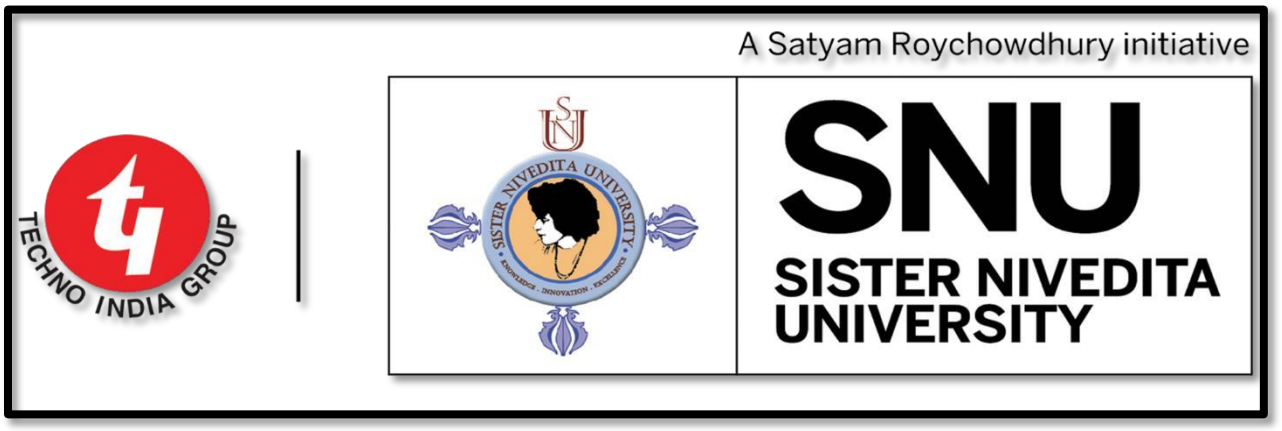


SIX SEMESTER SYLLABUS

OF

B.Sc. HONOURS WITH CHEMISTRY

UNDER

UGC-CBCS SYSTEM

Vice-Chancellor,

Sister Nivedita University

Subject Expert

Raj K Datta

Chief General Manager - Product Development, Technical Support & QA

Haldia Petrochemicals Limited

Industry Expert

Head of the Department,
Chemistry, SNU

B.Sc. Chemistry (H) Course Structure

Category definition

Type	Duration (in Hour)	Credit
Lecture (L)	1	1
Tutorial (T)	1	1
Practical (P)	2	1

Total credit

Year	**Semester**	**hrs./Week**	**Credit**
1st	1st	24	20
	2nd	33	27
2nd	3rd	33	27
	4th	33	27
3rd	5th	33	25
	6th	36	24
Total			**150**

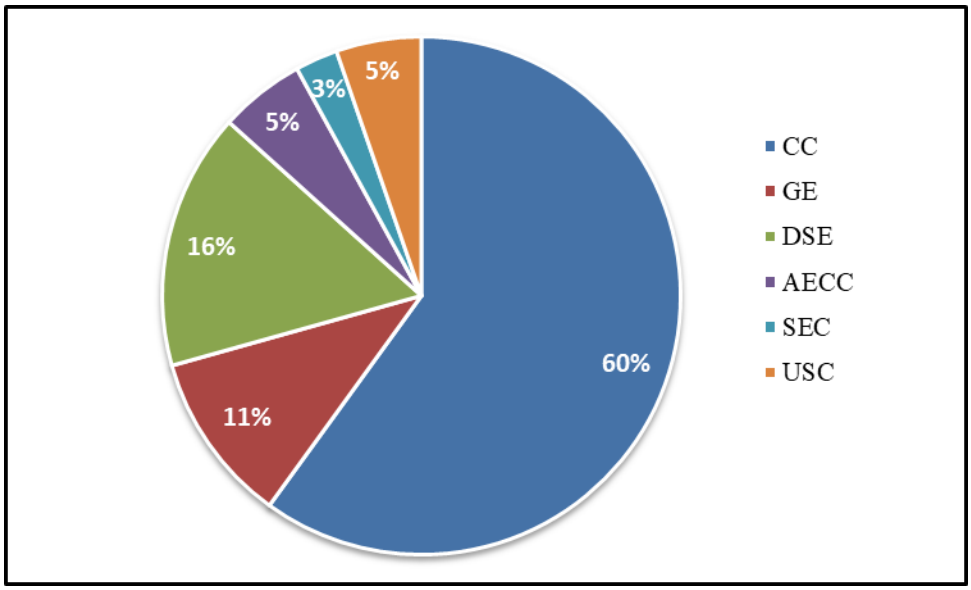
Category Codification with Credit Break up

Definition of category	**Code**	**No**	**Credit**
Core Courses	CC	1	90
General Elective	GE	2	16
Discipline Specific Elective (Professional Elective)	DSE	3	24
Ability Enhancement Compulsory Course	AECC	4	8
Skill Enhancement Courses	SEC	5	4
Mandatory / University Specified Course	USC	6	8
Total			**150**

Semester	Credit						
	CC	DSE	GE	AECC	SEC	USC	Total/Sem
First	12		4	2		2	20
Second	12	6	4	2	1	2	27
Third	12	6	4	2	1	2	27
Fourth	12	6	4	2	1	2	27
Fifth	18	6			1		25
Sixth	24						24
Total Credit/ Course	90	24	16	8	4	8	
Total Credit							150

CC: Core Courses; **GE**: General Elective; **AECC:** Ability Enhancement Compulsory Course; **SEC**: Skill Enhancement Courses; **DSE**: Discipline Specific Elective; **USC:** University specified course

Category wise Credit Distribution:



Subject Codification:

Second Year

Category	Course Name	Code	Credit	Teaching Scheme		
				L	T	P
Semester – III						
CC – 5	Inorganic Chemistry-II: Chemical bonding and s & p- Block Elements		4	4	0	0
	Inorganic Chemistry-II LAB		2	0	0	4
CC – 6	Organic Chemistry-II: Halogenated Hydrocarbons & Functional Groups		4	4	0	0
	Organic Chemistry-II LAB		2	0	0	4
DSE – 2	Essential Physics		4	4	0	0
	Essential Physics Lab		2	0	0	4
GE – 3	Generic Elective		4	4	0	0
AECC – 3	Environmental Science – I		2	2	0	0
SEC – 2	Mentored Seminar – II		1	1	0	0
USC – 3	Foreign Language III		2	2	0	0
Total Credit = 27 (CC: 12; AECC: 02; DSE: 06; GE: 04; USC:02; SEC: 01)				**Teaching Hour = 33 (hrs/week)**		
Semester – IV						
CC – 7	Inorganic Chemistry-III: Coordination Chemistry & d- and f- Block Elements, noble gases, inorganic polymers		4	4	0	0
	Inorganic Chemistry-III LAB		2	0	0	4
CC – 8	Physical Chemistry-II: Thermodynamics II; Chemical Kinetics, Chemical Equilibrium		4	4	0	0
	Physical Chemistry-II LAB		2	0	0	4
DSE – 3	Biochemistry		4	4	0	0
	Biochemistry LAB		2	0	0	4
GE – 4	Generic Elective		4	4	0	0
AECC – 3	Environmental Science – II		2	2	0	0
SEC – 3	Mentored Seminar – III		1	1	0	0
USC – 4	Foreign Language – IV		2	2	0	0
Total Credit = 27 (CC: 12; AECC: 02; DSE: 06; GE: 04; USC:02; SEC: 01)				**Teaching Hour = 33 (hrs/week)**		

Third Year

Category	Course Name	Code	Credit	Teaching Scheme		
				L	T	P
Semester – V						
CC – 9	Inorganic Chemistry-IV: Reaction Mechanism, Bioinorganic Chemistry and Organometallic Chemistry		4	4	0	0
	Inorganic Chemistry-IV LAB		2	0	0	4
CC – 10	Organic Chemistry-III: Heterocyclic Compounds, Dyes & Rearrangement Reactions		4	4	0	0
	Organic Chemistry-III LAB		2	0	0	4
CC – 11	Physical Chemistry-III: Photochemistry; Phase diagram; Quantum Mechanics		4	4	0	0
	Physical Chemistry-III-LAB		2	0	0	4
DSE – 4	Basics of Computer Science		4	4	0	0
	Basics of Computer Science Lab		2	0	0	4
SEC – 4	Mentored Seminar – IV		1	1	0	0
Total Credit = 25 (CC: 18; DSE: 06; SEC: 01)				**Teaching Hour = 33 (hrs/week)**		
Semester – VI						
CC – 12	Organic Chemistry-IV: Spectroscopy, Pericyclic Reactions & Biomolecules		4	4	0	0
	Organic Chemistry-IV LAB		2	0	0	4
CC – 13	Physical Chemistry-IV: Statistical Thermodynamics, Molecular spectroscopy		4	4	0	0
	Physical Chemistry-IV LAB		2	0	0	4
DSE-5	Analytical Methods in Chemistry		4	4	0	0
	Analytical Methods in Chemistry LAB		2	0	0	4
CC – 14	Final Project & Dissertation		6	0	0	12
Total Credit = 24 (CC: 24)				**Teaching Hour = 36 (hrs/week)**		

B.Sc. Chemistry (H) Course Structure

Organic Chemistry Syllabus

Third Semester

CC-6: Organic Chemistry II

Halogenated hydrocarbons & Functional Groups

(Credits: 4; Lecture – 03, Tutorial – 00, Practical – 00)

Component: Theory **Organic Chemistry II** **Credits: 4**

(48 Lectures)

Unit 1: Chemistry of Halogenated Hydrocarbons: **14 L**

Alkyl halides:

Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 mechanisms with stereo chemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides:

Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.

Unit 2: Alcohols, Phenols, Organometallic Compounds, Ethers and Epoxides: **18 L**

Alcohols:

preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Preparation and properties of glycols: Pinacol-Pinacolone rearrangement.

Phenols:

Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Kolbe's–Schmidt Reactions, Fries Rearrangement.

Organometallic compounds:

Mg and Li – Use in synthesis of organic compounds.

Ethers and Epoxides:

Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

Unit 3: Carbonyl Compounds: **10 L**

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, noevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH4, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition.

Unit 4: Carboxylic Acids and their Derivatives: **6 L**

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; Claisen condensation, Reduction with DIBAL-H.

Reference Books:

1. Organic Chemistry, 8th Edition by Leroy G. Wade, Junior, Pearson.
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Dr. R. L. Madan, Organic Chemistry (For B.Sc. I, II, III Year), S. Chand
4. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of
7. Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.

Component: Lab **Organic Chemistry II** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Lassaigne's tests of special elements (N, S, X) for different organic compounds.
2. Functional group tests for:
   a) Alcohols (aliphatic -OH): Esterification test
   b) Phenols (aromatic -OH): $FeCl_3$ test, Back dye test
   c) Carbonyl groups (aldehydes and ketones): 2,4-DNP test, Tollens's test, Fehling's test
   d) Carboxylic acid groups: Sodium bi-carbonate test, Esterification test, $FeCl_3$ test
   e) Aromatic amine: Dye test
   f) Anilido groups: Dye test (after hydrolysis), Tafel's test ($KMnO_4$ test)
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Reference Books:

1. Subhash C Das, *Advanced Practical Chemistry*, (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).

Course Outcomes:

After completion of the course, the students will:

CO1: Learn about different nucleophilic substitution and elimination reactions with mechanisms with stereo chemical aspects and effect of solvents. Also learn nucleophilic aromatic substitution and Benzyne mechanism.

CO2: Learn different preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Phenols, Organometallic Compounds, Ethers and Epoxides.

CO3: Understand nucleophilic addition-elimination reactions of carbonyl compounds, ClaisenSchmidt, Perkin, Cannizzaro and Wittig reaction, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions,

CO4: Learn oxidation and reduction reactions of carbonyl compounds (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PCC and PDC); and addition reactions of unsaturated carbonyl compounds.

CO5: Understand typical reactions of monocarboxylic and dicarboxylic acids, hydroxy acids and unsaturated acids namely succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; preparation and reactions of acid chlorides, anhydrides, esters and amides; Claisen condensation, Reduction with DIBAL-H.

CO6: Learn the laboratory methods of qualitative analysis of unknown organic compounds containing simple functional groups namely alcohols, carboxylic acids, phenols and carbonyl compounds.

Fifth Semester

CC-10: Organic Chemistry III

Heterocyclic Compounds, Dyes & Rearrangement Reactions

(Credits: 6; Lecture – 04, Tutorial – 00, Practical – 02)

Component: Theory **Organic Chemistry III** **Credits: 4**

(48 Lectures)

Unit 1: Nitrogen Containing Functional Groups: **16 L**

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, Hofmann-elimination reaction (Hoffmann's exhaustive methylation), Diazonium Salts: Preparation and their synthetic applications, Group Migration from N to Phenyl ring.

Unit 2: Polynuclear Hydrocarbons: **4 L**

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

Unit 3: Heterocyclic Compounds: **12 L**

Classification and nomenclature, Structure, Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole, Thiophen, Pyridine, Pyrimidine, indole, quinoline, isoquinoline.

Unit 4: Dyes: **8 L**

Classification, Colour and constitution; Mordant Azo-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.

Unit 5: Rearrangement Reactions: **8L**

Hofmann Rearrangement, Curtius and Lossen-Smith rearrangement, Beckmann, Benzilic acid rearrangement, Dienone-Phenol rearrangement, Wagner-Meerwin rearrangement, Wolff rearrangement in Arndt-Eistert reaction, Favorskii rearrangement, Demjanov rearrangement, Tiffneau-Demjanov rearrangement.

Reference Books:

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

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

3. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

Component: Lab **Organic Chemistry III** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Hydrolysis of amides (Benzamide).
2. Hydrolysis of esters (methyl/ propyl benzoate).
3. Semicarbazone of the following compounds:
    a) acetone,
    b) ethyl methyl ketone,
    c) cyclohexanone,
    d) benzaldehyde.
4. Iodoform reaction of Alcohols, aldehydes and ketones.
5. Reduction of nitro group and dye test.

Reference Books:

1. Subhash C Das, *Advanced Practical Chemistry*, (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).

Course Outcomes:

After completion of the course, the students will:

CO1: Learn about the synthesis and reactions of nitro, nitriles, isonitriles, amino, diazo compounds. Also gain knowledge about Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction and Hofmann-elimination reaction.

CO2: Understand elucidation of structures of naphthalene, anthracene and other polynuclear aromatic hydrocarbons. Also gain knowledge in the synthesis and the reactions of naphthalene, phenanthrene and anthracene.

CO3: Understand classification and nomenclature of heterocycles. Also learn about the synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole, Thiophen, Pyridine, Pyrimidine, indole, quinoline and isoquinoline.

CO4: Acquire knowledge on classification, Colour and constitution of dyes, mordant azo-dyes and chemistry of dyeing. Also learn about the synthesis and applications of Azo dyes e.g., Methyl Orange and Congo Red, Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet.

CO5: Learn about different important rearrangement reactions viz Hofmann Rearrangement, Curtius and Lossen-Smith rearrangement, Beckmann, Benzilic acid rearrangement, Dienone-Phenol rearrangement, Wagner-Meerwin rearrangement, Wolff rearrangement in Arndt-Eistert reaction, Favorskii rearrangement, Demjanov rearrangement and Tiffneau-Demjanov rearrangement.

CO6: Demonstrate one-step synthesis and reactions of common organic molecules using traditional methods.

Sixth Semester

CC-12: Organic Chemistry IV

Spectroscopy, Pericyclic Reactions & Biomolecules

(Credits: 6; Lecture – 04, Tutorial – 00, Practical – 02)

Component: Theory **Organic Chemistry IV** **Credits: 4**

(40 Lectures)

Unit 1: Spectroscopy **20 L**

UV Spectroscopy:

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

IR Spectroscopy:

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

NMR Spectroscopy:

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

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

Unit 2: Pericyclic Reactions **3 L**

Electrocyclic reactions, Cycloaddition: Diels Alder, Sigmatropic Rearrangement: Cope, Claisen, [1,3] and [1,5] proton shift.

Unit 3: Biomolecules **20 L**

Amino acids, Peptides and Proteins:

Amino acids classification, structure and properties; Zwitterions; Isoelectric point (pI); pKa values; α-Amino Acids: synthesis and reactions with detailed mechanism-synthesis:

Peptide synthesis: synthesis strategies using N-protection & C-protection, Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

Nucleic acids:

Pyrimidine and purine bases, nucleosides, nucleotides corresponding to DNA and RNA; Basic idea about Watson-Crick model: double helical structure of DNA; base–pairing in DNA.

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; Reactions of Monosaccharides: side reactions in Base, Reduction of Monosaccharides, Chain shortening: The Ruff degradation, Chain lengthening: The Kiliani-Fischer Synthesis

Disaccharides: Structure elucidation of maltose, lactose and sucrose.

Polysaccharides: Elementary treatment of starch, cellulose and glycogen.

Lipids:

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils.

Reference Books:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistr*y. 6th Ed. W.H. Freeman and Co.
6. Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry. IV Edition.* W.H. Freeman and Co.
7. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's Illustrated Biochemistry.* XXVIII edition. Lange Medical Books/ McGraw-Hill.

Component: Lab **Organic Chemistry IV** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Qualitative tests for identification of Carbohydrates –Molisch's test
2. Identification of monosaccharaides and reducing disaccharides- Barfoed's test
3. Detection of reducing sugar-Benedict's test
4. Separation of amino acids by thin layer chromatography.
5. Quantitative analysis of Phenol by bromination method.
6. Quantitative analysis of Aniline by bromination method.

Reference Books

1. Subhash C Das, *Advanced Practical Chemistry*, (2012)
2. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
3. Arthur, I. V. Quantitative Organic Analysis, Pearson.

Course Outcomes:

After completion of the course, the students will:

CO1: Gain basic concept of interaction of electromagnetic radiation with molecules that give rise to the spectroscopy so important for identification/ structural analysis of organic molecules.

CO2: Acquire theoretical knowledge about three most important spectroscopic techniques namely UV-visible, Infrared and Nuclear Magnetic Resonance spectroscopy.

CO3: Understand the classification, structure and properties of amino acids, peptides and proteins.

CO4: Gain knowledge about chemistry of nucleic acids.

CO5: Acquire knowledge on occurrence, classification and biological importance of carbohydrates. Also learn about the wide variety of reactions associated with them.

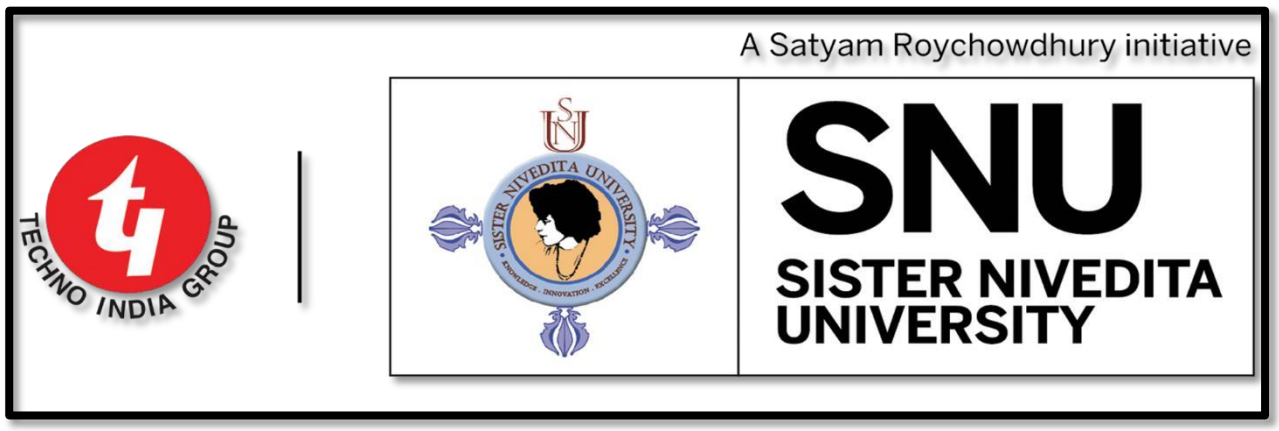
CO6: Acquire knowledge on qualitative analysis of amino acid and carbohydrates.

Course: CC-14: – Final Project & Dissertation

(Credits: 12, Lecture – 00, Tutorial – 00, Practical – 24)

Component: Practical **Final Project & Dissertation** **Credit: 12**

A research project work should be done individually under the guidance of one faculty of Chemistry department at SNU or anywhere else on any topic related to the subject & can be recorded as dissertation & also be presented by the candidate in front of external and internal examiners in a seminar presentation.



SIX SEMESTER SYLLABUS

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B.Sc. HONOURS WITH CHEMISTRY

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Vice-Chancellor,

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Subject Expert

Raj K Datta
Chief General Manager - Product Development, Technical Support & QA
Haldia Petrochemicals Limited

Industry Expert

Head of the Department, Chemistry,
SNU

Inorganic Chemistry Syllabus

Third Semester

CC-5: Inorganic Chemistry II

Chemical Bonding and *s, p* Block Elements

(Credits: 6; Lecture – 04, Tutorial – 00, Practical – 02)

Component: Theory **Inorganic Chemistry II** **Credits: 4**

(40 Lectures)

Unit 1: Chemical Bonding-II **10 L**

Molecular orbital concept: Linear combination of atomic orbitals (LCAO)): sigma and pibonds and delta interaction, multiple bonding, gerade, ungerade, HOMO, LUMO. Orbital mixing, MO diagrams of H_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, and their ions. Heteronuclear systems: CO, NO, NO^+, CN^- , HF, BeH_2, CO_2 and H_2O and interpretation of their properties from MO diagram

Unit 2: s- Block Elements **8 L**

Hydrogen : Isotopes, Ortho and para-hydrogen, Hydrides and their classification. Chemical properties of the metals: reaction with water, air, nitrogen; uses of s-block metals and their compounds. Diagonal relationship, solvation and complexation tendencies, Compounds of s-block metals: oxides, hydroxides, peroxides, superoxides-preparation and properties, anomalous behavior of Li, Be.

Unit 3: p-Block elements:

Boron family (Group 13) **5 L**

Comparative study of physical and chemical properties of these elements with their oxides, hydrides, halides and nitirides. inert pair effect, Preparation and properties of boric acids (ortho & meta boric acids) and borax, hydrides of boron, structure and bonding in diboranes, an idea of three center-two electron bon in the light of molecular orbital theory, borazine, borohydrides.

Unit 4: Carbon and Nitrogen family (Group 14, 15) 8L

Comparative study of physical and chemicals properties of these elements with special references to their oxides, hydrides, nitrides, sulphides and carbides, study of silicates (structuralaspects only), silicones. allotropy, metallic and non-metallic character, catenation, fullerenes andits applications. oxoacids of nitrogen and phosphorus.

Unit 5: Oxygen and Halogens family (Group 16, 17) 9 L

Comparative study of physical and chemical properties of these elements with special reference to their hydrides, oxides, halides and oxyhalides. Study of oxyacids, peroxyacids and thio-oxyacids of sulphur .

Comparative study of physical and chemical properties of these elements, oxidizing power, reactivity of the elements, hydrides, oxides and oxyacids.

Detailed study of oxyacids, hypohalous acid HOX, halous acid HXO_2, halic oxide HXO_3, perhalic acid HXO_4, strength of oxoacids. Interhalogens, polyhalides ions: ClF, ICl; ClF_3, BrF_3, IF_3; ClF_5, IF_5.

Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of
3. Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
4. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-
5. Heinemann. 1997.
6. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.

Component: Lab **Inorganic Chemistry II** **Credits: 2**

(Experiments will be conducted based on availability of apparatus and reagents)

1. Determination of concentration of Ca^{2+} or Mg^{+2} ions by EDTA using Eriochrome black T as indicator.
2. To determine the saponification value of a given fat/oil.
3. Estimation of carbonate and bicarbonate present together in a mixture.
4. Estimation of available chlorine in bleaching powder.

Iodo / Iodimetric Titrations

1. Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodometrically)

.

Reference Books:

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

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

Course Outcomes:

CO1: To discuss the molecular orbital theory, draw the MO diagram of homo diatomic and tri atomic molecules
CO2: To describe the existence of Ortho and Para hydrogen, Hydrides and their utility, how to isolate the s-block elements. Explain chemical properties of the metals and the anomalous behaviour of Li, Be.

CO3: To describe the physical and chemical properties of boron family. To discuss three Centred two electron bond and the chemical properties of oxides and hydrides.

CO4: To discuss the physical and chemical properties of carbon and nitrogen family, allotropy and inert pair effect. To demonstrate chemical properties of nitrous acid, nitric acid, hypo nitrous acid, hydrazoic acid.

CO5: To discuss the properties of oxygen and halogen family, their oxides, halides and oxy halides and oxidizing power of the halogens. To describe oxy acids, hypohalous and halous acid.

CO6: To develop experimental skills of preparation and purification of Inorganic compounds.

Fourth Semester

CC-7: Inorganic Chemistry III

Coordination Chemistry & d- and f- Block Elements, noble gases

(Credits: 6; Lecture – 04, Tutorial – 00, Practical – 02)

Component: Theory **Inorganic Chemistry II** **Credits: 4**

(40 Lectures)

Unit 1: Noble Gases **4 L**

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

Unit 2: d & f-block elements **14 L**

General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry, ionization potential; Lanthanoids and Actinoids: general comparison on electronic configuration, oxidation states, color, spectral and magnetic properties; lanthanide contraction; Extraction, purification scheme and technical uses of the following metals: Ti, V, Cr, Mn, Co, Ni, Pt, Ag, Au, Cd, Hg and U; separation of lanthanides-ion-exchange method.

Unit 3: Coordination Chemistry-I **12 L**

Werner‘s theory of coordination complexes; Classification of ligands-ambidentate and polydentate ligands; coordination number; IUPAC system of nomenclature of coordination compounds; Isomerism in coordination compounds-constitutional and stereo isomerism, geometrical isomerism, optical isomerism in respect to coordination numbers 4 and 6. Bonding in coordination complexes: EAN rule, electro-neutrality principle, valence bond theory, its limitations. Crystal field theory and ligand field theory: splitting of d^n configurations in

octahedral, square planar and tetrahedral fields; crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy; calculation of CFSE and pairing energy.

Unit 4: Coordination Chemistry-II **10 L**

Magnetic behavior and nature of spectra including charge transfer spectra of transition metal complexes; Orgel diagram for d^n systems, Jahn-Teller distortion; spectrochemical series; elementary idea of charge transfer spectra

Component: Lab **Inorganic Chemistry II** **Credits: 2**

(Experiments will be conducted based on availability of apparatus and reagents)

1. Determination of phosphoric acid content in soft drinks.
2. Determination of the amount of citric acid in fruit juices.
3. Synthesis of a polymer/drug.
4. Estimation of free alkali present in different soaps/detergents.
5. Preparation and crystallization of inorganic compounds (e.g., $[Ni(NH_3)_6]Cl_2$)

Reference Books:

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

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

Course Outcomes:

CO1: Able to compare the stability and reactivity of various noble gases.

CO2: Learn to demonstrate the physio-chemical characteristics and reactivity of f-block elements.

CO3: Analyse various issues involved in separation techniques of lanthanides and actinides elements

CO4: Illustrate the salient features and characteristic properties of 3d-elements and be able to categorize the coordination compounds.

CO5: Able to compare the reactivity, magnetic and optical properties of transition metal complexes.

CO6: Learn to estimate various metal ions.

Fifth Semester

CC-9: Inorganic Chemistry IV

Reaction Mechanism, Bioinorganic Chemistry, Organometallic Chemistry and Inorganic Polymer

(Credits: 6; Lecture – 04, Tutorial – 00, Practical - 02)

Component: Theory **Inorganic Chemistry III** **Credits: 4**

(40 Lectures)

Unit 1: Organometallic Chemistry **8 L**

Classification, synthesis, reactions, structure and bonding and applications with typical examples. hapticity of ligands; Application of 18- electron and 16- electron rules to transition metal organometallics, structure, bonding (pictorial MO-approach) and reactions of □2-ethylinic,

□3-allylic and □5- cyclopentadienyl compounds: K [Pt (□2 -C_2H_4)Cl_3], [(□3 -C_3H_5) PdCl]$_2$, (□5- C_5H_5)$_2$ Fe]; Zeise's salt, :carbene and carbyne complexes. Metal-metal single and multiple bonding (pictorial-MO-approach). Organozinc Compounds: synthesis and chemical reactions; Organilithium Compounds: Synthesis and chemical reactions. Organometallic catalysts.

Unit 2: Bioinorganic Chemistry **7 L**

Essential and Trace Elements in Biological Processes, Metalloporphyrins with special reference to Hemoglobin and Myoglobin, oxygen transport with reference to hemoglobin Biological role of alkali and alkaline earth metal ions with special reference to Na^+ and Ca^{2+}.

Unit 3: Reaction Kinetics and Mechanism **7 L**

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect and its application in complex synthesis, 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.

Unit 4: Inorganic Polymers **6L**

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

Unit 5: Radioactivity **7 L**

Nuclear stability and nuclear binding energy. Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Radio chemical methods: principles of determination of age of rocks and minerals, hazards of radiation and safety measures

Reference Books:

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

2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of

3. Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.

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

Component: Lab **Inorganic Chemistry III** **Credits: 2**

(Experiments will be conducted based on availability of apparatus and reagents)

1. **Complexometric Titrimetric Estimations (any two)**
   a) Estimation of Ca and Mg in a mixture
   b) Estimation of Mg^{2+}, Zn^{2+}
   c) Estimation of Ca^{2+} by substitution method
   d) Quantitative estimation of oxidisable organic matter in soil, carbonate and bicarbonates by volumetry and calcium and magnesium by EDTA titration
   e) Estimation of permanent and temporary hardness of water.

2. **Qualitative analysis of the soil from different locations for pH and different water soluble cations and anions**

Course Outcomes:

CO1: Demonstration of different organometallic complexes their stability, synthesis, uses and various applications.

CO2: Demonstration of the chemistry of haemoglobin, myoglobin and importance of alkali and alkaline earth metal ions in living organism.

CO3: Illustrate the complex mechanisms of important inorganic reactions and can explain the reaction pathway and predict product in particular reaction condition.

CO4: Illustrate the important inorganic polymers and their applications.

CO5: Compare the reactivity and use of radioactive materials. Illustration of its reaction pathway and precautions.

CO6: Learn to identify different inorganic compounds and their synthesis process and usefulness in daily life.

Sixth Semester

DSE-5: Analytical Methods in Chemistry

(Credits: 6; Lecture – 04, Tutorial – 00, Practical - 02)

Component: Theory **Analytical Methods in Chemistry** **Credits: 4**

(40 Lectures)

Unit 1: Introduction: Instrumentation and Data Analysis **2L**

Classification and sources of errors, Precision and Accuracy, Propagation of measurement uncertainities, Useful statistical test: test of significance, Q test, F test, student _t' test, and chi-test. Correlation coefficient, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method).

Basic principles of instrumentation: Atomic Absorption and emission spectrometry: source, monochromator, detector, burner designs; Techniques of atomization and sample introduction; Methods for the quantitative estimation of trace level of metal ions from water samples.

Unit 2: Thermogravimetry (TG): **3 L**

Basic principles, instrumentation, quantitative estimation of Ca and Mg from their mixture

Unit 3: Electroanalytical methods: **10 L**

Classification of electroanalytical methods, general principles of pH metric, potentiometric and conductometric titrations; determination of equivalence points; Techniques for the determination of pK_a values.

Unit 4: Separation techniques: **25 L**

Solvent extraction: Classification and principle and efficiency of the technique; Mechanism of extraction: extraction by solvation and chelation; Technique of extraction: batch, continuous, counter current extractions, Solid phase extraction, Extraction and chromatography; Qualitative

and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media: Precipitation, filtration, distillation; Chromatography: Classification and principle and efficiency of the technique. Mechanism of separation: adsorption, partition, ion exchange, size exclusion and electrochromatography. Development of chromatograms: frontal, elution and displacement methods. Chromatographic methods of analysis and their features: Paper chromatography, Thin Layer Chromatography (TLC), Gel Permeation Chromatography (GPC); Measurement of optical rotation; calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios; determination of Enantiomeric composition using NMR, Chiral solvents and chiral shift reagents; Role of computers in instrumental methods of analysis. Sampling for different analytical techniques.

Unit 5: High Performance Liquid Chromatography and Gas Chromatography: **3 L**

Column efficiency in LC, mobile phase reservoirs, solvent treatment systems pumping systems, sample introduction systems, types of columns: Chiral chromatographic techniques using chiral columns (GC and HPLC), types of detectors: EC and diode array detectors, fluorimetic detectors.

Reference Books:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6thEd., Pearson, 2009.

2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988. 55

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.

Component: Lab **Analytical Methods in Chemistry** **Credits: 2**

(Experiments will be conducted based on availability of apparatus and reagents)

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 R_f values.

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

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

II. Solvent Extractions:

1. 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.

2. Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.

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

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

5. Analysis of soil:

   (i) Determination of pH of soil.

   (ii) Total soluble salt

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

6. Ion exchange:

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

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

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

III. Spectrophotometry

a. Determination of pKa 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).
f. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H.
2. Jeffery and others) 5th Ed. The English Language Book Society of Longman. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth
3. Publishing Company, Belmont, California, USA, 1988.
4. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

Course Outcomes:

CO1: Discuss about different types of errors, accuracy, precision levels which may occur in experiments. They will learn about basic principles of instrumentation: Atomic Absorption and emission spectrometry.

CO2: Illustrate the various steps of thermogravimetric analysis and quantitative estimation of different metals

CO3: Compare principles and technical parts of different electrochemical techniques.

CO4: Demonstrate a theoretical as well as a practical introduction to principles and techniques of some chromatographic techniques.

CO5: Elaborate about classification, principle and efficiency of different separation technique and the separation process of different mixture.

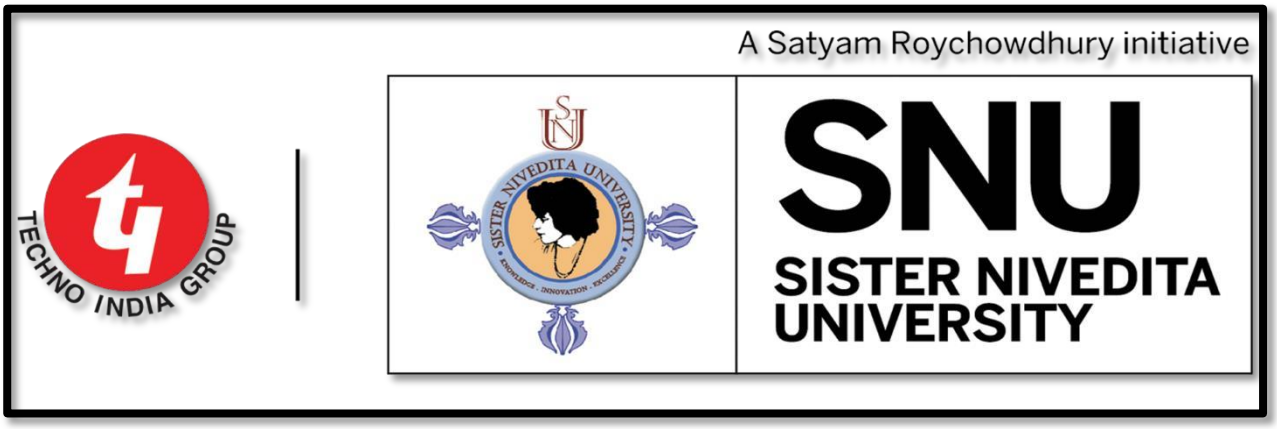
CO6: Illustrate how to determine COD, BOD of different samples, structural characterization of compounds by infrared spectroscopy.

Course: CC-14: – Final Project & Dissertation

(Credits: 12, Lecture – 00, Tutorial – 00, Practical – 24)

Component: Practical **Final Project & Dissertation** **Credit: 12**

A research project work should be done individually under the guidance of one faculty of Chemistry department at SNU or anywhere else on any topic related to the subject & can be recorded as dissertation & also be presented by the candidate in front of external and internal examiners in a seminar presentation.



SIX SEMESTER SYLLABUS

OF

B.Sc. HONOURS WITH CHEMISTRY

UNDER

UGC-CBCS SYSTEM

Vice-Chancellor,

Sister Nivedita University

Subject Expert

Raj K Datta

Chief General Manager - Product Development, Technical Support & QA

Haldia Petrochemicals Limited

Industry Expert

Head of the Department, Chemistry,
SNU

Physical Chemistry Syllabus

Fourth Semester

CC-8: Physical Chemistry-II

Thermodynamics II, Chemical Kinetics, Chemical Equilibrium
(Credits: 6; Lecture – 04, Tutorial – 00, Practical – 02)

Component: Theory **Physical Chemistry-II** **Credits: 4**

(40 Lectures)

Unit 1: Thermodynamics II & Chemical Equilibrium 20 L

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

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state. Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Criteria of thermodynamic equilibrium; Concept of fugacity; Gibbs free energy of reaction and reaction quotient; Equilibrium constants and their quantitative dependence on temperature, pressure and concentration; Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

Unit 3: Solutions and Colligative Properties 8 L

Dilute solutions; lowering of vapour pressure, Raoult‘s and Henry‘s Laws and their applications. Excess thermodynamic functions. Colligative properties: (i) relative lowering of vapour pressure,

(iii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Unit 4: Chemical Kinetics **10 L**

Temperature dependence of reaction rates; Arrhenius equation; activation energy; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment); kinetics of complex reactions (1) Opposing reactions (2) parallel reactions and (3) consecutive reactions and their differential rate equations (steady-state approximation) (iv) chain reactions. Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; Homogeneous catalysis with reference to acid-base catalysis; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number. Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

Unit 5: Colloids **2 L**

Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena (qualitative idea only); Stability of colloids and zeta potential; Micelle formation.

Reference Books:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Laidler, K. J., & Keith, J. (1965). Chemical kinetics (Vol. 2). New York: McGraw-Hill.
4. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).
5. Kapoor, K. L. (2001). A textbook of physical chemistry (Vol. 1-5) Macmillan.

Component: Lab **Physical Chemistry II** **Credits: 2**

(Experiments will be conducted based on availability of apparatus and reagents)

1. Study of viscosity of unknown liquid (glycerol, sugar) with respect to water.
2. Study of the variation of viscosity with the concentration of the solution
3. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate
4. Conductometric titration of an 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
5. Determination of surface tension of a liquid using Stalagmometer

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.
2. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry
4. 8th Ed.; McGraw-Hill: New York (2003).
5. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.
6. Freeman & Co.: New York (2003).

Course Outcomes:

CO1: Students will learn the thermodynamics of more practical system: open system. Concept of equilibrium and factors affecting equilibrium will be discussed. La Chatelier principle and its application will be discussed.

CO2: Properties of ideal systems, vapour pressure, colligative properties, real solutions, deviating from ideality will be discussed.

CO3: Students will learn Rate law, order and molecularity, basics of chemical kinetics

CO4: Students will learn temperature dependence of chemical reactions. Deviations of different complex reactions will be discussed. Students will study homogeneous and heterogeneous catalysis and their applications.

CO5: Students will get the idea of electrokinetic phenomenon, colloids, micelle formation.

CO6: Students will be proficient in surface tension, viscosity measurements. They will also learn conductometric titrations and measure different parameters from it.

Fifth Semester

CC-11: Physical Chemistry-III Photochemistry; Phase diagram; Quantum Mechanics

(Credits: 6; Lecture – 04, Tutorial – 00, Practical – 02)

Component: Theory **Physical Chemistry-III** **Credits: 4**

(40 Lectures)

Unit 1: Quantum Chemistry **20 L**

Black body radiation, Planck's radiation law, photoelectric effect, harmonic oscillator; de Broglie hypothesis; Wave-particle duality, light as particles; Postulates of quantum mechanics; Uncertainty principle; Quantum mechanical operators and its properties: Eigen functions and Eigen values, commutation of operators, Expectation value (x, x^2, p_x and p_x^2), Hermitian operator, Commutators, Orthogonality of operators, Linear Operators.

Schrödinger's time independent equation, acceptability of wave function; acceptability conditions for the wave functions and probability interpretations of wave function, Orthonormality of wave function degeneracy of energy levels; Particle in a 1-d box: Schrodinger equation for one-dimensional box and its solutions and applications, Properties of _Particle in a 1-d box' wave functions (normalization, orthogonality, probability distribution)-its energy levels, _Particle in a box' problem to two and three dimensions and the concept of degenerate energy levels; Problem of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, separation of radial and angular parts, solution of Φ part and emergence of magnetic quantum number, quantization of energy.

Unit 2: Photochemistry **5 L**

Electromagnetic radiation: definition and properties; Lambert-Beer's law, its limitations; molar extinction coefficient; Laws of photochemistry, Stark-Einstein law of photochemical equivalence, quantum yield: definition, calculation and examples of low and high quantum yield values; photochemical equilibrium and the differential rate of photochemical reactions; Photosensitised reactions, HI decomposition, H_2-Br_2 reaction, dimerisation of anthracene; Photostationary state; Chemiluminescence; Role of photochemical reactions in biochemical processes.

Unit 3: Phase Diagram **10 L**

Concept of phase, component and degrees of freedom; Phase rule and its derivations for both for nonreactive and reactive systems; phase diagram for one-component system: water and carbon dioxide; First order phase transition; Clapeyron equation; Clausius-Clapeyron equation - derivation and applications in its applications to solid-liquid, liquid-vapour and solid-vapour equilibria; Phase diagrams for solid-liquid equilibrium systems-eutectic, congruent and incongruent melting points, solid solutions. Principle of fractional distillation; Three component systems, water-chloroform-acetic acid system, triangular plots

Unit 4: Electrical & Magnetic Properties of Atoms and Molecules **5 L**

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

Reference Books:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).
4. Kapoor, K. L. (2001). A textbook of physical chemistry (Vol. 1-5) Macmillan.
5. McQuarrie, D. A., & Simon, J. D. (1997). Physical chemistry: a molecular approach (Vol. 1). Sausalito, CA: University science books.
6. Acrivos, J. (1988). Physical chemistry, (Levine, Ira N.).

Component: Lab **Physical Chemistry III** **Credits: 2**

(Experiments will be conducted based on availability of apparatus and reagents)

1. Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$ and $KMnO_4$ solution
2. Determination of K_{sp} for AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution
3. Determination of solubility product of $BaSO_4$ using conductivity measurements
4. Determination of pka of unknown buffer, using conductivity measurements
5. Study of Phase diagram of Phenol-Water system.
6. Study of saponification reaction conductometrically

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.
2. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry
4. 8th Ed.; McGraw-Hill: New York (2003).
5. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.
6. Freeman & Co.: New York (2003).

Course Outcomes:

CO1: The students will learn the transition from classical mechanics to Quantum mechanics and the basic features of Quantum Mechanics in turn. They will learn about the need for operators and also about different operators and wave functions. Different features of wave functions and different degree of confinement will also be learnt in due course.

CO2: Interaction of light with matter and its laws will be learned. Light assisted reactions and their properties will also be learned.

CO3: Explanation of common photochemical and photophysical processes.

CO4: Explain phase, component and degrees of freedom in the light of phase rule and phase diagram. Concept of Phase separation and its classifications and underlying principles will be studied.

CO5: Fundamental electrical and magnetic properties of atoms and molecules,their measurements and interpretations will be studied

CO6: Principle of electrochemical (Potentiometric) method of titration for solubility constant measurement and spectrophotometric method for pH determination will be learnt. Phase diagram and heat of neutralization will also be learnt experimentally.

Sixth Semester

CC-13 Physical Chemistry-IV

Statistical Thermodynamics, Molecular spectroscopy

(Credits: 06, Lecture – 04, Tutorial – 00, Practical – 02)

Component: Theory **Physical Chemistry-IV** **Credits: 4**

(40 Lectures)

Unit 1: Statistical Thermodynamics **10 L**

Macrostates & microstates. Probabilty & Thermodynamic Probabilty; Confuguratin; Occupation Number; Boltzmann distribution: Entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution; Partition function, concept of ensemble - canonical ensemble and grand canonical ensembles

Partition function: molecular partition function and thermodynamic properties, 3rd law: Absolute entropy, Plank‘s law, Calculation of entropy, Nernst heat theorem. Adiabatic demagnetization: Approach to zero Kelvin, adiabatic cooling

Unit 2: Molecular Spectroscopy **30 L**

Interactions of electromagnetic radiation with matter: origin of spectroscopy, types and energy domain of various spectroscopies; Born Oppenheimer approximation;

Rotational spectroscopy: Principles and origin of rotational spectroscopy, selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical approach and equation to vibrational spectroscopy of linear diatomic molecules, its limitations; force constant- Simple Harmonic Oscillator (SHO) model; emergence of anharmonicity; Morse potential, dissociation energies, zero point energy, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, Rotational-vibrational spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Electronic Spectroscopy: Franck-Condon principle and vibrational structure of electronic spectra; electronic transitions, singlet and triplet states; bond dissociation; decay of excited state

by radiative and non-radiative processes; Pre-dissociation; fluorescence and phosphorescence, Jablonsky diagram

Raman spectroscopy: Classical approach; Qualitative treatment of Rotational Raman effect; Effect of nuclear spin; Vibrational Raman spectra; Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Component: Lab **Physical Chemistry IV** **Credits: 2**

(Experiments will be conducted based on availability of apparatus and reagents)

1. Determination of the indicator constant of an acid base indicator spectrophotometrically
2. Verification of Beer and Lambert's Law for $KMnO_4$ and $K_2Cr_2O_7$ solution
3. Study of kinetics of $K_2S_2O_8$ + KI reaction, spectrophotometrically
4. Kinetic study of inversion of cane sugar using a Polarimeter
5. Fitting data in MS Excel
6. Determination of CMC of a micelle from Fluorescence/Conductance Measurement

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.
2. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry
4. 8th Ed.; McGraw-Hill: New York (2003).
5. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.
6. Freeman & Co.: New York (2003).

Course Outcomes:

CO1: Allows a student to calculate macroscopic (bulk) properties of pure substances and mixtures from the microscopic properties of the molecules and their interactions.

CO2: Students will learn basic principles of interaction between light and molecules, and the formation of excited states.

CO3: All the four different spectroscopy will teach students to understand fundamental properties of matter through analysis of molecular spectroscopy and to determine structure and property relationships in molecules.

CO4: The student will learn how to use spectroscopic principals for various chemical problems

CO5: Students will learn how to use the laws of chemical kinetics to understand and solve real life problems.

CO6: Students will have a basic understanding of using physical methods to study properties of materials that are used in everyday life.

Course: CC-14: – Final Project & Dissertation

(Credits: 12, Lecture – 00, Tutorial – 00, Practical – 24)

Component: Practical **Final Project & Dissertation** **Credit: 12**

A research project work should be done individually under the guidance of one faculty of Chemistry department at SNU or anywhere else on any topic related to the subject & can be recorded as dissertation & also be presented by the candidate in front of external and internal examiners in a seminar presentation.