of Separation technique

CO3: To give the knowledge of Mass spectroscopy and instrumentation

CO4: To give the knowledge of NMR and X-ray

CO5: To give the knowledge of electoanalytical instruments and data interpretation

Contents

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.

UV-Visible/ Near IR – emission, absorption, fluorescence and photoaccoustic. 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, photoaccoustic, fluorescent tags).

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.

Mass spectroscopy: 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).

Elemental analysis:

Mass spectrometry (electrical discharges).

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).

NMR spectroscopy: **P**rinciple, Instrumentation, Factors affecting chemical shift, Spin coupling, Applications.

Electroanalytical Methods: Potentiometry & Voltammetry

Radiochemical Methods

X-ray analysis and electron spectroscopy (surface analysis)

Suggested Readings

BSC 605B: DSE III INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

Text Book / Reference books:

1. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7).

2. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

3. P.W. Atkins: Physical Chemistry.

4. G.W. Castellan: Physical Chemistry.

5. C.N. Banwell: Fundamentals of Molecular Spectroscopy.

6. Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.

BSC: 606A DSE-IV: POLYMER CHEMISTRY **Marks: 30+70=100**
Total Credits: 4

Objective: To learn the structures, functions, kinetic behaviour and polymerization mechanisms of polymers.

Course Outcome: The students will gain insight into the details of polymers used for various applications.

CO1: To give the knowledge of polymeric materials

CO2: To give the knowledge of Kinetics of Polymerization

CO3: To give the knowledge of Structure of polymers

CO4: To give the knowledge of molecular weights of polymers

CO5: To give the knowledge of properties of polymer solution

Contents

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.

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.

Determination of molecular weight of polymers (*Mn*, *Mw*, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

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

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-phenylene sulphide polypyrrole, polythiophene)].

Suggested Readings

BSC: 606A DSE-IV: POLYMER CHEMISTRY

Text Books / Reference Books:

1. *Seymour's Polymer Chemistry,* Marcel Dekker, Inc.

2. G. Odian: Principles of Polymerization, John Wiley.

3. F.W. Billmeyer: Text Book of Polymer Science, John Wiley.

4. P. Ghosh: Polymer Science & Technology, Tata Mcgraw-Hill.

5. R.W. Lenz: Organic Chemistry of Synthetic High Polymers.

BSC: 606B DSE-IV: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

Marks: 30+70=100
Total Credits: 4

Objective: To impart knowledge on industrially important inorganic materials for various Applications.

Course Outcome: Students will be able to know in detail the composition, properties and applications of important inorganic materials

CO1: To give the knowledge of Glass and ceramics

CO2: To give the knowledge of fertilizer

CO3: To give the knowledge of pains and pigments, battery

CO4: To give the knowledge of catalysis and explosives

CO5: Acquiring knowledge on industrial application of silicate materials

Contents

Silicate Industries

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

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

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Fertilizers:

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, 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, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

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.

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

BSC: 606B DSE-IV: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

Text Books / Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.

2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.

3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, Wiley Publishers, New Delhi.

4. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.

5. P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.

6. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, Vikas Publications, New Delhi.

7. B. K. Sharma: *Engineering Chemistry*, Goel Publishing House, Meerut

BSC 607A: IT FUNDAMENTALS (SEC III) **Marks: 15+35=50**
Total Credits: 2

Objective: To know the basic fundamentals of Computers

Course Outcome: Students will be able to know the programming aspects in computer based data analysis

CO1: To give the knowledge of computer system and hardware

CO2: To give the knowledge of software

CO3: To give the knowledge of Graphical based softwares and analysis

CO4: To give the knowledge of WEB and Internet Services

Contents

Computer System Concepts, Brief History of Development of Computers, Computer System Characteristics, Capabilities and Limitations, Types of Computers- Desktop, Laptop, Notebook, Palmtop, Workstations, Basic Components of a Computer System - Control Unit, ALU, Input/output Functions and Characteristics, Memory RAM, ROM, EPROM, PROM and other types of Memory.

Input/ Output & Storage Units - Keyboard, Mouse, Trackball, Joystick, Digitizing tablet, Scanners, Digital Camera, MICR, OCR, OMR, Barcode Reader, Voice Recognition, Light pen, Touch Screen, Monitors - Characteristics and types of monitor. Printers and its Types. Primary Vs Secondary data Storage, Various Storage Devices - Hard Disk Drives, Floppy Disks ,Optical Disks, Flash Drives. **Ms-Word :** Features , Toolbar and Buttons, Text Editing, Bullets And Numbering , Auto Formatting , Spell Checking, Thesaurus, Find And Replace, Mail –Merge , Tab & Indents , Headers, **Ms-Excel**: Workbook And Worksheets, Using Different Features, Using Wizards , Using Graphs, Cell Formatting, Inserting Formulas. Introduction to Power Point.

Software and its Need, Types of Software - System Software, Application Software, System Software - Operating System, Utility Program, Programming Languages, Assemblers, Compilers and Interpreter, Programming Languages- Machine, Assembly, High Level, 4GL, Application Software – Word Processing, Spreadsheet, Presentation Graphics, Data Base Management Software. Use of Communication and IT, Types of Network - LAN, WAN, MAN, World Wide Web and its Applications and Internet Services.

BSC 607B: IT SKILLS FOR CHEMISTS (SEC III) **Marks: 15+35=50**
Total Credits: 2

Objective: To know the applications of computers in chemistry

Course Outcome: Students will be able to know the different programming in solving preliminary structure of molecules

CO1: To give the knowledge of mathematics for chemistry

CO2: Construction of simple programs using matrix

CO3: Employing numerical methods in programming language

CO4: Understanding of the simultaneous equations

Contents

Mathematics

Fundamentals, mathematical functions, polynomial expressions, logarithms, the exponential function, units of a measurement, interconversion of units, constants and variables, equation of a straight line, plotting graphs.

Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities.

Uncertainty in measurement: types of uncertainties, combining uncertainties. Statistical treatment. Mean, standard deviation, relative error. Data reduction and the propagation of errors. Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression).

Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms).Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary –bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).

Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).

Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

Computer programming:

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

BASIC programs for curve fitting, numerical differentiation and integration (Trapezoidal rule, Simpson's rule), finding roots (quadratic formula, iterative, Newton-Raphson method).

HANDS ON

Introductory writing activities: Introduction to word processor and structure drawing (ChemSketch) software. Incorporating chemical structures, chemical equations, expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waals equation, etc.) into word processing documents.

Handling numeric data: Spreadsheet software (Excel), creating a spreadsheet, entering and formatting information, basic functions and formulae, creating charts, tables and graphs. Incorporating tables and graphs into word processing documents. Simple calculations, plotting graphs using a spreadsheet (Planck's distribution law, radial distribution curves for hydrogenic orbitals, gas kinetic theory- Maxwell-Boltzmann distribution curves as function of temperature and molecular weight), spectral data, pressure-volume curves of van der Waals gas (van der Waals isotherms), data from phase equilibria studies. Graphical solution of equations.

Numeric modelling: Simulation of pH metric titration curves. Excel functions LINEST and Least Squares. Numerical curve fitting, linear regression (rate constants from concentration time data, molar extinction coefficients from absorbance data), numerical differentiation (e.g. handling data from potentiometric and pH metric titrations, pKa of weak acid), integration (e.g. entropy/enthalpy change from heat capacity data).

Statistical analysis: Gaussian distribution and Errors in measurements and their effect on data sets. Descriptive statistics using Excel. Statistical significance testing: The *t* test. The *F* test.

Presentation: Presentation graphics

Suggested Readings

BSC 607B: IT SKILLS FOR CHEMISTS (SEC III)

Text Books / Reference Books:

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).

2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).

3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).

4. Yates, P. Chemical calculations. 2nd Ed. CRC Press (2007).

5. Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.

6. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ. Press (2001) 487 pages.

7. Noggle, J. H. *Physical chemistry on a Microcomputer.* Little Brown & Co. (1985).

8. Venit, S.M. *Programming in BASIC: Problem solving with structure and style*. Jaico Publishing House: Delhi (1996).

BSC 608: Dissertation

Marks: 15+35=50
Total Credits: 2

Objective: To introduce the concept of creating a research topic.

Course Outcome: Students will be able to frame a problem and understand to approach the problem for research

CO1: To give the knowledge on the concept of literature survey
CO2: To give the knowledge on the concept of Writing a problem for research
CO3: To give the knowledge on the presentation of research data
CO4: Finally the write-up and presentation of the data.

The Topic of the dissertation shall be decided by the Department and informed to the student at the beginning of the semester. Each student shall choose a topic in consultation with the Department. The topics must be from any of the subjects of contemporary interest in Chemistry. Students must submit a Write-up of the assignment. Student will be examined by the department internally according to following scheme.

Marks distribution shall be as follows:

1. Write-up and content : 20 marks
2. Presentation : 20 marks
3. Questions/Answers : 10 marks