CHOICE BASED CREDIT SYSTEM

Syllabus of B.Sc.(Honours) in Chemistry

[Effective from the Academic Session 2019-2020]

JIS UNIVERSITY,
81, Nilgunj Road,Agarpara
Kolkata -700109

CREDIT DISTRIBUTION ACROSS THE COURSE				
Course Type	**Total Papers**	**Credit**		**Credit**
		Theory	**Practical**	
CC	14	14 × 4 = 56	14 × 2 = 28	56 + 28 = 84
DSE	4	4 × 4 = 16	4 × 2 = 08	16 + 8 = 24
GE	5	5 × 4 = 20	2 × 2 = 4	20 + 4 = 24
SEC	2	2 × 2 = 4		04
AECC (I)	4	2 × 4 = 8		08
			Total Credit	144
NON-CGPA				
AECC(II)	12	1× 12 = 12		12
			Grand Total Credit	**156**

Abbreviations Used:

CC = CORE COURSES
DSE = DISCIPLINE SPECIFIC ELECTIVES
GE = GENERAL ELECTIVES
SEC = SKILL ENHANCEMENT COURSES
AECC = ABILITY ENHANCEMENT COMPULSORY COURSES
NON-CGPA = NON CREDIT COURSES

CREDIT AND MARKS DISTRIBUTION ACROSS THE COURSE		
SEMESTER	**CGPA CREDIT**	**MARKS**
I	24	600
II	24	600
III	24	600
IV	24	600
V	24	600
VI	24	600
TOTAL	**144**	**3600**
SEMESTER	**NON CGPA CREDIT**	**MARKS**
I	2	50
II	2	50
III	2	50
IV	2	50
V	2	50
VI	2	50
TOTAL	**12**	**300**

B.Sc. (HONOURS) CHEMISTRY SYLLABUS

FIRST SEMESTER

COURSE TYPE	SUBJECT CODE	SUBJECT NAME	L	T	P	CREDIT	CONTACT HOURS	MARKS DISTRIBUTION
Core Course-1	**BCH-101**	INORGANIC CHEMISTRY I	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-2	**BCH-102**	PHYSICAL CHEMISTRY I	**3**	**1**	**0**	**4**	**4**	**100**
GE-1	**GPY-101**	PHYSICS I	**3**	**1**	**0**	**4**	**4**	**100**
GE-2	**GMTH-101**	MATHEMATICS I	**3**	**1**	**0**	**4**	**4**	**100**
AECC(I)-1	**GHU-101**	ENGLISH	**2**	**0**	**0**	**2**	**2**	**50**
Core Course-1L	**BCH-191**	INORGANIC CHEMISTRY I LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-2 L	**BCH-192**	PHYSICAL CHEMISTRY I LAB	**0**	**0**	**2**	**2**	**3**	**50**
GE-1 L	**GPY-191**	PHYSICS I LAB	**0**	**0**	**2**	**2**	**3**	**50**
		TOTAL	**14**	**4**	**6**	**24**	**27**	**600**
NON-CGPA								
AECC(II)-1	**BSD-181**	SEMINAR & OTHER ACTIVITIES	**0**	**0**	**1**	**1**	**1**	**25**
AECC(II)-2	**BSD-182**	SKILLX & NSS	**0**	**0**	**1**	**1**	**1**	**25**
		TOTAL	**14**	**4**	**8**	**26**	**29**	**650**

B.Sc. (HONOURS) CHEMISTRY SYLLABUS

SECOND SEMESTER

COURSE TYPE	SUBJECT CODE	SUBJECT NAME	L	T	P	CREDIT	CONTACT HOURS	MARKS DISTRIBUTION
Core Course-3	**BCH-201**	ORGANIC CHEMISTRY I	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-4	**BCH-202**	PHYSICAL CHEMISTRY II	**3**	**1**	**0**	**4**	**4**	**100**
GE-3	**GPY-201**	PHYSICS II	**3**	**1**	**0**	**4**	**4**	**100**
GE-4	**GMTH-201**	MATHEMATICS II	**3**	**1**	**0**	**4**	**4**	**100**
AECC(I)-2	**EVS-201**	ENVIRONMENTAL SCIENCES	**2**	**0**	**0**	**2**	**2**	**50**
Core Course-3 L	**BCH-291**	ORGANIC CHEMISTRY I LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-4 L	**BCH-292**	PHYSICAL CHEMISTRY II LAB	**0**	**0**	**2**	**2**	**3**	**50**
GE-3 L	**GPY-291**	PHYSICS II LAB	**0**	**0**	**2**	**2**	**3**	**50**
		TOTAL	**14**	**4**	**6**	**24**	**27**	**600**
NON-CGPA								
AECC(II)-3	**BSD-281**	SEMINAR & OTHER ACTIVITIES	**0**	**0**	**1**	**1**	**1**	**25**
AECC(II)-4	**BSD-282**	SKILLX & NSS	**0**	**0**	**1**	**1**	**1**	**25**
		TOTAL	**14**	**4**	**8**	**26**	**29**	**650**

B.Sc. (HONOURS) CHEMISTRY SYLLABUS

THIRD SEMESTER

COURSE TYPE	SUBJECT CODE	SUBJECT NAME	L	T	P	CREDIT	CONTACT HOURS	MARKS DISTRIBUTION
Core Course-5	**BCH-301**	INORGANIC CHEMISTRY II	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-6	**BCH-302**	ORGANIC CHEMISTRY II	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-7	**BCH-303**	PHYSICAL CHEMISTRY III	**3**	**1**	**0**	**4**	**4**	**100**
GE-5	**GMTH-301**	MATHEMATICS III	**3**	**1**	**0**	**4**	**4**	**100**
SEC-1	********	********	**2**	**0**	**0**	**2**	**2**	**50**
Core Course-5 L	**BCH-391**	INORGANIC CHEMISTRY II LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-6 L	**BCH-392**	ORGANIC CHEMISTRY II LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-7 L	**BCH-393**	PHYSICAL CHEMISTRY III LAB	**0**	**0**	**2**	**2**	**3**	**50**
		TOTAL	**14**	**4**	**6**	**24**	**27**	**600**
NON-CGPA								
AECC(II)-5	**BSD-381**	SEMINAR & OTHER ACTIVITIES	**0**	**0**	**1**	**1**	**1**	**25**
AECC(II)-6	**BSD-382**	SKILLX & NSS	**0**	**0**	**1**	**1**	**1**	**25**
		TOTAL	**14**	**4**	**8**	**26**	**29**	**650**

B.Sc. (HONOURS) CHEMISTRY SYLLABUS

FOURTH SEMESTER

COURSE TYPE	SUBJECT CODE	SUBJECT NAME	L	T	P	CREDIT	CONTACT HOURS	MARKS DISTRIBUTION
Core Course-8	**BCH-401**	INORGANIC CHEMISTRY III	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-9	**BCH-402**	ORGANIC CHEMISTRY III	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-10	**BCH-403**	PHYSICAL CHEMISTRY IV	**3**	**1**	**0**	**4**	**4**	**100**
SEC-2	********	********	**2**	**0**	**0**	**2**	**2**	**50**
AECC(I)-3		VALUES & ETHICS	**2**	**0**	**0**	**2**	**2**	**50**
AECC(I)-4		MANAGEMENT PRACTICES & ENTREPRENEURSHIP DEVELOPMENT	**2**	**0**	**0**	**2**	**2**	**50**
Core Course-8L	**BCH-491**	INORGANIC CHEMISTRY III LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-9 L	**BCH-492**	ORGANIC CHEMISTRY III LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-10 L	**BCH-493**	PHYSICAL CHEMISTRY IV LAB	**0**	**0**	**2**	**2**	**3**	**50**
		TOTAL	**15**	**3**	**6**	**24**	**27**	**600**
NON-CGPA								
AECC(II)-7	**BSD-481**	SEMINAR & OTHER ACTIVITIES	**0**	**0**	**1**	**1**	**1**	**25**
AECC(II)-8	**BSD-482**	SKILLX & NSS	**0**	**0**	**1**	**1**	**1**	**25**
		TOTAL	**15**	**3**	**8**	**26**	**29**	**650**

B.Sc. (HONOURS) CHEMISTRY SYLLABUS

FIFTH SEMESTER

COURSE TYPE	SUBJECT CODE	SUBJECT NAME	L	T	P	CREDIT	CONTACT HOURS	MARKS DISTRIBUTION
Core Course-11	**BCH-501**	ORGANIC CHEMISTRY IV	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-12	**BCH-502**	PHYSICAL CHEMISTRY V	**3**	**1**	**0**	**4**	**4**	**100**
DSE-1	********	********	**3**	**1**	**0**	**4**	**4**	**100**
DSE-2	********	********	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-11 L	**BCH-591**	ORGANIC CHEMISTRY IV LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-12 L	**BCH-592**	PHYSICAL CHEMISTRY V LAB	**0**	**0**	**2**	**2**	**3**	**50**
DSE-1 L	********	DSE-1 LAB	**0**	**0**	**2**	**2**	**3**	**50**
DSE-2 L	********	DSE-2 LAB	**0**	**0**	**2**	**2**	**3**	**50**
		TOTAL	**12**	**4**	**8**	**24**	**28**	**600**
NON-CGPA								
AECC(II)-9	**BSD-581**	SEMINAR & OTHER ACTIVITIES	**0**	**0**	**1**	**1**	**1**	**25**
AECC(II)-10	**BSD-582**	SKILLX & NSS	**0**	**0**	**1**	**1**	**1**	**25**
		TOTAL	**12**	**4**	**10**	**26**	**30**	**650**

B.Sc. (HONOURS) CHEMISTRY SYLLABUS

SIXTH SEMESTER

COURSE TYPE	SUBJECT CODE	SUBJECT NAME	L	T	P	CREDIT	CONTACT HOURS	MARKS DISTRIBUTION
Core Course-13	**BCH-601**	INORGANIC CHEMISTRY IV	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-14	**BCH-602**	ORGANIC CHEMISTRY V	**3**	**1**	**0**	**4**	**4**	**100**
DSE-3	********	********	**3**	**1**	**0**	**4**	**4**	**100**
DSE-4	********	********	**3**	**1**	**0**	**4**	**4**	**100**
Core Course-13 L	**BCH-691**	INORGANIC CHEMISTRY IV LAB	**0**	**0**	**2**	**2**	**3**	**50**
Core Course-14 L	**BCH-692**	ORGANIC CHEMISTRY V LAB	**0**	**0**	**2**	**2**	**3**	**50**
DSE-3 L	********	DSE-3 LAB	**0**	**0**	**2**	**2**	**3**	**50**
DSE-4 L	********	DSE-4 LAB	**0**	**0**	**2**	**2**	**3**	**50**
		TOTAL	**12**	**4**	**8**	**24**	**28**	**600**
NON-CGPA								
AECC(II)-11	**BSD-681**	SEMINAR & OTHER ACTIVITIES	**0**	**0**	**1**	**1**	**1**	**25**
AECC(II)-12	**BSD-682**	SKILLX & NSS	**0**	**0**	**1**	**1**	**1**	**25**
		TOTAL	**12**	**4**	**10**	**26**	**30**	**650**

❖ **Core Papers:(Credit: 06 each) (1 period/week for tutorials or 3 periods/week for practical)**

1. Inorganic Chemistry I: Atomic Structure & Chemical Bonding (4 + 3)
2. Physical Chemistry I: States of Matter & Ionic Equilibrium (4 + 3)
3. Organic Chemistry I: Basics and Hydrocarbons (4 + 3)
4. Physical Chemistry II: Chemical Thermodynamics and Chemical Equilibrium (4 + 3)
5. Inorganic Chemistry II: Acid base &Chemistry of s- and p-block Elements (4 + 3)
6. Organic Chemistry II: Oxygen Containing Functional Groups (4 + 3)
7. Physical Chemistry III: Phase Equilibria and Chemical Kinetics (4 + 3)
8. Inorganic Chemistry III: Coordination& Bioinorganic Chemistry (4 + 3)
9. Organic Chemistry III: Heterocyclic Chemistry& Natural Products (4 + 3)
10. Physical Chemistry IV: Electrochemistry (4 + 3)
11. Organic Chemistry IV: Biomolecules (4 + 3)
12. Physical Chemistry V: Quantum Chemistry &Photochemistry (4 + 3)
13. Inorganic Chemistry IV: Organometallic Chemistry &Reaction Kinetics (4 + 3)
14. Organic Chemistry V: Spectroscopy: Molecular and Organic (4 + 3)

❖ **Discipline Specific Elective Papers: (Credit: 06 each)(4 papers to be selected):DSE 1-4**

1. Applications of Computers in Chemistry (4) + Lab (3)
2. Analytical Methods in Chemistry (4) + Lab (3)
3. Novel Inorganic Solids (4) + Lab (3)
4. Polymer Chemistry& Nanotechnology (4) + Lab(3)
5. Carbohydrate & Dye (4) + Lab(3)
6. Green Chemistry (4) + Lab(3)
7. Dissertation

❖ **Other Discipline: GE 1 to GE 5**

1. Mathematics (3) + Tut(1) [Credit:04]
2. Physics (4) + Lab(3) [Credit:06]
3. Computer Science (4) + Lab(3) [Credit: 06]
4. Biotechnology (4) + Lab (3) [Credit: 06]

➢ **[Students of Chemistry Major are advised to take Mathematics as one of the Generic Electives, along with any two papers from Other Discipline may be selected]**

❖ **Skill Enhancement Courses (Any two papers) (Credit: 02 each): SEC1-2**

1. IT Skills for Chemists
2. Basic Analytical Chemistry
3. Pharmaceutical Chemistry
4. Fuel Chemistry
5. Intellectual Property Rights

Detailed Syllabus of First Semester

BCH-101: Inorganic Chemistry I

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Atomic Structure

X-ray spectra and atomic number, Bohr's theory of hydrogen atom, Sommerfeld's extension of Bohr's theory,

Wavemechanics: deBroglieequation,Heisenberg'sUncertaintyprincipleanditssignificance,Schrödinger wave equation, quantum numbers and their significance, Normalized and orthogonal wave functions, spectrum of hydrogen atom, radial and angular wave functions, Quantum numbers and concept of orbitals, shapes of s, p, d, f- orbitals, Aufbau principle, Pauli's exclusion principle, Hund's rule, effective nuclear charge, Slater rule.

Unit-2: Chemical Periodicity

Periodic classification of elements, modern form of Periodic table, periodicity of properties: atomic radii, ionic radii, covalent radii, van der Waals radii, ionisation energy, electron affinity, electronegativity (Pauling, Mulliken-Jaffe, Allred and Rochow scales), ionic potential. Applicationsinpredictingthechemicalbehaviour of different elements, and inert pair effect.

Unit-3: Chemical Bonding

Ionicbond: Typesofionicsolids,radiusratioruleandcoordinationnumber,limitationsofradiusratio,latticedefects,latticeenergy, Born-Landé equation with derivation, Born-Habercycle and its applications,solvationenergyandsolubility ofionicsolids,polarizing powerandpolarizability,Fajan'srules.

Covalent bond: Lewis structures, formal charge, Valence Bond theory, directional character of covalent bonds, Bent's rule. VSEPR theory: shapes of molecules and ions containing lone pairs and bond pairs, dipole moment, partial ionic character of covalent bonds, resonance. Molecular orbital theory of homonuclear and heteronuclear diatomic molecules.Weak chemical forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Hydrogen bonding and their applications.

Unit-4: Redox Reaction

Complementary/non-complementary redox reactions, standard/formal electrode potentials, influence of pH, complex formation and precipitation reaction on formal potential, principles of redox titration, redox indicator, disproportionation, comproportionation.

Recommended Books

1.Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS /Longman, U.K.
6.Inorganic Chemistry, D. F. Shriver and P. W. Atkins, 3rd Edition (1999), ELBS, London.

BCH-191: Inorganic Chemistry ILab

L-T-P: 0-0-3 **Credit: 2**

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 $KMnO_4$ solution.

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

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilicacid) and external indicator.

Any other experiment carried out in the class.

Recommended Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
3. G. N. Mukherjee, Handbook of Practical Chemistry

BCH-102: Physical Chemistry I

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Gaseous State

The gas laws, equation of state, concept of molar volume, vapour density, limiting density and abnormal density. Kinetic theory of gas: postulates and derivation of the kinetic gas equation, concept of pressure and temperature, different gas laws from kinetic theory, idea of distribution functions, properties of Gamma functions, Maxwell's distribution of speeds and their significance, kinetic energy, calculations of average, root mean square and most probable values, principle of equipartition of energy, molar heat capacity of gases, binary collision among gas molecules of similar/different molecules, collision frequency, collision diameter, mean free path.

Viscosity of gases, its variation with temperature and pressure, relation between mean free path and coefficient of viscosity. Real gas: deviations from ideal gas, causes of its deviation, compressibility factor (*Z*), Andrew's and Amagot's plots, van der Waals equation and its characteristic features, other equations of state (Dietrici, Berthelot, etc.), critical phenomena: critical constants of a gas and their determination, continuity of state, the van der Waals equation and critical state, law of corresponding states.

Unit-2: Liquid State

Physicalpropertiesofliquids:vapourpressure,surfacetension, viscosity, parachor and their dependence on temperature, principles of determination of vapourpressure (Ramsay and Young method),surfacetension (capillary-rise and drop-weight methods), and viscosity (Ostwald viscometer and falling sphere viscometer). Fluidity, Reynolds number.

Unit-3: Solid State

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Millerindices, 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.

Unit-4: Ionic Equilibrium

Electrolytes, Ostwald's dilution law, ionic product of water (K_w), concept of pH, salt hydrolysis, buffer solution and buffer capacity, indicators (acid base).

Recommended Books

1. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
2. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
3. R. G. Mortimer, Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
5. Rastogi, R.P. Mishra, An Introduction to Chemical Thermodynamics.

BCH-192: Physical Chemistry I Lab

L-T-P: 0-0-3 **Credit: 2**

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 withconcentration

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 ofsolute

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.

Recommended Books

1. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, ELBS
2. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
3. G. N. Mukherjee, Handbook of Practical Chemistry
4. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).
5. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry8th Ed.; McGraw-Hill: New York (2003).
6. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.Freeman & Co.: New York (2003).

Detailed Syllabus of Second Semester

BCH-201: Organic Chemistry I

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Fundamental of Organic Chemistry

Classification, and nomenclature, hybridization, shapes of molecules, influence of hybridization on bond properties. Localised and delocalised bonds, inductive effect, field effect, electromeic effect, conjugation, resonance, hyperconjugation, steric assistance and steric inhibition of resonance, tautomerism.Dipole moment; Organic acids and bases; their relative strength.Formation, structure, stability and reactions of classical and non-classical carbocations, carbanions, carbenes, benzynes. Classification of reactions: substitution, elimination, addition, rearrangement.

Unit-2: Stereochemistry

Concept of constitution, stereochemical representation: Fischer, Newman, Sawhorse, Flying-wedge and their interconversions, molecular symmetry: plane, centre, simple and alternating axes; symmetry operations, stereogenicity, Optical Activity, Specific Rotation , chirotopicity, achirotopicity; Axial chirality. Enantiomerism & Diastereoisomerism, Stereogenic centers involving C=C, C=N; D/L, R/S, E/Z, syn/ anti, cis/trans, meso/dl,threo/erythro nomenclature with CIP rules. Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Unit-3: Chemistry of Aliphatic Hydrocarbons

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Freeradical substitutions: Halogenation -relative reactivity and selectivity.Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cbreactions.Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ AntiMarkownikoff 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, ethylbenzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to formcarbonyl compounds, Alkylation of terminal alkynes.

Unit-4: Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions andheterocyclic compounds with suitable examples. Electrophilic aromatic substitution:halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with theirmechanism. Directing effects of the groups.

Recommended Books

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural 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. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning IndiaEdition, 2013.

BCH-291: Organic Chemistry I Lab

L-T-P: 0-0-3 **Credit: 2**

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

Any other experiment carried out in the class.

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 OrganicChemistry, 5th Ed., Pearson (2012)

BCH-202: Physical Chemistry II

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Thermodynamics-I

Introduction of different terms and processes in thermodynamics : systems (isolated, closed, open) and surrounding, diathermal and adiabatic wall, extensive and intensive properties, different processes, state function and path function, concept of thermal equilibrium and the zeroth law of thermodynamics.

First law of thermodynamics: concept of heat, work, internal energy and statement of first law, IUPAC sign convention of heat and work, nature of work: reversible, irreversible, isothermal and adiabatic, Joule's experiment and its consequences, enthalpy, heat capacities, relation between C_P and C_V for ideal gas, van der Wall's gas, and for all state of matter.

Thermochemistry: heat changes during physicochemical processes at constant pressure/volume, Kirchoff's equations, bond dissociation energies and resonance energy from thermochemical data, changes of thermodynamic properties in different chemical changes, adiabatic flame temperature, explosion temperature.

Unit-2: Thermodynamics-II

Second law of thermodynamics: limitation of first law, spontaneous processes and statement of the second law of thermodynamics, Carnot cycle and refrigeration, Carnot's theorem, thermodynamic scale of temperature, concept of entropy, Clausius inequality, entropy changes of an ideal gas in different processes, entropy of an ideal gas, entropy changes in mixture of ideal gases, entropy and unavailable work, Joule-Thomson's experiment and its consequences, inversion temperature, Joule-Thomson coefficient for a van der Waal's gas, Gibbs and Helmholtz energy, Gibbs-Helmholtz equation, criteria for spontaneity and equilibrium, free energy of mixing, Maxwell's relations, thermodynamic equation of state, Clapeyron-Clausius equation and its applications, chemical potential, Gibbs-Duhem relations, partial molar quantities, activity and activity coefficients, fugacity of gases and fugacity coefficient.

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

Unit-3: Chemical Equilibrium

Law of mass action, criteria of thermodynamic equilibrium, degree of advancement of reaction and Le-Chatelier's principle, various equilibrium constants *(K_p, K_c*and *K_x)* from thermodynamics and their quantitative dependence on temperature, pressure and concentration, van't Hoff isotherm, isobar and isochore.

Recommended Books

1. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
2. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
3. R. G. Mortimer, Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
5. Rastogi, R.P. Mishra, An Introduction to Chemical Thermodynamics
6. K. L. Kapoor, A Textbook of Physical Chemistry

BCH-292: Physical Chemistry IILab

L-T-P: 0-0-3 **Credit: 2**

Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change ofenthalpy data of a known system (method of back calculation of heat capacity of calorimeterfrom known enthalpy of solution or enthalpy of neutralization).
(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization ofhydrochloric 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 andexothermic) solution of salts.
(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method interms of the changes of temperatures observed in the graph of temperature versus time fordifferent 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.

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).
2. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry

Detailed Syllabus of Third Semester

BCH-301: Inorganic Chemistry II

L-T-P: 3-1-0 **Credit: 4**

Unit-1: General Principles of Metallurgy

Latimer/Forst/Pourbaix diagram, electrochemical series and its implication towards metal extraction principle, 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.

Unit-2: Acid base and Non aqueous

Acid-base reactions**,** Arrhenius concept, theory of solvent system (in H_2O, NH_3, SO_2 and HF), Bronsted-Lowry's concept, relative strength of acids, Pauling rules, amphoterism, Lux-Flood concept, Lewis concept, Superacids, HSAB principle, acid baseequilibria in aqueous solution and pH Acid-base neutralisation curves, indicator, choice of indicators.

Physical properties of a non-aqueous solvent for functioning as an effective reaction medium, types of solvents and their general characteristics, liquid NH_3 as a non-aqueous solvent.

Unit-3: Chemistry of s, 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 andnitrate.

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

Unit-4: Noble Gases

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation andproperties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valencebond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds(VSEPR theory).

Recommended Books

1.Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS /Longman, U.K.
6.Inorganic Chemistry, D. F. Shriver and P. W. Atkins, 3rd Edition (1999), ELBS, London.

BCH-391: Inorganic Chemistry II Lab

L-T-P: 0-0-3 **Credit: 2**

1. Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution(Iodimetrically).

(ii) Estimation of (a) arsenite and (b) antimony in tartar-emetic iodimetrically

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

2. 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) orChrome alum.

Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, ELBS
3. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
4. G. N. Mukherjee, Handbook of Practical Chemistry

BCH-302: Organic Chemistry II

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNimechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitutionvs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromaticsubstitution; SNAr, Benzyne mechanism.Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilicsubstitution reactions.

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

Unit-2: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-BlancReduction; Preparation and properties of glycols: Oxidation by periodic acid and leadtetraacetate, Pinacol-Pinacolone rearrangement;

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitutionreactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisenrearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides withalcohols, ammonia derivatives and $LiAlH_4$.

Unit-3: 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, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α- substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$,NaBH4, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Unit-4: Carboxylic Acids and their Derivatives

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

Unit-5: Sulphur containing compounds

Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Books

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

BCH-392: Organic Chemistry II Lab

L-T-P: 0-0-3 **Credit: 2**

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

2. Organic Preparations:

i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*toluidinesand *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylicacid) 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 methylketone, 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 above derivatives should be prepared using 0.5-1g of the organic compound. The solidsamples must be collected and may be used for recrystallization, melting point and TLC.

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 OrganicChemistry, 5th Ed.* Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

BCH-303: Physical Chemistry III

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Thermodynamics of Solution

Lewis-Randall rule, thermodynamic functions of mixing (ΔG_{mix}, ΔS_{mix}, ΔV_{mix}, ΔH_{mix}), Henry's and Raoult's laws, Konowaloff's rule, ideal solutions and their characteristic properties, positive and negative deviations from ideal behavior, Duhem-Margules equation and its application,

Thermodynamics of colligative properties: relative lowering of vapor pressure, elevation of boiling point, freezing point depression, Osmotic pressure, inter relationships, van't Hoff equation, applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Unit-2: Phase Equilibria

Concept of phases, components and degrees of freedom, thermodynamic derivation of Gibbs phase rule for non-reactive and reactive systems, phase diagrams of one-component system (water, CO_2), two component systems (phenol-water, triethylamine-water, nicotine-water and lead-silver), three component systems (water-chloroform-acetic acid), CST, steam distillation, azeotropic solution, eutectic mixture, Nernst distribution law: its derivation and applications.

Unit-3: Chemical Kinetics &Catalysis

Order and molecularity, rate law, integrated rate law, kinetics of zero, first, second and fractional order reactions, determination of order by half-life and differential method, opposing, consecutive and parallel reactions, concept of steady state and rate determining step, chain reactions, temperature dependence of reaction rates, Arrhenius equation, activation energy, collision theory of bimolecular reactions, Lindemann theory, theory of absolute reaction rate and its thermodynamic formulation, primary kinetic salt effect.

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces, effect of particle size and efficiency of nanoparticles as catalysts, acid-base catalysis, and Enzyme catalysis: Properties of enzymes, Michaelis–Menten equation, Lineweaver–Burk equation, turnover frequency, catalytic efficiency, effect of temperature and pH.

Unit-4: Surface Chemistry & Interfaces

Adsorption-Physical and chemical adsorptions, Langmuir, Freundlich, and Gibbs adsorption isotherms, surface excess and BET equation.

Colloidal state-Definition, colloids classification, properties, Tyndall effect, electrokinetic phenomena, zeta potential, iso-electric point, Schulze-Hardy rule, protective colloids, gold number, Perrin method for determination of Avogadro number, colloidal electrolytes, micelle and reverse micelle, critical micelle constant, emulsions, gels, thixotropy.

Recommended Books

1. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
2. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
3. R. G. Mortimer, Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
5. Rastogi, R.P. Mishra, An Introduction to Chemical Thermodynamics
6. K. L. Kapoor, A Textbook of Physical Chemistry
7. K.J. Lailder, Chemical Kinetics, 3rd Edition, Pearson

BCH-393: Physical Chemistry III Lab

L-T-P: 0-0-3 **Credit: 2**

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

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

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

4. Study the equilibrium of at least one of the following reactions by the distributionmethod:

(i) $I_2(aq) + I^- \rightarrow I^{3-}(aq)^{2+}$, (ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

5. Study the kinetics of the following reactions.

A. Initial rate method: Iodide-persulphate reaction

B Integrated rate method:(a) Acid hydrolysis of methyl acetate with hydrochloric acid, (b)Saponification of ethyl acetate, (c) Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methylacetate.

6.Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid onactivated charcoal.

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).
4. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry

BCH-401: Inorganic Chemistry III

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Coordination Chemistry

IUPACNomenclature, Werner's theory, isomerism, Chelate effect, polynuclear complexes, labile and inert complexes, stereochemistry of coordination compounds with coordination noumbers 4, 5 and 6.

Sedgwick's EAN concept and Valence Bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding, limitations of valence bond theory, crystal-field theory, measurement of 10 Dq (Δ_o), CFSE in weakand strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δ_o, Δ_t).Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometryJahn-Teller theorem, square planar geometry.Term symbol, Laporte selection rules, charge transfer spectra, Orgel diagram, Tanabe-Sugano diagram, Nephelauxetic effect, Racah parameter, vibronic coupling, band broadening, spin-orbit coupling, spin-forbidden transition, intensity stealing, magnetic properties, anomalous and subnormal magnetic moments.Qualitative aspects of Ligand field and Molecular Orbital theory.

Unit-2: Chemistry of d and f-block Elements

General comparison of 3d, 4d and 5d elements in terms of electronic configuration,color, elemental forms, metallic nature, atomization energy, oxidation states, redox properties,coordination chemistry, spectral and magnetic properties, chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states.

f-block elements: electronic configuration, ionization energies, oxidation states,variation in atomic and ionic (3+) radii, lanthanide contraction, magnetic and spectral properties of lanthanides and actinides, separation of lanthanides (by ion-exchange method), chemistry of some representative compounds: $K[Ni(CN)_4]$, H_2PtCl_6, $Na_2[Fe(CN)NO]$.

Unit-3: 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.

Recommended Books

1.Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS, U.K.

BCH-491: Inorganic Chemistry III Lab

L-T-P: 0-0-3 **Credit: 2**

1. 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 $Al(oxine)_3$ (aluminiumoxinate).

2. 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)

3. Chromatography of Metal Ions

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

Recommended Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, ELBS
3. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
4. G. N. Mukherjee, Handbook of Practical Chemistry

BCH-402: Organic Chemistry III

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: 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.

Unit-2: Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction. Derivatives of furan: Furfural and furoic acid.

Unit-3: Alkaloids

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

Unit-4: Terpenes

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

Recommended 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. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
9. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).

BCH-492: Organic Chemistry III Lab

L-T-P: 0-0-3 **Credit: 2**

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

Recommended Books

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

BCH-403: Physical Chemistry IV

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Electrochemistry-I

Arrhenius theory of electrolytic dissociation, conductance and its measurement, cell constant, specific, equivalent and molar conductances, their variation with respect to dilution; temperature; viscosity; etc, Kohlrausch's law of independent migration of ions, ionic velocities, ionic mobilities, transport number, determination of transport number by Hittorf and moving boundary methods, various applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product ofsparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

Qualitative idea of Debye-H *ü* ckel theory of solution without derivation, qualitative idea of electrophoretic and relaxation effects, Debye-H*ü*ckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Unit-2: Electrochemistry-II

Types of cell: electrolytic, electrochemical, and fuel cells, electrode potential, standard cells, cell reactions, electromotive force (EMF) of a cell and its measurement, Nernst equation, concentration cells with and without transference, liquid junction potential and its elimination, applications of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell, (ii) equilibrium constants, (iii) pH, and (iv) potentiometric titrations (acid-base, redox, precipitation) etc.

Unit-3: 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.

Recommended Books

1. Samuel Glasstone, An Introduction To Electrochemistry, Affiliated East-West Press Pvt. Ltd.New Delhi (2000)
2. J. O'M. Bockris, A. K. N. Reddy, Modern Electrochemistry, Vol. 2 A & B, 2nd Edition,Plenum Press, New York (1998)
3. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
4. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
5. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
6. K. L. Kapoor, A Textbook of Physical Chemistry

BCH-493: Physical Chemistry IV Lab

L-T-P: 0-0-3 **Credit: 2**

1. Conductometry

I. Determination of cell constant

II. Determination of equivalent conductance, degree of dissociation and dissociationconstant 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

2. Potentiometry

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

Recommended Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical 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).
4. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry

BCH-501: Organic Chemistry IV

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Nucleic Acids

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

Unit-2: 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: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

Unit-3: Enzymes

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes.

Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Unit-4: Lipids

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Unit-5: Concept of Energy in Biosystems

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

Recommended Books

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

BCH-591: Organic Chemistry IV Lab

L-T-P: 0-0-3 **Credit: 2**

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

Recommended Books

1. Manual of Biochemistry Workshop, 2012, Department of Chemistry, Universityof Delhi.
2. Arthur, I. V. Quantitative Organic Analysis, Pearson.

BCH-502: Physical Chemistry V

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Quantum Chemistry

Drawback of classical mechanics, black body radiation, photoelectric effect, Compton effect, wave particle duality, Wilson-Sommerfeld quantization rule, its application to Bohr atom, harmonic oscillator, rigid rotator and particle in 1-d box, de Broglie hypothesis, Heisenberg's uncertainty principle, Bohr's correspondence principle and its applications.

Concept of operators, different types of operators, hermitian operator and its properties, normalization, orthogonality, probability distribution of wave functions, eigen function, eigen values, commutation of operators.

Postulates of quantum mechanics, time-independent Schr*ö*dinger equation, stationary state, stationary state wave function, probabilistic interpretation of wave functions, applications of Schr*ö*dinger equation to free particles, particle in 1-d, 2-d & 3d box, and harmonic oscillators to generate respective acceptable wave functions and corresponding energy, concept of degeneracy, expectation values of x, x^2, p_x, p_x^2 and their significance in relation to the uncertainty principle.

Stationary Schrödinger equation for the H-atom in polar coordinates, separation of radial and angular (θ, ϕ) parts, solution of ϕ part and emergence of magnetic quantum number, energy expression, hydrogenic wave functions up to n = 2 (only expressions), real wave functions, concept of orbitals and shapes of s and p orbitals.

Unit 2: Photochemistry

Characteristics of electromagnetic radiation, Jablonsky diagram, Lambert-Beer's law and its limitations, physical significance of absorption coefficients, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence, quantum yield and its measurement for a photochemical process, actinometry, photochemical equilibrium, photostationary state, chemiluminescence, photosensitized reactions, quenching, role of photochemical reactions in biochemical processes, and properties of excited state.

Unit 3: Molecular Statistics

Nernst heat theorem and its implications, Planck's formulation of third law of thermodynamics, approach to zero Kelvin, absolute entropies, and adiabatic demagnetization.

Microstates, thermodynamic probability, entropy and probability, Boltzmann distribution law, concept of partition function, thermodynamic parameters from partition function.

Recommended Books

1. I. N. Levine, Quantum Chemistry, 5th Edition (2000), Pearson Educ., Inc. New Delhi
2. Donald A McQuarrie,Quantum Chemistry, Viva Student Edition, Viva Books, NewDelhi
3. K. L. Kapoor, A Textbook of Physical Chemistry
4. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
5. A. K. Chandra, Quantum Chemistry
6. R. K. Prasad, Quantum Mechanics
7. T. Engel, P. Reid, Physical Chemistry
8. Samuel Glasstone, An Introduction To Electrochemistry, Affiliated East-West Press Pvt. Ltd.New Delhi (2000)
9. Statistical Mechanics(1988), B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi.
10. Statistical Mechanics(2000), D.A. Mcquarrie, California University Science Books.

BCH-592: Physical Chemistry V Lab

L-T-P: 0-0-3 **Credit: 2**

1. UV/Visible spectroscopy

I. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$(in 0.1 M H_2SO_4)and determine the λ_{max} values. Calculate the energies of the two transitions indifferent units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).

II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.

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

2. Colorimetric

I. Verify Lambert-Beer's law and determine the concentration of$CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration

II. Determine the concentrations of $KMnO_4$ and$K_2Cr_2O_7$ in a mixture.

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

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

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

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

Recommended Books

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

BCH-601: Inorganic Chemistry IV

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type.Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behavior 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.

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

Unit-2: 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.

Recommended Books

1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Bioinorganic Chemistry, A. K Das.
5. R. H. Crabtree, The Organometallic Chemistry of Transition Metals
6. B.D.Gupta and A.J. Elias, Basic Organometalltic Chemistry
7. I. Bertini, H. B. Grey, S. J. Lippard, J. S. Valentine, Bioinorganic Chemistry

BCH-691: Inorganic Chemistry IV Lab

L-T-P: 0-0-3 **Credit: 2**

1. 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^+, 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.

2.

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.

Recommended Books

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

BCH-602: Spectroscopy: Molecular and Organic

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Molecular Spectroscopy

Fundamentals

Interaction of electromagnetic radiation with molecules and various types of spectra, Born-Oppenheimer approximation.

Rotation spectroscopy of diatomic molecules

Rigid rotor model, selection rules, spectrum, spacing and intensities of spectral lines, determination of bond length, effect of isotopic substitution.

Vibrational spectroscopy of diatomic molecules

Simple harmonic oscillator model, selection rules, spectra, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands. *Vibration-rotation spectroscopy:* diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy

Characteristic features and conditions of Raman activity, qualitative treatment of rotational Raman spectrs, effect of nuclear spin. V*ibrational 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.

Nuclear Magnetic Resonance (NMR) spectroscopy

Principle, 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

Principle, hyperfine structure, ESR of simple radicals.

Unit-2: 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, Interpretation of NMR spectra of simple compounds.
Applications of IR, UV and NMR for identification of simple organic molecules.

Recommended Books

1. J. M. Hollas, Modern Spectroscopy, 4th edition (2004) John Wiley & Sons, Ltd., Chichester.

2. C. N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.
3. K. L. Kapoor, A Textbook of Physical Chemistry
4. T. Engel, P. Reid, Physical Chemistry
5. W. Kemp, Organic Spectroscopy
6. R. M. Silverstein and F.X. Webster, Spectroscopic Identification of Organic Compounds, 6th Edition (2003) John Wiley, New York.
7. D. H. Williams and I.F. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Edition (1988), Tata-McGraw Hill, New Delhi.
8. W. Kemp, NMR in Chemistry-A Multinuclear Approach.

BCH-692: Spectroscopy: Principles and Applications Lab

L-T-P: 0-0-3 **Credit: 2**

1. Identification of simple organic compounds by IR spectroscopy and NMRspectroscopy (Spectra to be provided).

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

Recommended Books

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

Discipline Specific Elective-1

BCHDSE-1: Applications of Computers in Chemistry

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Basics

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

Unit-2: Numerical Methods

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

Differential calculus: Numerical differentiation.

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

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

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

Conceptual background of molecular modelling: Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Recommended Books

1. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
2. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
3. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co. (1985).
4. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi (1996).

BCHDSE-1L: Applications of Computers in Chemistry Lab

L-T-P: 0-0-3 **Credit: 2**

Computer programs based on numerical methods for

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van derWaals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

Recommended Books

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
5. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) 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.
8. Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).
9. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi (1996).

Discipline Specific Elective-2

BCHDSE-2: Analytical Methods in Chemistry

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Qualitative and quantitative aspects of analysis

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

Unit-2: Optical methods of analysis

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy andselection 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 complexesusing Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator& detector) for single and double beam instrument; sampling techniques.Structural illustration through interpretation of data, Effect and importance of isotopesubstitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniquesof atomization and sample introduction; Method of background correction, sources ofchemical interferences and their method of removal. Techniques for the quantitativeestimation of trace level of metal ions from water samples.

Unit-3: Thermal methods of analysis

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

Unit-4: Electroanalytical methods

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

Unit-5: 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 fromaqueous 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.

BCHDSE-2L: Analytical Methods in Chemistry Lab

L-T-P: 0-0-3 **Credit: 2**

I. Separation Techniques

1. Chromatography:

(a) Separation of mixtures: (i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.

(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 themon the basis of their Rf values.

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

II. Solvent Extractions:

(a) To separate a mixture of Ni^{2+}& $Fe^{2+}$by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(b) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

(c) Analysis of soil: (i) Determination of pH of soil,(ii) Total soluble salt,(iii) Estimation of calcium, magnesium, phosphate, and nitrate.

(d). 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

(a). Determination of pK_a values of indicator using spectrophotometry.

(b) Structural characterization of compounds by infrared spectroscopy.

(c) Determination of dissolved oxygen in water.

(d) Determination of chemical oxygen demand (COD).

(e) Determination of Biological oxygen demand (BOD).

Recommended Books

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

Discipline Specific Elective-3

BCHDSE-3: Novel Inorganic Solids

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Solid State

Structure and properties of solids, ionic, covalent, hydrogen and molecular bonded solids, perovskite, ilmenite and rutile; spinel and inverse spinel, diamond cubic, silicates: single/double chain, 3D network, pyroxene, amphibole, talc, mica, clay, zeolite; crystal defects, non-stoichiometric compounds; electronic properties of solids, F-centre, conductors, insulators, semiconductors, superconductors; ferroelectricity, antiferroelectricity, pyroelectricity, piezoelectricity, liquid crystals, cooperative magnetism.

Unit-2:Synthesis and Modification of Inorganic Solids

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

Unit-3:Inorganic Solids of Technological Importance

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

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

Unit-4:Introduction to Engineering Materials for Mechanical Construction

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

Recommended Books

1.Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, JonathanRourke, 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 structuralchemistry. John Wiley & Sons, 1974.

3. Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley & Sons, 2003.

Discipline Specific Elective-3 Lab

BCHDSE-3L: Novel Inorganic Solids Lab

L-T-P: 0-0-3 **Credit: 2**

1. Determination of cation exchange method
2. Determination of total difference of solids
3. Synthesis of hydrogel by co-precipitation method

Recommended Books

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

Discipline Specific Elective-4

BCHDSE-4: Polymer Chemistry & Nanotechnology

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Introduction

Classification of polymers, copolymers, inorganic polymers, tacticity of polymers, glass transition (T_g) temperature and melting temperature (T_m) and their determination, factors affecting T_g and T_m, degree of polymerization, number and weight average molecular weights, polydispersity index, determination of molecular weight by viscosity, colligative property measurement, light scattering, and end group analysis, mechanical properties of polymers.

Unit-2: Different Polymerization Techniques

Addition and condensation polymerization, kinetic and mechanistic study of cationic, anionic and free radical polymerization, controlled polymerization, metallocene polymerization, bulk, suspension & emulsion polymerization.

Unit-3: Properties of Polymers *(Physical, thermal, Flow & Mechanical Properties)*

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

Unit-4: Nanotechnology

Origin and importance of nanomaterials, properties and size effect of nanomaterials: optoelectronic, mechanical, magnetic, and catalytic properties, different synthetic methodology, characterization techniques and various applications of nanotechnology in industry.

Recommended Books

1. Principle of Polymerization G. Odian, 3rd edition (1991) John Wiley, Singapore.
2. Textbook of Polymer Science, Billmayer, F. W. John Wiley & Sons, Inc.
3. Gowariker, V. R., Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd.
4. Polymer Chemistry, by Seymour R.B. and Carraher, Marcel Dekker (2000).
5. Introduction to Polymer Chemistry, C.E Carraher Jr. ,Taylor and Francis Ist edition (2007), Boca Raton.
6. 1. G. Ozoin, Nanochemistry: A Chemical approach to nanomaterials, Springer-Verlag, 2005.
7. C. N. R Rao, A. Muller, A. K Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007.
8. C. N. R. Rao, A. Müller, A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Vols 1 and 2, Wiley-VCH, Weinheim, 2004.

Discipline Specific Elective-4 lab

BCHDSE-4L: Polymer Chemistry & Nanotechnology Lab

L-T-P: 0-0-3 **Credit: 2**

Polymer Synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) /Methyl Acrylate (MA) / Acrylic acid (AA).

a. Purification of monomer

b. Polymerization using benzoyl peroxide (BPO) / 2,2′-azo-bis-isobutylonitrile(AIBN)

2. Preparation of nylon 6,6 by Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC)and phenolphthalein

3. Redox polymerization of acrylamide

4. Precipitation polymerization of acrylonitrile

5. Preparation of urea-formaldehyde resin

Polymer Characterization

1. Determination of molecular weight by viscometry:

(a) Polyacrylamide-aq.$NaNO_2$ solution, (b) Poly vinyl proplylidine (PVP) in water

2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol)(PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.

3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG)(OH group).

4. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer Analysis

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

Nanomaterials Synthesis

1. Synthesis of metal or metal oxide nanoparticles and their characterization
2. Synthesis of semiconductor nanoparticles and their characterization

at least 7 experiments to be carried out.

Recommended Books

1. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press,1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed.Prentice-Hall (2003)
3. F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
5. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. JohnWiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons(2005)

Discipline Specific Elective-5

BCHDSE-5: Carbohydrate & Dye

L-T-P: 3-1-0 **Credit: 4**

Unit-1: Carbohydrates

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation;

Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

Unit-2: Pharmaceutical Compounds: Structure and Importance

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

Unit-3: 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.

Unit-4: Polynuclear Hydrocarbons

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

Recommended Books

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
2. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
3. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
6. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan (2010).

BCHDSE-5L: Carbohydrate & Dye Lab

L-T-P: 0-0-3 **Credit: 2**

1. Extraction of caffeine from tea leaves.
2. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
3. Qualitative analysis of unknown organic compounds containing monofunctionalgroups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, aminesand amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid,nitrophenols, etc.
4. Preparation of methyl orange.
5. Preparation of Malachite green.
6. Synthesis of polynuclear organic compounds.

Recommended Books

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

Discipline Specific Elective-6

BCHDSE-6: Green Chemistry

L-T-P: 3-1-0 **Credit: 4**

Unit-1: 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.

Unit-2: Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples and specialemphasis on the following:

♣ Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts;maximum incorporation of the materials used in the process into the final products ,Atom Economy, calculation of atom economy of the rearrangement, addition,substitution and elimination reactions.

♣ Prevention/ minimization of hazardous/ toxic products reducing toxicity.risk = (function) hazard × exposure; waste or pollution prevention hierarchy.

♣ Green solvents– supercritical fluids, water as a solvent for organic reactions, ionicliquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solventsand how to compare greenness of solvents.

♣ Energy requirements for reactions – alternative sources of energy: use of microwavesand ultrasonic energy.

♣ Selection of starting materials; avoidance of unnecessary derivatization – careful useof blocking/protecting groups.

♣ Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents;catalysis and green chemistry, comparison of heterogeneous and homogeneouscatalysis, biocatalysis, asymmetric catalysis and photocatalysis.

♣Prevention of chemical accidents designing greener processes, inherent safer design,principle of ISD "What you don't have cannot harm you", greener alternative toBhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (saferroute to cyclohexanol) subdivision of ISD, minimization, simplification, substitution,moderation and limitation.

♣ Strengthening/ development of analytical techniques to prevent and minimize thegeneration of hazardous substances in chemical processes.

Unit-3: Examples of Green Synthesis/ Reactions and Some Real World Cases

1. Green Synthesis of the following compounds: adipic acid, catechol, disodiumiminodiacetate (alternative to Strecker synthesis)

2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoicacid, oxidation of toluene and alcohols; microwave assisted reactions in organic solventsDiels-Alder reaction and Decarboxylation reaction

3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonicalternative to Iodine)

4 Surfactants for carbon dioxide – replacing smog producing and ozone depletingsolvents with CO_2 for precision cleaning and dry cleaning of garments.

5 Designing of Environmentally safe marine antifoulant.

6.Right fit pigment: synthetic azopigments to replace toxic organic and inorganicpigments.

7. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

8. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification forproduction of no Trans-Fats and Oils

9. Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

Unit-4: Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial greenchemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis(C_2S_3); Green chemistry in sustainable development.

Recommended Books

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

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

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

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

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

6. Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition,2010.

Discipline Specific Elective-6Lab

BCHDSE-6L: Green Chemistry Lab

L-T-P: 0-0-3 **Credit: 2**

1. Safer starting materials

- Preparation and characterization of nanoparticles of gold using tea leaves.

2. Using renewable resources

- Preparation of biodiesel from vegetable/ waste cooking oil.

3. Avoiding waste

Principle of atom economy.

- Use of molecular model kit to stimulate the reaction to investigate how the atomeconomy can illustrate Green Chemistry.
- Preparation of propene by two methods can be studied(I) Triethylamine ion + OH^- → propene + trimethylpropene + water(II) 1-propanolH_2SO_4/Δpropene + water
- Other types of reactions, like addition, elimination, substitution and rearrangementshould also be studied for the calculation of atom economy.

4. Use of enzymes as catalysts

- Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

5. Alternative Green solvents

Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.Mechanochemical solvent free synthesis of azomethines

6. Alternative sources of energy

- Solvent free, microwave assisted one pot synthesis of phthalocyanine complex ofcopper (II).
- Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Recommended Books

1. Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
3. Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment:A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN978-93-81141-55-7 (2013).
5. Cann, M.C. & Connelly, M. E. Real world cases in Green Chemistry, AmericanChemical Society (2008).
6. Cann, M. C. & Thomas, P. Real world cases in Green Chemistry, American ChemicalSociety (2008).
7. Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition,2010.
8. Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach, W.B.Saunders,1995.

Discipline Specific Elective-7

BCHDSE-7: Dissertation

L-T-P: 0-0-9 **Credit: 6**

SKILL ENHANCEMENT COURSE

BCHSEC-1: IT SKILLS FOR CHEMISTS

L-T-P: 2-0-0 **Credit: 2**

Mathematics

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

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

Uncertainty in measurement: types of uncertainties, combining uncertainties. Statisticaltreatment. Mean, standard deviation, relative error. Data reduction and the propagation oferrors.Graphical and numerical data reduction. Numerical curve fitting: the method of leastsquares (regression).

Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation indifferent 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 aweak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibriumconstant expressions).

Differential calculus: The tangent line and the derivative of a function, numericaldifferentiation (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 fromheat capacity data).

Computer Programming

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

BASIC programs for curve fitting, numerical differentiation and integration (Trapezoidalrule, 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, expressionsfrom chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waalsequation, etc.) into word processing documents.

Handling Numeric Data: Spreadsheet software (Excel), creating a spreadsheet, entering andformatting 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 forhydrogenic orbitals, gas kinetic theory- Maxwell-Boltzmann distribution curves as functionof temperature and molecular weight), spectral data, pressure-

volume curves of van derWaals gas (van der Waals isotherms), data from phase equilibria studies. Graphical solutionof equations.

Numeric Modelling: Simulation of pH metric titration curves. Excel functions LINEST andLeast Squares. Numerical curve fitting, linear regression (rate constants from concentrationtimedata, 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 ondata sets. Descriptive statistics using Excel. Statistical significance testing: The *t* test. The *F*test.

Presentation: Presentation graphics.

Recommended Books

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical calculations. 2nd Ed. CRC Press (2007).
5.Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
6.Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001).

SKILL ENHANCEMENT COURSE

BCHSEC-2: Basic Analytical Chemistry

L-T-P: 2-0-0 **Credit: 2**

Introduction: Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analyticalmeasurements.Presentation of experimental data and results, from the point of view of significant figures.

Analysis of Soil: Composition of soil, Concept of pH and pH measurement, Complexometrictitrations, Chelation, Chelating agents, use of indicators

a. Determination of pH of soil samples.

b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of Water: Definition of pure water, sources responsible for contaminating water,water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample.

b. Determination of dissolved oxygen (DO) of a water sample.

Analysis of Food Products: Nutritional value of foods, idea about food processing and foodpreservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida,chilli powder, turmeric powder, coriander powder and pulses, etc.

b. Analysis of preservatives and colouring matter.

Chromatography: Definition, general introduction on principles of chromatography, paperchromatography, TLC etc.

a. Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}).

b. To compare paint samples by TLC method.

Ion-exchange: Column, ion-exchange chromatography etc.

Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

Analysis of Cosmetics: Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Suggested Applications (Any one):

a. To study the use of phenolphthalein in trap cases.

b. To analyze arson accelerants.

Suggested Instrumental Demonstrations:

a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.

b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks.

Recommended Books

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods ofAnalysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
2. Skoog, D.A., Holler, F.J. & Crouch, S. Principles of Instrumental Analysis, CengageLearning India Edition, 2007.
3. Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction 6thEd., Saunders College Publishing, Fort Worth, Philadelphia (1994).
4. Harris, D. C. Quantitative Chemical Analysis, 9th ed. Macmillan Education, 2016.
5. Dean, J. A. Analytical Chemistry Handbook, McGraw Hill, 2004.
6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India, 1992.
7. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996.

SKILL ENHANCEMENT COURSE

BCHSEC-3: Fuel Chemistry

L-T-P: 2-0-0 **Credit: 2**

Review of energy sources (renewable and non-renewable). Classification of fuels and theircalorific value.
Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization ofcoal. 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.
Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining anddifferent 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 derivedfrom biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels.
Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and itsderivatives 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.

Recommended Books

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

SKILL ENHANCEMENT COURSE

BCHSEC-4: Pharmaceutical Chemistry

L-T-P: 2-0-0 **Credit: 2**

Unit-1: Drugs & Pharmaceuticals

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

Unit-2: Fermentation

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

Recommended Books

1. Patrick, G. L. Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
2. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.
3. Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

SKILL ENHANCEMENT COURSE

BCHSEC-5: Intellectual Property Rights (IPR)

L-T-P: 2-0-0 **Credit: 2**

Introduction to Intellectual Property
Historical Perspective, Different Types of IP, Importance of protecting IP.

Copyrights
Introduction, How to obtain, Differences from Patents.

Trade Marks
Introduction, How to obtain, Different types of marks – Collective marks, certification marks,service marks, Trade names, etc. Differences from Designs.

Patents
Historical Perspective, Basic and associated right, WIPO, PCT system, TraditionalKnowledge, Patents and Healthcare – balancing promoting innovation with public health,Software patents and their importance for India.

Geographical Indications
Definition, rules for registration, prevention of illegal exploitation, importance to India.

Industrial Designs
Definition, How to obtain, features, International design registration.

Layout design of integrated circuits
Circuit Boards, Integrated Chips, Importance for electronic industry.

Trade Secrets
Introduction and Historical Perspectives, Scope of Protection, Risks involved and legalaspects of Trade Secret Protection.

Different International agreements

(a) Word Trade Organization (WTO):
(i) General Agreement on Tariffs & Trade (GATT), TradeRelated Intellectual Property Rights (TRIPS) agreement
(ii) General Agreement on Trade related Services (GATS)
(iii) Madrid Protocol
(iv) Berne Convention
(v) Budapest Treaty

(b) Paris Convention

WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity

IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcementagencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assetsand their valuation, Intellectual Property in the Indian Context – Various laws in IndiaLicensing and technology transfer.

Recommended Books

1. Acharya, N.K. Textbook on intellectual property rights, Asia Law House (2001).
2. Guru, M. & Rao, M.B. Understanding Trips: Managing Knowledge in DevelopingCountries, Sage Publications (2003).
3. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, TataMcGraw-Hill (2001).
4. Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks andCopyright in a Nutshell, West Group Publishers (2000)