Course Structure and detailed syllabi for

B.Sc.B.Ed. (Chemistry)

Starting Year: 2018, Autumn Semester

(Revised)

(Approved in 38th Academic Council 02.09.2020)

Department of Chemical Sciences

(DST-FIST and UGC-SAP DRS-II SUPPORTED)

TEZPUR UNIVERSITY

Preamble

The four year (4 year) Integrated BSc.BEd. program in Chemistry aims at integrating general studies of bachelor degree in Chemistry subject (B.Sc.) and professional studies comprising foundations of education and development, teaching approaches and learning resources, classroom organization and management, IT skill , basic computer applications, pedagogy of school subject, and school internship related to the tasks and functions of school teacher. The content of curriculum maintains a balance between theory and practice in school level with integration among the various courses, thus representing a wide knowledge base of a secondary school teacher. The purpose of this program is to create highly skilled teachers for secondary stages of education. The syllabus is designed as per norms of National Council for Teacher Education NCTE guidelines and regulations. The programme follows UGC's Choice Based Credit System (CBCS). The Choice Based Credit System (CBCS) provides an interdisciplinary approach in learning and enables students to learn at their own pace to complete a programme of study, choose electives from a wide range of courses across departments/centers/institutions, study add on courses and acquire more than required number of credits. In CBCS system the courses are divided into three main categories viz. Core Courses, Elective Courses and Ability Enhancement Courses. Each course is assigned with a fixed number of credits based on the contents to be learned. The number of credits earned by the student reflects the knowledge or skill acquired by them. For assessment of students continuous comprehensive evaluation shall be followed to reduce the weightage on the semester-end examination so that students enjoy a de-stressed learning environment. The grade points earned for each course reflects the student's proficiency in in that course.

1. Introduction

The main objective is to impart the key basic knowledge of chemical sciences and laboratory resources to prepare quality teaching professionals in the field of chemistry in addition to prepare students for the post graduate and higher study in chemistry and in education. The eligibility criteria for enrolment in the programme is 10+2 Standard qualified with minimum 60% aggregate marks in Physics, Chemistry and Mathematics. The curriculum for the B.Sc. B.Ed. in Chemistry programme is based on Choice Based Credit System (CBCS) and learning outcome based curriculum framework (LOCF). The CBCS provides an opportunity to a student to choose any elective courses from the syllabus comprising of different elective courses. The syllabus offers a flexibility of programme structure while ensuring that students get a strong foundation and gains in-depth knowledge in chemistry. The LOCF strategy gives students a clear view to focus their learning effort and enable them to make a choice of the elective courses they prefer to study. The B.Sc. B.Ed. in chemistry programme comprises eight semesters course spread over four academic years. The total credit requirement to acquire the B.Sc. B.Ed. degree is 180 credits. The details of the courses and credit system are explained in the annexure. The syllabus fulfils the current needs to acquire a good chemistry degree and to secure a good choice in higher education in chemistry and the area of their interest as well as employment.

2. Qualification descriptors for the graduates

Knowledge & Understanding:

- Gains comprehensive knowledge and understanding on fundamental principles and concepts chemical sciences that covers the sub-disciplines (Physical, Inorganic, and Organic) as well as advanced and emerging topics.
- Able to interpret underlying ideas and principles in chemistry teaching and learning process.

Skills and Techniques:

- Exhibition of skills required for conducting the documented laboratory procedure as well as developed skills for the planning new experiments, data

analysis and presentation of quantitative and/or qualitative data or information, ideas, concepts etc.

- Acquisition of skills in the handling of chemicals and operation of standard instruments.
- Development of information searching and modern teaching-learning skills

Competence:

- Acquisition of competence in the use of routine materials, techniques and practices of chemistry
- Development of competence in intellectual, practical, IT skills and Communication skills necessary for employment as teaching professional as well as chemist.
- Development of responsibilities of the uses of chemistry in everyday life.

3. Graduate Attributes

- Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
- Students will learn to act with integrity and good ethics in their profession and their obligation to society.
- Students will be able to seek new knowledge, skills and manage relevant information from various sources.
- Students will be able to demonstrate knowledge and skills in the teaching and learning process.
- Students will be able to demonstrate leadership, to take action and to get others involved.

4. Program Outcomes

PO1. Students will have a firm foundation in the fundamentals and application of current chemical and basic science theories including those in Physical, Organic, Inorganic, Analytical and Biochemistry.

PO2. Students will learn different theories of education, classroom management and skills for chemistry, mathematics, bioscience as well as physical science teaching.

PO3. Students will be trained to work effectively and safely in the laboratory environment. Students will learn to work in teams as well as independently.

PO4. Students will be able to design and carry out scientific experiments as well as accurately draw logical inferences from the results of such experiments.

P05. Students will be able to clearly communicate the results of scientific work in oral, written and ICT formats to both science community and society.

5. Program structure

Total Credits: 180

Structure of the curriculum:

Course category	No of courses	Credits per course	Total credits
I. Core courses	41	3/4	141
II. Elective courses			
Generic Elective Courses	8	3/4	25
Discipline Specific Elective courses	1	3	03
III. Ability Enhancement compulsory courses	3	3/2	08
IV. Skill Enhancement Courses	1	3	03
Total Credit			180

6. SEMESTER-WISE SCHEDULE

SEMESTER I

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (CH)	Credits
Core	CD 101: Chemistry-I	3	0	0	3	3
	CD 103: Chemistry Lab-1	0	0	3	6	3
	ED 106: Education: An Evolutionary Perspective	2	0	1	4	3
Generic Elective (GE)	PD 101: Physics-I	2	1	0	3	3
	MD101: Mathematics-I	3	0	0	3	3
	PD 197: Physics Lab	0	0	3	6	3
	CD107: Chemistry Laboratory (for Maths)	0	0	3	6	3
Ability Enhancement Course (AEC)	ED 104: Communicative English (Language Proficiency)	2	1	0	3	3
	ED 105: Basics in Computer Applications	2	0	1	4	3

SEMESTER II

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (CH)	Credits
Core	CD 102: Chemistry-II	3	0	0	3	3
	CD 104: Chemistry Lab-II	0	0	3	6	3
	ED 107: Education and Development	2	0	1	4	3
Generic Elective (GE)	PD 102: Physics-II	3	0	0	3	3
	MD102: Mathematics-II	2	1	0	3	3
	ES 103: Environmental Studies	4	0	0	4	4
	CD 107: Chemistry Laboratory (for Physics)	0	0	3	6	3
Ability Enhancement Course (AEC)	NS 106: National Service Scheme	0	0	2	4	2

SEMESTER III

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (CH)	Credits
Core	CD 203: Physical Chemistry-I	3	0	0	3	3
	CD 205: Organic Chemistry-I	3	0	0	3	3
	CD 207: Inorganic Chemistry-I	3	0	0	3	3
	CD 209: Chemistry Lab-III	0	0	4	8	4
	ED 205: Environmental Education	2	0	1	4	3

	ED 202: Learner and Learning	2	0	1	4	3
Generic Elective (GE)	MD 219: Mathematics III	2	1	0	3	3
	PD201: Physics-III	2	1	0	3	3
	CD 201: Chemistry-III (For non majors)	3	0	0	3	3

SEMESTER IV

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (per week)	Credits
Core	CD 204: Physical Chemistry-II	3	0	0	3	3
	CD 206: Organic Chemistry-II	3	0	0	3	3
	CD 208: Inorganic Chemistry-II	3	0	0	3	3
	CD 212: Chemistry Laboratory-IV	0	0	4	8	4
	ED 203: Contemporary Issues in Education	2	0	1	4	3
	ED 204: Assessment and Evaluation	2	0	1	4	3
Skill Enhancement Course (SEC)	CD 214: IT Skills for Chemists	3	0	0	3	3

SEMESTER V

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (CH)	Credits
Core	CD 301: Physical Chemistry–III	3	0	0	3	3
	CD303: Organic Chemistry-III	3	0	0	3	3
	CD 305: Inorganic Chemistry-III	3	0	0	3	3
	CD 307: Quantum Chemistry	3	0	0	3	3
	CD 309: Chemistry Laboratory-V	0	0	4	8	4
	ED 301: Teaching Approaches and Learning Resources	2	0	1	4	3
	ED 302: Classroom Organization and Management	2	0	1	4	3

SEMESTER VI

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (CH)	Credits
Core	CD 302: Physical Chemistry-IV	3	0	0	3	3
	CD 304: Organic Chemistry-IV	3	0	0	3	3
	CD 306: Inorganic Chemistry-IV	3	0	0	3	3
	CD 308: Principles of Spectroscopy	3	0	0	3	3
	CD 310: Chemistry Laboratory-VI	0	0	4	8	4
	ED 308: Pedagogy A: Physical	2	0	1	4	3

	Science I					
	ED 307 : Pedagogy B: Mathematics I Or, ED 309: Pedagogy B: Bio Science I	2	0	1	4	3
	ED303: School Education in NE India	2	0	0	2	2

SEMESTER VII

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (CH)	Credits
Core	CD 401: Principles of Inorganic Chemistry	3	0	0	3	3
	CD 407: Principles of Organic Chemistry	3	0	0	3	3
	CD409: Chemistry laboratory -VII	0	0	3	6	3
	ED408: Pedagogy A: Physical Science II	2	0	1	4	3
	ED 407 : Pedagogy B: Mathematics II Or, ED 409: Pedagogy B: Bio Science II	2	0	1	4	3
	ED404: Initial School Experience/ School Internship-I (Four Weeks)	0	0	4	8	4

SEMESTER VIII

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hours (CH)	Credits
Core	CD 402: Chemistry Laboratory-VIII	0	0	4	8	4
	ED405: School Internship-II	0	0	16	32	16
Discipline Specific Elective (DSE)	CD 416:History of Chemistry	3	0	0	3	3

7. Mapping of course with program outcome (POs)

Course Title	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CD 101: Chemistry-I	✓	✓			✓
CD 103: Chemistry Lab-1	✓	✓	✓	✓	✓
ED 106: Education: An Evolutionary Perspective		✓			
PD 101: Physics-I	✓	✓			✓
MD101: Mathematics-I	✓	✓			✓
PD 197: Physics Lab			✓	✓	✓
CD107: Chemistry Laboratory (for Maths)	✓	✓	✓	✓	✓
ED 104: Communicative English (Language Proficiency)					✓
ED 105: Basics in Computer Applications					✓
CD 102: Chemistry-II	✓	✓			✓
CD 104: Chemistry Lab-II	✓	✓	✓	✓	✓

ED 107: Education and Development		✓			✓
PD 102: Physics-II	✓	✓			✓
MD102: Mathematics-II	✓	✓			✓
ES 103: Environmental Studies	✓				✓
CD 107: Chemistry Laboratory (for Physics)	✓	✓	✓	✓	✓
NS 106: National Service Scheme			✓		
CD 203: Physical Chemistry-I	✓	✓			✓
CD 205: Organic Chemistry-I	✓	✓			✓
CD 207: Inorganic Chemistry-I	✓	✓			✓
CD 209: Chemistry Lab-III	✓	✓	✓	✓	✓
ED 205: Environmental Education	✓				✓
ED 202: Learner and Learning	✓	✓			✓
MD 219: Mathematics III	✓	✓			✓
PD201: Physics-III	✓	✓			✓
CD 201: Chemistry-III (For non majors)	✓	✓			✓
CD 204: Physical Chemistry-II	✓	✓			✓
CD 206: Organic Chemistry-II	✓	✓			✓
CD 208: Inorganic Chemistry-II	✓	✓			✓
CD 212: Chemistry Laboratory-IV	✓	✓	✓	✓	✓
ED 203: Contemporary Issues in Education		✓			
ED 204: Assessment and Evaluation		✓			✓
CD 214: IT Skills for Chemists	✓	✓			✓
CD 301: Physical Chemistry–III	✓	✓			✓
CD303: Organic Chemistry-III	✓	✓			✓
CD 305: Inorganic Chemistry-III	✓	✓			✓
CD 307: Quantum Chemistry	✓	✓			✓
CD 309: Chemistry Laboratory-V	✓	✓	✓	✓	✓
ED 301: Teaching Approaches and Learning Resources		✓			
ED 302: Classroom Organization and Management	✓				

CD 302: Physical Chemistry-IV	✓	✓			✓
CD 304: Organic Chemistry-IV	✓	✓			✓
CD 306: Inorganic Chemistry-IV	✓	✓			✓
CD 308: Principles of Spectroscopy	✓	✓	✓		✓
CD 310: Chemistry Laboratory-VI	✓	✓	✓	✓	✓
ED 308: Pedagogy A: Physical Science I		✓			
ED 307 : Pedagogy B: Mathematics I Or, ED 309: Pedagogy B: Bio Science I		✓			
ED303: School Education in NE India		✓			
CD 401: Principles of Inorganic Chemistry	✓	✓			✓
CD 407: Principles of Organic Chemistry	✓	✓			✓
CD409: Chemistry laboratory -VII	✓	✓	✓	✓	✓
ED408: Pedagogy A: Physical Science II		✓			
ED 407 : Pedagogy B: Mathematics II Or, ED 409: Pedagogy B: Bio Science II		✓			
ED404: Initial School Experience/ School Internship-I (Four Weeks)		✓			
CD 402: Chemistry Laboratory-VIII	✓	✓	✓	✓	✓
ED405: School Internship-II		✓			
CD 416:History of Chemistry		✓			✓

8. Evaluation plan

Students shall be evaluated separately in each course through a Continuous Comprehensive Evaluation (CCE) system as mentioned in the academic guideline of Tezpur University.

9. Detailed Syllabus

SEMESTER I

CD 101 Chemistry-I L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course, the students will be able to understand:

CO1 : Atomic theory and its evolution

CO2: Periodic propertied of elements

CO3: Basic of organic molecules, structure, bonding and organic reaction mechanisms

CO4: Synthesis of hydrocarbons

CO5: Basics of Chemical thermodynamics and thermodynamic laws, Fundamentals of solution and colligative properties

Course Content:

Unit 1 [3 Lectures]

Structure of atom, Hund's rule, Aufbau principle, Pauli's exclusion principle.

Unit 2 [4 Lectures]

Periodic Properties: Periodicity of the elements, shielding, effective nuclear charge, Slater's rule, the size of the atoms, atomic, covalent and van der Waals radii, ionization energy, electron affinity, electronegativity.

Unit 3 [5 Lectures]

Basics of organic chemistry-1 : Bonding, structure and physical properties of organic compounds: Valence bond theory: Concept of hybridization of organic compounds and shapes of molecules; MO theory: Acyclic π orbital system and cyclic π orbital systems; Physical properties: Melting point, boiling point, solubility, dipole moment.

Unit 4 **[3 Lectures]**

Basics of organic chemistry-2: Electronic and steric effects: Inductive effect, resonance, hyperconjugation, steric effect, steric inhibition of resonance.

Unit 5 **[3 Lectures]**

Basics of organic chemistry-3: Thermodynamics and kinetics of organic reactions:

Free energy and equilibrium, enthalpy and entropy factor, intermolecular & intramolecular reactions, rate constant and free energy of activation, free energy profiles for one step and multi-step reactions, catalyzed reactions, kinetic control and thermodynamic control, kinetic isotopic effect, principle of microscopic reversibility, Hammond postulate.

Unit 6 **[3 Lectures]**

Alkanes: Synthesis by: Decarboxylation, reduction of alkyl halides and tosylates, Kolbe electrolysis, Wurtz reaction, Corey–House synthesis; Reactions of alkanes: Halogenation, nitration, sulphonation, oxidation and cracking of alkanes.

Unit 7 **[3 Lectures]**

Alkenes and alkynes: Synthesis, Dehydration of alcohols, pyrolysis of esters, Cope reaction, Elimination of alkyl halides, germinal- and vicinal dihalides, Hofmann elimination; Reactions: Addition of X_2 (X = halogen), H-X, HO-X, interhalogens, water, Oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, catalytic reduction, dihydroxylation, epoxidation, polymerization, alkylation of alkynes, oxidation of alkynes to 1,2-diketones, allylic and benzylic halogenation of alkenes mediated by radicals.

Unit 8 **[4 Lectures]**

First Law of Thermodynamics: Thermodynamics terms, state and path functions, concept of heat and work, internal energy, enthalpy, first law of thermodynamics; w, q, ΔU and ΔH for expansion and compression of ideal gases, heat capacities, physical

change, standard enthalpies of physical and chemical changes, Hess's law, Kirchhoff's law.

Unit 9 **[4 Lectures]**

Second Law of Thermodynamics: Spontaneous processes, Carnot cycle, entropy, criteria of spontaneity, statements of the second law of thermodynamics, entropy changes, Clausius inequality, Gibbs energy, Helmholtz energy, Third law of thermodynamics.

Unit 10 **[2 Lectures]**

Solutions: Ideal and non-ideal solutions

Unit 11 **[2 Lectures]**

Colligative properties

Text Book(s)

1. Lee, J. D. *Concise Inorganic Chemistry,* 5th Edn.*,* (Chapman & Hall, 2002).
2. Atkins, P. and Paula, J. de. *Atkins' Physical Chemistry*, 10thEdn., (Oxford University Press 2014).
3. Clayden, J., Greeves, N., Warren, S. and Wothers, P. *Organic Chemistry*, 2ndEdn., (Oxford University Press, 2012).
4. Finar, I. L. *Organic Chemistry* (Volume 1), 6thEdn., (Pearson Education, 2002).

Reference Book(s)

1. Levine, I. N., *Physical Chemistry*, 6thEdn., (McGraw Higher Ed 2008).
2. Carey, F. A. and Sundberg, R. J. *Advanced Organic Chemistry, Part A: Structure and Mechanisms,* 5thEdn., (Springer, New York, 2007).
3. March, J. and Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6thEdn., (Wiley, 2007).

CD 103 Chemistry Laboratory- I L 0 T 0 P 3 CR 3

1. Qualitative Analysis of Inorganic Mixtures (excluding interfering radicals)
2. Preparation of Mohr's salt
3. Estimation of Glucose
4. Nitration of organic compounds
5. Reduction of functional groups
3. Preparation of buffer solution and measurement of pH
4. Viscosity measurement of solution
5. Conductometric acid-base titration
6. Measurement of surface tension of liquid by stalagmometer
7. Verification of Beer-Lamberts law
8. Titration of a mixture of AcOH, HCl and $CuSO_4$ by conductometric method

Text Book(s)

1. Furniss, B. S., Ford, A. J. H., Smith, P. W. H. and Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry,* 5thEdn., *(Wiley, 1989).*
2. Jadav, J. B. *Advanced Practical Physical Chemistry*, (Krishna Prakashan, 2015).
3. Mendham, J., Danney, R. C. and Barnes, J. D., Thomas, M. *Vogel's Textbook of Quantitative Chemical Analysis,* 6thEdn., (Prentice Hall, 2009).
4. Gurdeep, R. *Advanced Practical Inorganic Chemistry,* (Krishna Prakashan, 2013).

CD 107 Chemistry Laboratory (for Maths) L 0 T 0 P 3 CR 3

1. Qualitative Analysis of Inorganic Mixtures (excluding interfering radicals)
2. Preparation of Mohr's salt
3. Estimation of Glucose
4. Nitration of organic compounds
5. Reduction of functional groups
3. Preparation of buffer solution and measurement of pH

4. Viscosity measurement of solution
5. Conductometric acid-base titration
6. Measurement of surface tension of liquid by stalagmometer
7. Verification of Beer-Lamberts law
8. Titration of a mixture of AcOH, HCl and $CuSO_4$ by conductometric method

Text Book(s)

1. Furniss, B. S., Ford, A. J. H., Smith, P. W. H. and Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry,* 5thEdn., *(Wiley, 1989).*
2. Jadav, J. B. *Advanced Practical Physical Chemistry*, (Krishna Prakashan, 2015).
3. Mendham, J., Danney, R. C. and Barnes, J. D., Thomas, M. *Vogel's Textbook of Quantitative Chemical Analysis,* 6thEdn., (Prentice Hall, 2009).
4. Gurdeep, R. *Advanced Practical Inorganic Chemistry,* (Krishna Prakashan, 2013).

SEMESTER II

CD102 Chemistry-II L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course, the students will be able to understand:

CO1: Structure and bonding of homonuclear diatomic molecule, Polarizability of ions

CO2: Stereochemistry of organic molecules – conformation and configuration, Asymmetric molecules and nomenclature,Aromatic compound and aromaticity

CO3: Organic Intermediates, their generation and reactivity

CO4: Thermodynamic properties of gases and liquids, fundamentals of electrochemistry

CO5: Kinetics of simple reactions, Factors affecting the rate of the reaction

Course Content:

Unit 1 **[8 Lectures]**

Structure and Bonding: Valence Bond and LCAO-MO theory, bonding in homonuclear diatomic molecules (e.g.: H_2, N_2, O_2, F_2), covalent and ionic bonding, bond order, resonance, formal charge, VSEPR model, Polarizability of cations and anions, Fazan's rules.

Unit 2 **[4 Lectures]**

Basics organic chemistry- 4: Nucleophiles, electrophiles, keto-enol tautomerism, acidity and basicity of organic compounds, Frost diagram, Hückel's rules for aromaticity, antiaromaticity, homoaromaticity.

Unit 3 **[6 Lectures]**

Stereochemistry-1:Representation of organic molecules in Fischer, saw horse, Newman, and flying-wedge, projection formulae and their interconversion, symmetry elements, molecular chirality, optical activity, optical purity, meso compounds, racemic mixture, resolution, enantiomers, diastereomers, epimers, anomers, atropisomers, basic concepts of stereochemical nomenclatures: *threo*/*erythro*, *syn*/*anti*, *R*/*S*, *cis*/*trans* and *E*/*Z*).

Unit 4 **[4 Lectures]**

Reactive intermediates: Carbocation, carbanion, carbene, nitrene, free radical and benzyne: Generation, stability and reactions.

Unit 5 **[4 Lectures]**

Properties of gases and liquids: Equations of state, kinetic model of gases, collision theory, real gases, Maxwell distribution of molecular speeds, qualitative description of the structure of liquids, surface tension and viscosity.

Unit 6 **[6 Lectures]**

Electrochemistry: Conduction in electrolyte solutions, ionic mobility, Kohlrausch law, Ostwald's dilution law, transport number, Debye-Huckel Limiting Law, electrochemical cells, EMF, Nernst equation.

Unit 7 **[4 Lectures]**

Rate of reactions: Rate equations of zero, first, second, pseudo 1st order reactions, determination of order of a reaction, activation energy, activated complex theory, collision theory.

Text Book(s)

1. Atkins, P. and Paula, J. de. *Atkins' Physical Chemistry*, 10thEdn., (Oxford University Press, 2014).
2. Overton, T., Armstrong, F., Rourke, J. and Weller, M. *Inorganic Chemistry,* 6thEdn., (Oxford University Press, 2015).
3. Clayden, J., Greeves, N., Warren, S. andWothers, P. *Organic Chemistry*, 2ndEdn., (Oxford University Press, 2012).
4. Sengupta, S. *Basic Stereochemistry of Organic Molecules*, 1stEdn., (Oxford University Press, 2014).

Reference Book(s)

1. Laidler, K. J., Meiser, J. H. and Sanctuary, B. C.*Physical Chemistry,* 4thEdn.,(Brooks Cole, 2002).
2. Carey, F. A. and Sundberg, R. J. *Advanced Organic Chemistry, Part B: Reactions and Synthesis,* 5thEdn.,(Springer, New York, 2007).
3. March, J. and Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6thEdn., (Wiley, 2007).
4. Eliel, E. L., Wilen, S. H. and Doyle, M. P. *Basic Organic Stereochemistry*, 1stEdn., (Wiley-Interscience, 2001).

CD 104 Chemistry Laboratory-II L 0 T 0 P 3 CR 3

Section A: Inorganic Chemistry

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture
2. Estimation of oxalic acid by titrating it with $KMnO_4$
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)

2. Separation of mixtures by chromatography: Measure the R_f value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of *α* amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

Text Book(s)

1. Svehla, G. and Sivasankar, B. *Vogel's Qualitative Inorganic Analysis,* 7thEdn., *(*Pearson Education, 2012*).*
2. Mendham, J., Denney, R. C., Barnes, J. D., Thomas, M. and Sivasankar, B. *Vogel's Quantitative Chemical Analysis*, 6thEdn., (Pearson Education, 2009).
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A. J. and Smith, P.W.G., *Textbook of Practical Organic Chemistry*, 5thEdn., (Prentice-Hall, 1996).
4. Mann, F.G. and Saunders, B.C. *Practical Organic Chemistry*, (Orient-Longman, 1960).

CD 107 Chemistry Laboratory (for Physics) L 0 T 0 P 3 CR 3

1. Qualitative Analysis of Inorganic Mixtures (excluding interfering radicals)
2. Preparation of Mohr's salt
3. Estimation of Glucose
4. Nitration of organic compounds
5. Reduction of functional groups
3. Preparation of buffer solution and measurement of pH
4. Viscosity measurement of solution
5. Conductometric acid-base titration
6. Measurement of surface tension of liquid by stalagmometer
7. Verification of Beer-Lamberts law
8. Titration of a mixture of AcOH, HCl and $CuSO_4$ by conductometric method

Text Book(s)

1. Furniss, B. S., Ford, A. J. H., Smith, P. W. H. and Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry,* 5thEdn., *(Wiley, 1989).*
2. Jadav, J. B. *Advanced Practical Physical Chemistry*, (Krishna Prakashan, 2015).
3. Mendham, J., Danney, R. C. and Barnes, J. D., Thomas, M. *Vogel's Textbook of Quantitative Chemical Analysis,* 6thEdn., (Prentice Hall, 2009).
4. Gurdeep, R. *Advanced Practical Inorganic Chemistry,* (Krishna Prakashan, 2013).

SEMESTER III

CD 201 Chemistry-III (For non-major) L 0 T 0 P 3 CR 3

Course outcomes:

On completion of this course, the students will be able to understand:

CO1: Concepts of acids and bases, and their strength

CO2: Fundamentals of coordination chemistry

CO3: Aromatic compounds and aromaticity

CO4: Synthesis and properties of hydrocarbons

CO5: Weak electrolyte and ionic equilibrium

Course Content:

Unit 1 **[5 Lectures]**

Acid -Base concept: Arrhenius concept, Brønsted-Lowry acids and bases, Lewis acids and bases, Hard Soft acids - bases and HSAB principle, Acid and base strength, levelling effect.

Unit 2 **[5 Lectures]**

Coordination chemistry: Werner's theory, classification of ligands, coordination number, nomenclature of coordination compounds, isomerism.

Unit 3 **[6 Lectures]**

Aromaticity and Hückel Rule, Orientation of substituents, Directive influence of substituents, o/p ration, kinetically and thermodynamically controlled reactions.

Unit 4

Alkynes: Preparation, properties and reactions. **[5 Lectures]**

Unit 5

Alkyl halides: Preparation, properties and reactions. **[5 Lectures]**

Unit 6 **[10 Lectures]**

Ionic equilibrium: Arrhenius theory of electrolytic dissociation, Ostwald dilution law, Dissociation constant of week acids and bases, Ionization of water, pK_w and pH, Salt effect, pH expressions for various neutralization reaction, Henderson- Hasselbalch equation, solubility product, common ion effect, Buffer solutions, theory of acid base indicators, acid base titration curves (pH variation).

Text Book(s)

1. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. *Inorganic Chemistry*: Principles of *Structure and Reactivity*, 4th Edn., (Pearson Education, 2006).
2. Barrow, G. M. *Physical Chemistry,* 5thEdn*.,* (McGraw Hill, 2007).
3. Finar, I. L. *Organic Chemistry* (Volume 1), 6thEdn., (Pearson Education, 2002).
4. Ghosh, S. K., *Advanced General Organic Chemistry,* 3rdEdn., (New Central Book Agency (P) Ltd., 2008).

Reference Book(s)

1. Smith, M. B., March, J. *March's Advanced Organic Chemistry, Reaction Mechanism and Structure* 6thEdn., (Wiley, 2007).
2. Clayden, J., Greeves, N., Warren, S., Wothers, P. *Organic Chemistry*, 2ndEdn., (Oxford University Press, 2012).

CD 203 Physical Chemistry-I L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to :

CO1: Understand the concept of system, variables, heat, work, and laws of thermodynamics.

CO2: Understand the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.

CO3: Understand the concept of entropy; reversible, irreversible processes.

CO4: Calculation of entropy using 3rd law of thermodynamics.

CO5: Understand the structure and thermodynamics of the three states of matters viz. solid, liquid, gas.

Course Content:

Unit 1

Chemical Thermodynamics: The basic concepts, thermodynamics terms, concept of system and surroundings, type of systems, concept of boundary or wall, steady state

and equilibrium state, thermodynamic coordinates, state of a system, equation of state, state and path functions, exact and inexact differential, Euler's theorem, concept of intensive and extensive variables, Partial derivatives and cyclic rule, reversible and irreversible process, concept of heat, work and energy (IUPAC convention), general expressions of work, graphical explanation of work done during expansion and compression of an ideal gas, Reversible and irreversible processes and work done.

[3 Lectures]

Zeroth and First law of Thermodynamics: Concept of thermal equilibrium and the zeroth-law of thermodynamics, First law of thermodynamics, internal energy (U) as a state function. Enthalpy as a state function, heat changes at constant volume and constant pressure; heat capacity, relation between C_P and C_V using ideal gas and van der Waals equations, the work of adiabatic changes, heat capacity ratio and adiabats, Joule's experiment and its consequence, Joule Thomson effect, explanation of term $(\delta U/\delta V)_T$, Isothermal and adiabatic processes. **[3 Lectures]**

Thermochemistry: Standard states, heats of reaction, thermochemical equation, standard enthalpy changes (enthalpies of physical changes and enthalpies of chemical changes), Hess's law, standard enthalpy of formation, Kirchhoff's equations and effect of pressure on enthalpy of reactions, bond energy, bond dissociation energy and resonance energy from thermochemical data.

[3 Lectures]

Second law of thermodynamics: Reservoirs and heat engines, Carnot cycle, physical concept of Entropy, Carnot engine and refrigerator, Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation, Carnot's theorem, Clausius inequality, entropy change of systems and surroundings for various processes and transformations, Entropy and unavailable work, state functions (Helmholtz energy (A) and Gibb's energy(G)) and their variation with T, P and V, criteria for spontaneity and equilibrium, Thermodynamic relations: Gibbs- Helmholtz equation, Maxwell's relations; pressure dependence of Gibb's energy, chemical potential of pure substances. **[8 Lectures]**

Third law of Thermodynamics: Nernst heat theorem, Third law entropies. **[1 Lecture]**

Unit 2

Properties of States of matter: Properties of gases:Perfect Gas**:** Properties of gases, concept of pressure and temperature, mixture of gases, concept of partial pressure, Dalton's law, equations of state, Boyle's law, Charle's Law, Avogadro's Law, Ideal gas equation. **[2 Lectures]**

Kinetic theory of gases: Kinetic model of gases, relationship between pressure and molecular speeds, Maxwell-Boltzmann distribution of speeds, mean velocity, root mean square velocity, most probable velocity, relative velocity, collision frequency (similar and different molecules), mean free path, viscosity of gases, effusion, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases. **[3 lectures]**

Real Gases: Deviations from perfect behaviour, compressibility factor, Boyle temperature, van der Waals equation and its features, existence of critical state, critical constants in terms of van der Waals constants, virial equation of state, van der Waals equation expressed in virial form and significance of second virial coefficient; principles of corresponding states, intermolecular forces (Debye, Keesom and London interactions; Mie potential, Lennard-Jones potential - elementary idea).

[3 Lectures]

Properties of Liquids: Qualitative description of the structure of liquids, molecular interactions in liquids, the radial distribution function, boiling point, vapour pressure, viscosity, liquid vapour interface, surface tension, curved surfaces, Laplace equation, vapour pressure over curved surface, Kelvin equation, capillary action measurement of surface tension, surface pressure. **[5 Lectures]**

Properties of Solids:General properties of solids, forms of solids, crystal systems, unit cells, Bravais lattice types, symmetry elements, Miller indices of different planes and

interplanar distance, Bragg's law, structures of ionic solids (qualitative treatment only); defects in crystals. **[5 Lectures]**

Text Book(s)

1. Atkins, P. and Paula, J. de. *Atkins' Physical Chemistry*, 10thEdn., (Oxford University Press, 2014).
2. Silbey, R. J., Alberty, R. A. and Bawendi, M. J. *Physical Chemistry*, 4thEdn., (Wiley, 2004).
3. Levine, I. N., *Physical Chemistry,* 6thEdn., (McGraw Higher Ed, 2008).

Reference Book(s)

1. Laidler, K. J., Meiser, J. H. and Sanctuary, B. C., *Physical Chemistry,* 4thEdn., (Brooks Cole, 2002).
2. McQuarrie, D. A. and Simon, J. D., *Physical Chemistry: A Molecular Approach*, (University Science Books, 1997).
3. Mortimer, R. G. *Physical Chemistry,* 3rdEdn.,(Elsevier, 2008).
4. Adamson, A. A., A Textbook of Physical Chemistry, 2ndEdn., (Elsevier, 1973).

CD205 Organic Chemistry-I L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course, the students will be able to understand:

CO1: Concepts of aliphatic nucleophilic substitution reactions

CO2: Fundamentals of elimination reactions

CO3: Aromatic electrophilic substitution reactions

CO4: Aromatic nucleophiic substitution reactions

CO5: Preparation of alcohols and phenols with their reactivity

Course Content:

Unit 1 **[8 Lectures]**

Nucleophilic substitution at sp^3 carbon: Mechanism: S_N1, S_N2, S_Ni mechanisms, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles, substitution involving NGP; relative rate & stereochemical features.

Unit 2 **[6 Lectures]**

Elimination reaction: El, E2 and ElcB; reactivity, orientation (Saytzeff / Hofmann) and stereoselectivity; substitution vs elimination.

Unit 3 **[7 Lectures]**

Electrophilic aromatic substitution: Mechanisms: π- and σ-complex, ipso substitution, activating and deactivating groups, orienting influence.

Reactions: Friedel-Crafts alkylation/acylation, nitration, sulfonation, halogenation, formylation.

Unit 4 **[5 Lectures]**

Nucleophilic aromatic substitution:Mechanisms, orientation and reactivity.

Unit 5 **[10 Lectures]**

Alcohols: Classification of alcohols and their synthesis and reactions; Synthesis of phenols: From sodium arylsulphonates, diazonium salts, S_NAr, Grignard reagents, cumene-phenol process, boronic acids, Dakin reaction; Reaction of phenols: Reimer-Tiemann reaction, Kolbe's reaction, Lederer-Manasse reaction, Fries rearrangement, Claisen rearrangement, nitration, sulphonation, halogenation, oxidation, coupling with diazonium salt, oxidation of phenols by hypervalent iodine(iii) reagents and other oxidizing agents to quinones; Reactions of quinones: Reactions with HCl, amines, alcohols, Thiele acetylation and dienone phenol rearrangement.

Text Book(s)

1. Clayden, J., Greeves, N., Warren, S. andWothers, P. *Organic Chemistry*, 2nd Edn., (Oxford University Press, 2012) .
2. Sykes, P. *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., (Orient Longman Ltd., New Delhi, 1997).
3. Finar, I. L. *Organic Chemistry* (Volume 1), 6th Edn., (Pearson Education, 2002).

Reference Book(s)

1. Zweifel, G. S., Nantz, M. H. andSomfai, P. *Modern Organic Synthesis: An Introduction*, 2nd Edn., (Wiley, New York, 2017).
2. Norman, R. O. C. andCoxon, J. M. *Principles in Organic Synthesis*, 3rd Edn., (Blackie Academic & Professional, 1993).
3. Carey, F. A. and Sundberg, R. J. *Advanced Organic Chemistry, Part B: Reactions and Synthesis,* 5th Edn., (Springer, New York, 2007).
4. March, J. and Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edn., (Wiley, 2007).

CD207 Inorganic Chemistry-I L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course the students will be able to understand:

CO1: Concept of acids and bases as well as the hard-soft acid base principle

CO2: History of co-ordination chemistry, nature of ligands, the nomenclature, and the isomerism in coordination complexes

CO3: Concept of oxidation and reduction, redox reactions, electrochemical potentials, and related equations with their implications

CO4: Statistical methods to find error and accuracy in data analysis and their real applications

CO5: Concept of molecular orbital theory (MOT) or band theory classifying the metals, conductors, semiconductors, and insulators

Course Content:

Unit 1 **[8-Lectures]**

Acid -Base concept: Arrhenius concept, Brønsted-Lowery acids and bases, Lewis acids and bases, Hard soft acids - bases and HSAB principle, Acid and base strength.

Unit 2 **[6-Lectures]**

Coordination chemistry: Werner's theory, classification of ligands, coordination number, nomenclature of coordination compounds, isomerism.

Unit 3 **[10 Lectures]**

Oxidation and Reduction: Oxidation numbers, redox potential, half-cell reaction, Nernst equation, electrochemical series, Latimer and Frost diagrams, Pourbaix diagrams.

Unit 4 **[6 Lectures]**

Statistical methods of analysis: Types of errors, accuracy, precision, significant figures, standard and mean deviations, f-test and t-test.

Unit 5 **[6 Lectures]**

Metallic bonding, band theory, semiconductor, bonding in alloys, intermetallic compounds, hydrogen bonding, clathrates.

Text Book(s)

1. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. *Inorganic Chemistry*: Principles of *Structure and Reactivity*, 4th Edn., (Pearson Education, 2006).
2. Mendham, J., Denney, R. C., Barnes, J. D., Thomas, M. and Sivasankar, B. *Vogel's Quantitative Chemical Analysis*, 6thEdn., (Pearson Education, 2009).

Reference Book(s)

1. Overton, T., Armstrong, F., Rourke, J. and Weller, M. *Inorganic Chemistry,* 6th Edn., (Oxford University Press, 2015).
2. Wulfsberg, G. *Inorganic Chemistry*, 2nd Edn*.,* (Viva, 2005).

CD209 Chemistry Laboratory-III L 0 T 0 P 4 CR 4

Unit 1

Inorganic: Qualitative Analysis of Inorganic Mixtures (including interfering radical)

Unit 2

Physical:

1. Thermochemistry experiment (determination of heat of hydration)

2. Electrochemistry (determination of redox potential)

3.Chemical kinetics (determination of rate constant of hydrolysis of methyl acetate catalysed by an acid)

4. Conductometric/potentiometric (determination of equivalence conductance of an electrolyte at infinite dilution)

5. UV-VIS spectrophotometric (determination of dissociation constant of ferrithiocyanate complex).

Text Book(s)

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis,* 7thEdn., (Prentice Hall, 1996).
2. Yadav, J. B. *Advance Practical Physical Chemistry*, (Goel Publishing House-Meerut, 2008).

Reference Book(s)

1. Viswanathan, B. and Raghavan, P. S. *Practical Physical Chemistry* (Viva Books Private Limited, 2008).

2. Gurdeep, R. *Advanced Practical Inorganic Chemistry,* (Krishna Prakashan, 2013).

SEMESTER IV

CD 204 PHYSICAL CHEMISTRY-II L 3 T 0 P 0 CR 3

Course outcomes:

The courses would fortify the students with in-depth subject knowledge of reaction kinetics. After completion of the course, the learner shall be able to understand:

CO1: Chemical kinetics of simple and complex reactions, Deduction of rate law from the mechanism, Factors affecting the rate of reactions

CO2: Kinetics theories like Hard sphere collision theory, activated complex theory

CO3: Kinetics of reactions in solution phase

CO4: Basics of photo-physical and photo-chemical processes

CO5: Adsorption, adsorption isotherms and their significances and Applications

Course Content:

Unit 1 [2 Lectures]

Reaction rate and rate laws: Reaction mechanism, elementary or simple reactions, complex reactions, definition of rate, monitoring the progress of reaction, rate laws and rate constants, order of reactions, reactions having no order, molecularity, Integrated rate law (zeroth, first and second order reactions), half-life, determination of the rate law.

Unit 2 [4 Lectures]

Factors affecting the rate of a reaction: Temperature dependence of reaction rate, Arrhenius equation, Arrhenius plot, Activation energy, relationship between activation energy and enthalpy, Pre-exponential factor, Hard-sphere collision theory, the steric requirement, Activated complex theory, Eyring equation, kinetic isotope effect.

Unit 3 **[6 Lectures]**

Kinetics of complex reaction: Complex reactions, evidence of complex reactions, types of complex reactions, steady state approximation, rate limiting step, opposing 1st order, consecutive, parallel, chain, and photochemical reactions, Explosion (thermal and chain branching explosion), kinetic and thermodynamic control of reaction, Law of microscopic reversibility, Lindemann theory of unimolecular reaction.

Unit 4 **[6 Lectures]**

Catalysis: Classification, characteristic of catalytic reaction, homogeneous and heterogeneous catalysis, turn over number, acid base catalysis, Brönsted relations, autocatalysis, oscillatory reactions, enzyme catalysis, Enzyme Inhibition, Michaelis-Menten equation, Lineweaver-Burk plot, kinetic salt effect (Primary and Secondary salt effect, salting in and salting out), Heterogeneous catalysis, Langmuir- Hinshelwood mechanism, Eley-Rideal mechanism.

Unit 5 **[6 Lectures]**

Photochemistry:Laws of photochemistry: Grotthus-Draper law, Stark-Einstein law of photochemical equivalence and Lambert-Beer's law; quantum yield and its measurement for a photochemical process, Jablonski Diagram, Fluorescence, Phosphorescence, Chemiluminiscence, Quenching, Stern-Volmer equation, Fluorescence lifetime, Photosensitized reactions, Kinetics of HI decomposition, hydrogen-halogen reactions, dimerisation of anthracene.

Unit 6 **[6 Lectures]**

Reactions in solution:Reactions in solution, cage effect, diffusion-controlled reaction, activation controlled reaction, the material balance equation, Influence of solvent dielectric constant, Influence of ionic strength, influence of hydrostatic pressure, Hammette relationship.

Unit 7 **[6 Lectures]**

Adsorption:Difference between absorption and adsorption, physical and chemical adsorption, factors influencing adsorption, adsorption isotherms (Langmuir, Freundlich and BET), application of adsorption isotherms for surface area measurement, application of adsorption, Gibbs adsorption isotherm and surface excess. Heterogeneous catalysis (single reactant).

Text Book(s)

1. Atkins, P. and Paula, J. de. *Atkins' Physical Chemistry*, 10thEdn.,(Oxford University Press, 2014).
2. Levine, I. N., *Physical Chemistry,* 6thEdn., (McGraw Higher Ed, 2008).
3. Laidler, K. J., *Chemical Kinetics*, 3rdEdn., (Pearson Education India, 2003).

Reference Book(s)

1. Laidler, K. J., Meiser, J. H. and Sanctuary, B. C.*Physical Chemistry,* 4thEdn., (Brooks Cole, 2002).
2. Silbey, R. J., Alberty, R. A. and Bawendi, M. J. *Physical Chemistry*, 4thEdn., (Wiley,2004*).*
3. McQuarrie, D. A. and Simon, J. D., *Physical Chemistry: A Molecular Approach*, (University Science Books).
4. Connors, K. A. *Chemical Kinetics: A Study of Reaction Rates in Solution*, (Wiley VCH, 1990).
5. Barrow, G. M. *Physical Chemistry*, 5thEdn., (Tata McGraw Hill Education, 2006).

CD 206 Organic Chemistry-II L 3 T 0 P 0 CR 3

Course outcomes:

On completion of the course, the learner shall be able to know:

CO1: Synthesis, properties, and reactions of ethers

CO2: Organonitrogen compound

CO3: Chemistry of aldehydes and ketones

CO4: Carboxylic acids and derivatives

CO5: Understanding of carbohydrate chemistry

Course Content:

Unit 1 **[6 Lectures]**

Ethers: Classification: Dialkyl, aryl alkyl and diaryl ethers; cyclic ethers: epoxides, oxetanes, THF, THP.

Synthesis: Williamson ether synthesis, dehydration of alcohols, alkoxymercuration-demercuration, diaryl- and aryl alkyl ethers by S_NAr, cycloetherification.

Reactions: S_N1/S_N2 cleavage of ethers by HI, HBr, BBr_3, TMSI, NaSR.

Synthesis and cleavage of well-known classes of ethers: OMe, OMOM, OTHP, OBn, OPMB

Synthesis and cleavage of well-known silyl ethers: OTMS, OTBS and TBDPS.

Unit 2 **[2 Lectures]**

Organonitrogen compounds: Synthesis and reactions of $RNO_2/ArNO_2$, RCN/ArCN, RNC/ArNC, $RNH_2/ArNH_2$, diazonium salts.

Unit 3 **[6 Lectures]**

Aldehydes and ketones: Reactions: Hydrates, cyanohydrin, bisulfite adduct, hemiacetal/acetal/thioacetal, imines, hydrazones, oximes, α-halogenation, reaction with nitrous acid, Cannizzaro reaction, Tischenko reaction, reactions with Grignard reagents and organolithium compounds, Reformatsky reaction, reaction with diazomethane and related compounds.

Unit 4 **[8 Lectures]**

Carboxylic acids and their derivatives: Synthesis: General synthetic methods of carboxylic acids, esters, acid chlorides, anhydrides and amides.

Reactions: Decarboxylation, esterification, ester hydrolysis, HVZ reaction, nucleophilic substitution at acyl carbon, reactions with Grignard reagents, organolithium and other organometallic compounds, reaction with diazomethane and related compounds.

Unit 5 **[8 Lectures]**

Rearrangements:(i) Rearrangement to electron-deficient carbon:

Wagner-Meerwein rearrangement, pinacol-pinacolon and related rearrangements, dienone-phenol, benzil-benzilic acid rearrangement.

(ii) Rearrangement to electron-deficient oxygen:

Baeyer-Villiger oxidation, hydroperoxide rearrangement cumene hydroperoxide-phenol rearrangement, Dakin reaction.

(iii) Rearrangement to electron-deficient nitrogen (Beckmann rearrangement, Schmidt rearrangement, Hofmann rearrangement, Lossen rearrangement, Curtius rearrangement).

(iv) Aromatic rearrangements:

Migration from oxygen to ring carbon (Fries rearrangement, Claisen rearrangement), migration from nitrogen to ring carbon (Hofmann-Martius rearrangement, Fischer-Hepp rearrangement, N-azo to C-azo rearrangement, Bamberger rearrangement, Orton rearrangement, Benzidine rearrangement.

Unit 6 **[6 Lectures]**

Carbohydrates: Monosaccharides, Aldoses up to 6 carbons, structure of D-glucose & D-fructose (configuration & conformation), anomeric effect, mutarotation, Important reactions and conversions including protection/deprotection protocol, Disaccharides and polysaccharide: nature of glycosidic linkages.

Text Book(s)

1. Clayden, J., Greeves, N., Warren, S. andWothers, P. *Organic Chemistry*, 2nd Edn., (Oxford University Press, 2012).
2. Sykes, P. *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., (Orient Longman Ltd., New Delhi, 1997).
3. Finar, I. L. *Organic Chemistry* (Volume 1), 6th Edn., (Pearson Education, 2002).

Reference Book(s)

1. Zweifel, G. S., Nantz, M. H. andSomfai, P. *Modern Organic Synthesis: An Introduction*, 2nd Edn., (Wiley, New York, 2017).
2. Norman, R. O. C. andCoxon, J. M. *Principles in Organic Synthesis*, 3rd Edn., (Blackie Academic & Professional, 1993).

3. Carey, F. A. and Sundberg, R. J. *Advanced Organic Chemistry, Part B: Reactions and Synthesis,* 5thEdn., (Springer, New York, 2007).
4. March, J. and Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6thEdn., (Wiley, 2007).

CD 208 Inorganic Chemistry-II L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course the students will be able to understand:

CO1: Chemistry of boron compounds including their preparation, properties and bonding nature

CO2: Wade's rule for predicting the structure of boron compounds

CO3: Chemistry of inorganic carbon compounds, the allotropy of carbons and their compounds with nitrogen and sulphur

CO4: Chemistry of silanes, silicones, silicon polymers

CO5: Nitrogen and phosphorous chemistry, properties of various compounds of nitrogen and phosphorous such oxides, halides etc.

Course Content:

Unit 1 [12 Lectures]

Chemistry of Group 13 Elements**:** The elements and their properties; Chemistry of Boron; Borides; Boron hydrides (Preparation, structure, bonding, reactions and properties); Wade's rule, Boron halides, Boron-Nitrogen chemistry; Boron-Oxygen chemistry, borane, carborane, metalloborane and metallocarboranes.

Unit 2 [12 Lectures]

Chemistry of Group 14 Elements: The elements and their properties; Allotropy of Carbon: Diamond, Graphite, and Fullerenes; Intercalation); Carbides; Carbon halides and oxides; Compounds with C-N and C-S bonds; Silane reagents, Synthesis, properties

and modifications on polysilanes. Condensation vs catenation, Silicides, Silicone Polymers; Oxygen compounds of silicon.

Unit 3 **[12 Lectures]**

Chemistry of Group 15 Elements: The elements and their properties; Nitrides; Hydrides of Nitrogen; Oxides of Nitrogen; Oxo acids and anions of Nitrogen; Activation of Nitrogen; Reaction of coordinated NO; Phosphides; Phosphorous halides and oxides; Oxoacids of phosphorous and their salts, phosphonitrilic compounds.

Text Book(s)

1. Greenwood, N. N. and Earnshaw, A. *Chemistry of the Elements,* 2nd Edn., (Pergamon Press, 1997).
2. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M. *Advanced Inorganic Chemistry*, 6th Edn., (John Wiley, 2007).

Reference Book(s)

1. Overton, T., Armstrong, F., Rourke, J. and Weller, M. *Inorganic Chemistry,* 6th Edn., (Oxford University Press, 2015).
2. Wulfsberg, G. *Inorganic Chemistry*, 2nd Edn.,(Viva, 2005).

CD212 Chemistry Laboratory-IV L 0 T 0 P 3 CR 3

Unit 1

Volumetric estimation of iron and copper, Determination of water of crystallization in a molecule of Hydrated Mohr's salt, Estimation of total Hardness of water.

Unit 2

Detection of N, S, and halogens in organic compounds, Preparation of suitable derivatives of functional groups and determination of mp/bp

Unit 3

One step organic preparation using common organic reactions such as nitration, acetylation, benzoylation, diazo- coupling etc.

Text Book(s)

1. Mendham, J., Denney, R. C., Barnes, J. D., Thomas, M. and Sivasankar, B. *Vogel's Quantitative Chemical Analysis*, 6thEdn.*,* (Pearson Education, 2009).
2. Furniss, B. S., Ford, A. J. H., Smith, P. W. H. and Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry,* 5thEdn., (John Wiley, 1989).

Reference Book(s)

1. Vishnoi, R. *Advanced Practical Organic Chemistry,* 2nd Revised Edn.,(Vikas Publisher, 2007).
2. Gurdeep, R. *Advanced Practical Inorganic Chemistry,* (Krishna Prakashan, 2013).

CD 214 IT Skills for Chemists L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: Important mathematical concept widely applied in chemistry

CO2: numerical methods for differentiation and integration

CO3: Computer Programming

CO4: Curve fitting methods

CO5: Different software used in data handling and analysis

Course Content:

Unit 1 [12 Lectures]

Mathematics:

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

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

Uncertainty in measurement: types of uncertainties, combining uncertainties, statistical treatment, mean, standard deviation, relative error, data reduction and the propagation of errors, graphical and numerical data reduction, numerical curve fitting: the method of least squares (regression).

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

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

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

Unit 2

Computer programming: **[8 Lectures]**

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions, elements of the BASIC language, BASIC keywords and commands, Logical and relative operators, strings and graphics, compiled versus interpreted languages, Debugging, simple programs using these concepts, matrix addition and multiplication, statistical analysis.

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

Unit 3 **[4 Lectures]**

HANDS ON:

Introductory writing activities: introduction to word processor and structure drawing (ChemSketch) software, incorporating chemical structures, chemical equations, and

expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waals equation, etc.) into word processing documents.

Unit 4

HANDS ON: **[4 Lectures]**

Handling numeric data:

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

Unit 5 **[4 Lectures]**

HANDS ON:

Numeric modelling:

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

Unit 6 **[4 Lectures]**

Statistical analysis:

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

Text Book(s)

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

2. Harris, D. C. *Quantitative Chemical Analysis*. 7thEdn., (Freeman, 2010).
3. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*, (Cambridge University Press, 2001).
4. Venit, S.M. *Programming in BASIC: Problem solving with structure and style*, 2ndEdn. (Jaico Publishing House, 2001).

Reference Book(s)

1. Mortimer, R. Mathematics for Physical Chemistry, 4thEdn., (Elsevier, 2013).
2. Steiner, E. *The Chemical Maths Book*,(Oxford University Press, 2008).
3. Yates, P. *Chemical calculations*. 2ndEdn., (CRC Press, 2007).

SEMESTER V

CD301 Physical Chemistry-III L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: Fundamentals of equilibrium and equation of states

CO2: Thermodynamic descriptions of pure condensed phase and their mixtures

CO3: Different colligative properties

CO4: Phases, components, Gibbs phase rule, Phase diagrams and applications

Course Content:

Unit 1

Thermodynamics and Equilibrium: **[15 Lectures]**

Open system, chemical potential and activity, partial molar quantities, chemical potential in terms of Gibb's free energy and other thermodynamic state functions and its variation with temperature and pressure, variation of thermodynamic functions for systems with variable composition (Equations of states for these systems), Gibbs-Duhem equation, variation of thermodynamic functions for systems with variable composition, equations of states for these systems.

Fugacity of gases and fugacity coefficient, standard states of real gases, relation between fugacity and pressure.

Thermodynamic conditions for equilibrium, van't Hoff's reaction isotherm (deduction from chemical potential), equilibrium constant and standard Gibbs free energy change, definitions of K_P, K_C and K_x; shifting of equilibrium due to change in external parameters e.g. temperature and pressure, Le Chatelier's principle.

Nernst's distribution law, finding out Keq using Nernst distribution law for different reactions ($KI+I_2 = KI_3$ and dimerization of benzene).

Pure ideal gas-its chemical potential and other thermodynamic functions and their changes during a change, Thermodynamic parameters of mixing, chemical potential of an ideal gas in an ideal gas mixture, concept of standard states and choice of standard states of ideal gases.

Unit 2 **[6 Lectures]**

Condensed Phase: Chemical potential of pure solid and pure liquids, Ideal solution, Ideally dilute solution, Definition, Raoult's law, Henry's law, Mixing properties of ideal solutions, chemical potential of a component in an ideal solution, Choice of standard states of solids and liquids.

Activity, the solvent activity, the solute activity (ideal-dilute solution and real solutes), Activities in terms of molalities, activity coefficients of electrolyte/ion in solution, Solubility equilibrium and influence of common ions and indifferent ions thereon, pH, buffer solution, buffer capacity, salt hydrolysis (detailed treatment).

Unit 3 **[5 Lectures]**

Colligative Properties: relative lowering of vapour pressure, elevation of boiling point, depression of freezing point, osmotic pressure and their thermodynamic interpretation, applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Unit 4 **[10 Lectures]**

Phase Equilibrium: Definitions of phase, component and degrees of freedom, Phase rule and its derivations, Definition of phase diagram, Phase diagram of component system

(H_2O, S and CO_2), two component system, first order phase transition and Clapeyron equation, Clausius-Clapeyron equation -derivation and use, liquid vapour equilibrium for two component systems (phenol-water system), three component systems (water-chloroform-acetic acid system), triangular plots, principle of fractional distillation, Azeotropic solution, Liquid-liquid phase diagram (phenol- water system), Solid-liquid phase diagram, Eutectic mixture, congruent and incongruent melting.

Text Book(s)

1. Atkins, P. and Paula, J. de. *Atkins' Physical Chemistry*, 10thEdn.*,* (Oxford University Press, New Delhi, 2014).
2. Silbey, R. J., Alberty, R. A. and Bawendi, M. J. *Physical Chemistry*, 4thEdn.*,* (Wiley, 2004).
3. Barrow, G. M. Physical Chemistry, 5thEdn., (Tata McGraw Hill Education, 2006).
4. Levine, I. N.*, Physical Chemistry,* 6thEdn.*,* (McGraw Higher Ed, 2008).

Reference Book(s)

1. Laidler, K. J., Meiser, J. H. and Sanctuary, B. C.**,** *Physical Chemistry,* 4thEdn.*,* (Brooks Cole, 2002).
2. McQuarrie, D. A. and Simon, J. D., *Physical Chemistry: A Molecular Approach*, (University Science Books, 1997).
3. Mortimer, R. G. *Physical Chemistry,* 3rdEdn.,(Elsevier, 2008).

CD 303 Organic Chemistry-III L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: Conformational analysis of acyclic systems and concept of prostereoisomerism

CO2: Conformation of cycloalkanes and reactivity of cyclohexane derivatives

CO3: Basic concepts of amino acids, proteins and heterocycles

CO4: Organic photochemistry and pericyclic reactions

Course Content:

Unit 1 **[4 Lectures]**

Stereochemistry-2: Conformation of acyclic systems, free and restricted rotation, Rotamers, their stability and nomenclature, concept of topicity and prostereoisomerism, Diasteromerism.

Unit 2 **[8 Lectures]**

Stereochemistry-3: Cycloalkanes and Conformational Analysis: Types of cycloalkanes and their relative stability, Baeyer strain theory, cyclohexane, mono and disubstituted cyclohexanes: chair, boat and twist boat forms; relative stability with energy diagrams, symmetry properties and optical activity, conformation & reactivity in cyclohexane system: elimination (E_2), rearrangement, nucleophilic substitution (S_N1, S_N2, NGP), oxidation of cyclohexanol, esterification, saponification, lactonisation.

Unit 3 **[6 Lectures]**

Amino acids and proteins: Amino acids: Synthesis: (Strecker, Gabriel, acetamido malonic ester, azlactone), isoelectric point, ninhydrin reaction, Peptides: peptide linkage, synthesis of peptides using N-protection & C-protection, solid phase synthesis, peptide sequence: C-terminal and N-terminal amino acid determination.

Proteins: Amino acids-properties, reactions; peptides, importance of proteins, primary, secondary and tertiary structure of proteins, denaturation, isoelectric point.

Unit 4 **[6 Lectures]**

Heterocycles (monocyclic and bicyclic) with one heteroatom: Heterocyclic compounds**:** furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline synthesis, structure and bonding, properties.

Unit 5 **[6 Lectures]**

Organic photochemistry: Theory of photochemistry, Jablonski diagram, Frank-Condon principle, Photosensitisers, Einstein's law of photochemical equivalence, typical photoreactions such as photoreaction of benzophenone, photolytic reactions of ketones.

Unit 6 **[6 Lectures]**

Pericyclic reactions**:** Basic concepts of pericyclic reaction and examples of electrocyclic, cycloaddition and sigmatropic rearrangements reactions, FMO analysis and Woodward Hoffmann selection rules for [2+2] cycloaddition reaction.

Text Book(s)

1. Sengupta, S. Basic Stereochemistry of Organic Molecules, 1stEdn., (Oxford University Press, 2014).
2. Finar, I. L. *Organic Chemistry* (Volumes 1 and 2), 6thEdn., (Pearson Education, 2002).
3. Clayden, J., Greeves, N., Warren, S. andWothers, P. *Organic Chemistry*, 2ndEdn., (Oxford University Press, 2012).
4. Sankararaman, S. *Pericyclic reactions—a textbook: reactions, applications and theory*, 1stEdn., (Wiley VCH, 2005).
5. Rohatgi-Mukherjee, K. K. *Fundamentals of Photochemistry,* 2nd Revised Edn., (New Age international Publishers, 2006).

Reference Book(s)

1. Eliel, E. L., Wilen, S. H. and Doyle, M. P. *Basic Organic Stereochemistry*, 1stEdn., (Wiley-Interscience, 2001).
2. Kalsi, P. S. *Stereochemistry, Conformation and Mechanism* (New Age international Publishers, 2009).
3. Fleming, I. *Molecular Orbitals and Organic Chemical Reactions,* (Oxford University Press, 2010).
4. Turro, N J., Ramamurthy, V. andScaiano, J. C. *Modern Molecular Photochemistry of Organic Molecules*, (University Science Books, CA, 2010).

CD 305 Inorganic Chemistry-III L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course the students will be able to understand:

CO1: The synthesis, structure and bonding analysis of interhalogen, pseudohalogens, xenon and other noble gas compounds

CO2: General properties of 3d transition elements and their comparison with 4d and 5d elements

CO3: Crystal Field Theory (CFT) and crystal field stabilization energy (CFSE)

CO4: Jahn Teller Effects, Term symbol and Orgel diagram

CO5: Basic concept of magnetism viz magnetic dipole, magnetic moment, magnetic susceptibility, magnetic flux and intensity, Bohrs magneton

Course Content:

1.

Unit 1 [8 Lectures]

The chemistry of the halogens and the noble gases: Halogen family: Electronic structure and valences, preparation, interhalogen compounds, polyhalides, pseudohalogens, charge transfer complexes of halogens, oxides and oxoacids of halogens.

Unit 2 [6 Lectures]

Noble gas family: Atomic and physical properties of the elements, compounds of xenon, bonding in noble gas compounds, compounds of other noble gases.

Unit 3 [14 Lectures]

Aspects of d- block elements: Elements of first transition series and their comparison with the second and third series, general periodic trends, chemistry of various oxidation states of first row transition metals and their comparison based on electronic configuration. Crystal Field Theory (CFT): Crystal field splitting of d-orbitals in octahedral, square planar and tetrahedral complexes. CFSE, factors affecting the

magnitude of Δ, strong and weak field ligands and spectrochemical series, distortion of octahedral complexes and Jahn-Teller Effect, Term symbols and Orgel diagram.

Unit 4 **[8 Lectures]**

Magnetic properties of transition metal complexes: Dia-, para-, ferro- and antiferromagnetic behaviour of compounds, Curie-Weiss law, Curie temperature, Neel temperature.

Text Book(s)

1. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. *Inorganic Chemistry*: Principles of *Structure and Reactivity*, 4th Edn., (Pearson Education, 2006).
2. Overton, T., Armstrong, F., Rourke, J. and Weller, M. *Inorganic Chemistry,* 6thEdn., (Oxford University Press, 2015).

Reference Book(s)

1. Greenwood, N. N. and Earnshaw, A. *Chemistry of the Elements,* 2ndEdn., (Pergamon Press, 1997).
2. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M. *Advanced Inorganic Chemistry*, 6th Edn.*,* (John Wiley, 2007).

CD 307 Quantum Chemistry L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: Drawbacks of classical mechanics and the origin of quantum theory

CO2: Postulates of quantum mechanics. concept of wave functions, operators and eigen value equation

CO3: Wave mechanics of different model system in describing the real system

CO4: Valence bond and molecular orbital theory

CO5: Approximation methods for the solution of the Schordinger equation for many body system

Course Content:

Unit 1 **[4 Lectures]**

Origin of the quantum theory of matter:Franck- Hertz experiment, Photoelectric effect, Compton Effect, Black body radiation, Planck's law, Wein's law, Bohr's theory and atomic spectra.

Unit 2 **[2 Lectures]**

Matter wave: Wave-particle duality, uncertainty principle.

Unit 3 **[8 Lectures]**

Operators and wave functions in quantum mechanics: Operator principles, Hamiltonian and Hermitian operators, postulates of quantum mechanics, Schrödinger equation, free particle, particle in a box (one and three dimensional).

Unit 4 **[8 Lectures]**

Wave mechanics of simple systems: One dimensional harmonic oscillator, rigid rotator, the hydrogen atom, angular momentum, electron spin, spin-orbit coupling.

Unit 5 **[6 Lectures]**

Molecular orbital theory: Born-Oppenheimer approximation, LCAO approximation, LCAO MO of H_2 and H_2^+, VB Theory, comparison of VB and MO.

Unit 6 **[4 Lectures]**

Approximate methods: Basic idea of variation and perturbation theory.

Unit 7 **[4 Lectures]**

Many electron wave function: Basic idea of Hartree Fock wave function and SCF MO.

Text Book(s)

1. Levine, I. N. *Quantum Chemistry,* 7thEdn., (Pearson, 2013).
2. Chandra, A. K. *Introductory Quantum Mechanics,* 3rd Edn*.,* (Tata McGraw Hill Publishing Company, New Delhi, 2002).

Reference Book(s)

1. Kauzmann, W. *Quantum Chemistry: An Introduction* (Academic Press, 2013).
2. Prasad, R. K. *Quantum Chemistry* (New Age, 2010).
3. Atkins, P. W. and Friedman, R. S. *Molecular Quantum Mechanics* (Oxford University Press, 2010).

CD 309 Chemistry laboratory-V L 0 T 0 P 4 CR 4

Unit 1

Inorganic: Inorganic preparations. Gravimetric estimation of copper and Nickel. Paper chromatographic separation of Ag(I),Hg(II) and Pb(II) ions.

Unit 2

Organic: Qualitative Analysis of solid and liquid organic compounds containing one or more functional groups.

Unit 3

Two step organic preparation using common reagents such as Benzil-Benzillic acid rearrangement, Beckman rearrangement etc.

Unit 4

Physical: Rate constant at elevated temperatures, energy of activation, Polarimetry, Partition function, Critical solution temperature etc.

Text Book(s)

1. Mendham, J., Danney, R. C., Barnes, J. D. and Thomas, M. *Vogel's Textbook of Quantitative Chemical Analysis* (Peterson Education, 2004).
2. Viswanathan, B. and Raghavan, P. S. *Practical Physical Chemistry* (Viva Books Pvt. Ltd., 2005).

Reference Book(s)

1. Furniss, B. S., Ford, A. J. H., Smith, P. W. H. and Tatchell, A., R. *Vogel's Textbook of Practical Organic Chemistry,* 5thEdn., (John Wiley, 1989).
2. Gurdeep, R. *Advanced Practical Inorganic Chemistry,* (Krishna Prakashan, 2013).

SEMESTER VI

CD 302 Physical Chemistry-IV L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: Transport processes in liquid phase and factors affecting the transport processes

CO2: Basic principle of laws of electrochemistry.

CO3: Understanding about electro chemical cells and cell reactions, electrode potential, potentiometric titration

CO4: Basics of colloidal dispersion

Course Content:

Unit 1 [8 Lectures]

Transport processes: Diffusion processes: Flux, force, Fick's laws, phenomenological coefficients & their inter-relationship (general form), different examples of transport properties.

General features of fluid flow (streamline flow and turbulent flow), Reynold number, nature of viscous drag for streamline motion, Newton's law of visocsity, viscosity coefficient, Poiseuille's equation (with derivation), temperature dependence of

viscosity, principle of determination of viscosity coefficient of liquids by falling sphere method.

Unit 2 **[20 Lectures]**

Electrochemistry:

Ionics: Ion conductance, Conductance and measurement of conductance, cell constant, specific conductance and molar conductance, Variation of specific and equivalent conductance with dilution for strong and weak electrolytes, Kohlrausch's law of independent migration of ions, Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes, Ostwald's dilution law, Ionic mobility, Debye–Huckel theory of Ion atmosphere (qualitative)-asymmetric effect, Transport number, Principles of Hittorf's and Moving-boundary method, relaxation effect and electrophoretic effect, Wien effect, Debye-Falkenhagen effect, Walden's rule Application of conductance measurement (determination of solubility product and ionic product of water), Conductometric titrations.

Electrodics: Types of electrochemical cells and examples, cell reactions, emf and change in free energy, ΔH and ΔS of cell reactions from emf measurements, Thermodynamic derivation of Nernst equation, Standard cells, Half-cells / electrodes, different types of electrodes (with examples), Standard electrode potential (IUPAC convention) and principles of its determination, types of concentration cells, Liquid junction potential and its minimisation.

Glass electrode and determination of pH of a solution, Ion-selective electrodes, Potentiometric titrations (acid-base and redox).

Electrical double layer, polarization and overvoltage**.**

Batteries, fuel cell, corrosion and its prevention.

Unit 3 **[8 Lectures]**

Definition of colloids and crystalloids, classification of colloids, preparation and purification techniques of colloidal dispersion, Tyndall effect, Brownian movement, electrophoresis, electro-osmosis, protective colloids, gold number, zeta potential, lyophobic and lyophilic sols, origin of charge and stability of lyophobic colloids,

coagulation and Schultz-Hardy rule, Zeta potential, DLVO theory, electrokinetic phenomenon (qualitative idea only), ampiphiles, surfactants, micelles, critical micelles concentration, emulsions, microemulsions, gels.

Text Book(s)

1. Atkins, P. and Paula, J. de. *Atkins' Physical Chemistry*, 10thEdn., (Oxford University Press, New Delhi, 2014).
2. Levine, I. N.*, Physical Chemistry,* 6thEdn.*,* (McGraw Higher Ed 2008).
3. Laidler, K. J., Meiser, J. H. and Sanctuary, B. C. **,** *Physical Chemistry,* 4thEdn.*, (*Brooks Cole, 2002).
4. Silbey, R. J., Alberty, R. A. and Bawendi, M. J. *Physical Chemistry*, 4thEdn., (Wiley, 2004).

Reference Book(s)

1. Adamson, A. A., A Textbook of Physical Chemistry, 2ndEdn., (Elsevier, 1973).
2. Glasstone, S., An introduction to Electrochemistry, (Maurice Press, 2008).
3. Bockris, J. O. M. and Reddy, A. K. N., Vol 1 & 2 (Plenum Press, 2001).

CD304 Organic Chemistry-IV L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: Oxidations of alcohol, alkene and alkynes

CO2: Reduction involving hydrogenation, dissolving metal reducing agents and complex metal hydrides

CO3: Selected organic name reactions

CO4: Concept of retrosynthetic analysis

Course Content:

Unit 1 **[10 Lectures]**

Oxidation:

(A) Oxidation of alcohols to aldehydes/ketones/carboxylic acids:

Transition metal-based oxidants: Jones reagent, Collins Reagent, PCC, PDC, $KMnO_4$, MnO_2, $Mn(OAc)_3$, $RuCl_3/NaIO_4$ (RuO_4).

Dimethyl sulfoxide-based oxidation: Moffatt-Pfitzner Oxidation, Parikh-Doering Oxidation, Corey-Kim Oxidation, Swern Oxidation.

Other oxidants: Dess-Martin reagent, TEMPO, TPAP.

(B) Oxidation of alkenes/alkynes:

Ozonolysis, $KMnO_4$, Prévost dihydroxylation, Woodward dihydroxylation, Upjhon dihydroxylation, epoxidation by peroxy acids and related reagents

(C) Other oxidation processes: Allylic oxidation by SeO_2, Oxidation of aldehydes/ketones by SeO_2, Cleavage of 1,2-diols, Hunsdiecker reaction.

Unit 2 **[8 Lectures]**

Reduction:

(A) Hydrogenation: H_2/Pd-C, H_2/Lindlar Catalyst, H_2/Wilkinson's Catalyst, transfer hydrogenation, diimide reduction.

(B) Dissolving Metal Reductions for: alkynes, aldehydes/ketones, esters, α,β-unsaturated ketones, aromatic compounds (Birch reduction), Clemmensen Reduction.

(C) Aluminium-based reagents: lithium aluminum hydride (LAH), lithium trimethoxyaluminium hydride (LTBA), lithium tri-(*tert*-butoxy)aluminium hydride (LTBA), Sodium *bis*(2-methoxyethoxy)aluminium hydride (Red-Al), selectrides, diisobutylaluminium hydride, alane.

Boron-based reagents: Sodium borohydride, zinc Borohydride, lithium borohydride, sodium cyanoborohydride, sodium triacetoxyborohydride, borane.

(D) Other reduction processes: Wolff-Kishner reduction, Clemmensen Reduction, MPV reduction.

Unit 3 **[6 Lectures]**

Selected important reactions: Aldol addition and condensation, directed aldol addition, Mukaiyama aldol addition, Robinson Annulation, Knoevenagel condensation, Perkin condensation, Stobbe condensation, Michael addition, Claisen condensation, Dieckmann

condensation, acyloin condensation, Stork enamine reaction, Pinacol Coupling Reaction, McMurry Reaction, benzoin condensation, Stetter reaction, Wittig and related reactions, Nef carbonyl synthesis.

Unit 4

Active methylene compounds: Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Unit 5 **[6 Lectures]**

Reactions involving free radical intermediates: Addition reaction (Peroxide effect), substitution reaction (allylic and benzylic halogenation), cyclization of free radical intermediates, Baldwin rules, fragmentation and rearrangement reactions by radical pathways.

Unit 6 **[6 Lectures]**

Retrosynthetic analysis: Basic concepts of retrosynthetic analysis, Analysis of one group disconnection approach for alcohol and keto compound, synthons, donor and acceptor synthons, functional group interconversion, C-C disconnections and synthesis, reconnection (1,6-di carbonyl), natural reactivity and umpolung, protection-deprotection strategy.

Text Book(s)

1. Clayden, J., Greeves, N., Warren, S. andWothers, P. *Organic Chemistry*, 2nd Edn., (Oxford University Press, 2012).
2. Carey, F. A. and Sundberg, R. J. *Advanced Organic Chemistry, Part B: Reactions and Synthesis,* 5th Edn., (Springer, New York, 2007).
3. March, J. and Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edn., (Wiley, 2007).

Reference Book(s)

1. Zweifel, G. S., Nantz, M. H. andSomfai, P. *Modern Organic Synthesis: An Introduction*, 2nd Edn. (Wiley, New York, 2017).

2. Norman, R. O. C. andCoxon, J. M. *Principles in Organic Synthesis*, 3rdEdn. (Blackie Academic & Professional, 1993).

CD 306 Inorganic Chemistry-IV L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course the students will be able to understand:

CO1: Definition of organometallic chemistry, EAN and 18-electron rule

CO2: Preparation and bonding analysis of metal carbonyls, allyl, enals, carbenes, metallocene

CO3: Kinetic and thermodynamic stability of metal complexes, stability constants

CO4: Importance of metals in biological systems and heme-proteins

CO5. Nuclear stability, isotopes and laws of radioactivity, carbon dating

Course Content:

Unit 1 [12 Lectures]

Introduction to Organometallic Chemistry: Classification of ligands, EAN rule, preparation, properties and bonding of metal carbonyls and olefin complexes. π-allyl and enyl systems; Transition metal-carbon σ-bond: metal-alkyls, metal-carbenes, metal-carbynes, Metallocene.

Unit 2 [10 Lectures]

Metal-ligand equilibria in solution: Stepwise and overall formation constants. Factors affecting the stability of metal complexes, chelate effect, determination of binary formation constants, inert and labile complexes.

Unit 3 [8 Lectures]

Bioinorganic chemistry: Essential and trace elements in biological systems, heme-protiens– haemoglobin, myoglobin, dioxygen binding, co-operativity, Bohr effect, Picket-fence model.

Unit 4 **[6 Lectures]**

Nuclear chemistry: Nuclear stability, isotopes, isobars and isotones, laws of radioactivity, artificial radioactivity, nuclear fission and fusion, radiocarbon dating.

Text Book(s)

1. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. *Inorganic Chemistry*: Principles of *Structure and Reactivity*, 4th Edn., (Pearson Education, 2006).
2. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M. *Advanced Inorganic Chemistry*, 6th Edn., (John Wiley, 2007).

Reference Book(s)

1. Overton, T., Armstrong, F., Rourke, J. and Weller, M. *Inorganic Chemistry,* 6thEdn., (Oxford University Press, 2015).
2. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. *Bioinorganic Chemistry*, (Viva Books Pvt. Ltd., 2004).

CD 308 Principles of Spectroscopy L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: The basic principles involved in the interaction of electromagnetic radiation with matter.

CO2: Different types of spectra

CO3: Spectroscopic techniques like IR, UV-Vis, NMR and the theory involved.

CO4: Use of the spectroscopy in deducing the chemical structure.

Course Content:

Unit 1 **[4 Lectures]**

Basic principle of spectroscopy: Interaction of matter and electromagnetic radiation, Factors affecting widths and intensity of spectral lines.

Unit 2 **[10 Lectures]**

IR spectroscopy: Principle, instrumentation, and applications of IR spectroscopy.

Unit 3 **[10 Lectures]**

Electronic spectroscopy: Basic principle, Lambert-Beer law, types of electronic transitions in organic molecules, applications in functional group detection.

Unit 4 **[12 Lectures]**

NMR spectroscopy: Origin of chemical shifts, factors affecting the chemical shifts and their Interpretation, spin-spin coupling, relaxation process.

Text Book(s)

1. Banwell, C. N. and McCash, E. M. *Fundamentals of Molecular Spectroscopy* (Tata McGraw Hill, 1994).
2. Kemp, W. *Organic Spectroscopy,* 3rdEdn.*,* (McMillan Press, 1991).

Reference Book(s)

1. Silverstein,R. M.*Spectrometric Identification of Organic Compounds,* 7thEdn. (John Wiley & Sons, 2005).
2. Chandra, S. *Molecular Spectroscopy* (Narosa, 2009).

CD 310 Chemistry Laboratory-VI L 0 T 0 P 4 CR 4

Unit 1

Computational practical's

1. DOS, WINDOWS and UNIX operating systems

Unit 2

1. Programming with FORTRAN77

Unit 3

1. Numerical methods in chemistry (using MS EXCEL)

2. Generation of an EXCEL chart to display the variation of the H_{1s} radial function with radial distance from the nucleus
3. Generation of an EXCEL chart to display the variation of the H_{2s} radial function with radial distance from the nucleus
4. Generation of an EXCEL chart to display the variation of the H_{2p} radial function with radial distance from the nucleus
5. EXCEL charts for the hydrogenic radial distribution functions

Unit 4

1. Generation of the numerical radial wave function for the helium atom "1s' atomic orbital.
2. Generation of the numerical radial wave functions Li_{1s} and Li_{2s} orbitals etc.

Unit 5

Quantum Chemical Calculations with GAUSSIAN and GAMESS

Text Book(s)

1. Balagurusamy, E. *Numerical Methods*, (Tata McGraw-Hill Publishing Company Limited, 2002).
2. Billo, E. J. *Excel for Chemists: A Comprehensive Guide*, (Willy-VCH, 2001).

Reference Book(s)

1. Quinn, C. M. *Computational Quantum Chemistry: An Interactive Guide to Basis Set Theory*, (Academic Press, 2002).

SEMESTER VII

CD 401 Principles of Inorganic Chemistry L 3 T 0 P 0 CR 3

Course outcomes:

On completion of this course the students will be able to understand:

CO1: Periodic properties of elements including lanthanides

CO2: Valence bond, molecular orbital theory and VSEPR model of inorganic systems

CO3: Fundamentals of group theory, Application of group theory in predicting the IR and Raman active vibrational modes, orbital symmetry and chemical reactions

CO4: Trace and essential metals in biological systems

CO5: Sodium potassium pump, heme and non-heme proteins and their biological importance

Course Content:

Unit 1 **[10 Lectures]**

Brief review of the following: Periodic properties, lanthanide contraction, ionic bonding, valence bond theory and LCAO-MO theory, orbital symmetry and overlap, bond energy and covalent radii, VSEPR model and Walsh diagram, Introduction to non-covalent interaction.

Unit 2 **[16 Lectures]**

Group theory: Symmetry elements and symmetry operations, symmetry groups, molecular dissymmetry and optical activity, symmetry point groups for compounds having co-ordination number 2 to 9, Historical development of Evariste Galois theory of groups, matrix representation of groups, reducible and irreducible representation, the great orthogonality theorem, Direct product representation. Projection operator, symmetry adapted linear combination, vibrational modes as bases for group representation, symmetry selection rules for IR and Raman spectra, orbital Symmetry and Chemical reactions –Woodward and Hoffman rules for electrocyclic and cycloaddition reactions.

Unit 3 **[10 Lectures]**

Bioinorganic chemistry: scope, inorganic elements in biological systems, basic bioenergetics, active transport of cations across membranes, Na^+/K^+ pump, heme-protiens–haemoglobin and myoglobin: structure, thermodynamics and kinetics of oxygenation, Cytochrome P_{450}, Hemerythrin, Ferritin and Transferrin.

Text Book(s)

1. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M. *Advanced Inorganic Chemistry*, 6th Edn., (John Wiley, 2007).
2. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. *Inorganic Chemistry*: Principles of *Structure and Reactivity*, 4th Edn., (Pearson Education, 2006).

Reference Book(s)

1. Cotton, F.A., *Chemical Application of Group Theory,* 3rdEdn., (John Wiley & Sons, 2008).
2. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. *Bioinorganic Chemistry,* (Viva Books Pvt. Ltd. 2004).

CD 407 Principles of Organic Chemistry L 3 T 0 P 0 CR 3

Course outcomes:

After completion of the course, the learner shall be able to understand:

CO1: Understanding of structure-activity relationship of organic molecules.

CO2: Stereochemistry of organic molecules, prostereogenic elements and asymmetric synthesis.

CO3: Basic concepts of nucleophilic substitution, elimination, addition and neighbouring group participation reactions with stereochemical outcomes of products.

CO4: Chemistry of five, six and fused heterocyclic compounds

Course content:

Unit 1 **[4 Lectures]**

Structure and Bonding: Reactivity of organic molecules, aromaticity, n-annulenes and hetero-annulenes, fullerenes (C_{60}), Graphene, Cryptans, bonds weaker than covalent: addition compounds, inclusion compounds and rotaxenes.

Unit 2 **[3 Lectures]**

Thermodynamics and Kinetics: Acids and bases, concept of hard and soft acids and bases, symbiosis, labeling and kinetic isotope effects, Hammett equation, σ–ρ relationship, non-classical carbenuim ion (or carbocation), kinetic and thermodynamic control, Hammand principle, Curtin-Hammett principle, transition state and intermediates.

Unit 3 **[10 Lectures]**

Stereochemistry: Chirality and isomerism in organic system, conformational analysis of simple cyclic and acyclic systems, conformation of saturated heterocycles, interconversion of Fischer, Newman and Sawhorse formula, *E-Z* isomerism, *R-S* nomenclature, diastereomerism in acyclic and cyclic systems, newer methods of asymmetric synthesis (including enzymatic and catalytic nexus), enantio-, and diastereo selective synthesis, determination of enantiomeric and diastereomeric excess, stereospecific synthesis, effect of conformation on reactivity, methods of resolution, optical purity, optical activity in absence of chiral atom, neighbouring group participation reactions and examples involving non-classical carbocation.

Unit 4 **[8 Lectures]**

General reaction mechanism, aliphatic substitution reaction,S_N1, S_N2, mixed S_N1 and S_N2 and S_Ni reaction, SET reaction, classical and nonclassical carbocations, electrophilic substitution reaction, S_E1, S_E2, S_Ei mechanism, electrophilic and nucleophilic aromatic substitution reaction, SNAr, Benzyne, SRN^1 mechanism, reactivity, effect of substrate, leaving group and attacking nucleophile, elimination reaction, E^1 E^2 and E^1Cb, protection-deprotection chemistry of selected functional groups such as aldehydes, ketone and –OH, NH_2.

Unit 5 **[6 Lectures]**

Addition Reaction: Mechanism and stereochemical aspects of addition reaction in carbon-carbon multiple bonds, region and chemoselectivity, orientation and

reactivity, mechanism of condensation reactions involving enolates- Aldol, cross Aldol, Knoevenagel, Claisen, Perkin and Stobbe reactions.

Unit 6 **[5 Lectures]**

Heterocyclic Chemistry: π-excessive and π-deficient heterocycles, synthesis, reactions and reactivity of heterocycles, e.g. furan, thiophene, pyrrole, pyridine, pyrazoles, pyridazines, pyrimidines, isoxazoles, tetrazoles, quinoline, isoquinoline and indole, Skraup synthesis, Fischer-Indole synthesis, Vilsmeyer-Heck formylation reaction..

Text Book(s)

1. Carey, F. A. and Sundberg, R. J. *Advanced Organic Chemistry, Part A: Structure and Mechanisms,* 5thEdn., (Springer, New York, 2007).
2. Clayden, J., Greeves, N., Warren, S. andWothers, P. *Organic Chemistry*, 2ndEdn., (Oxford University Press, 2012).
3. March, J. and Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6thEdn., (Wiley, 2007).
4. Sengupta, S. *Basic Stereochemistry of Organic Molecules*, 1stEdn., (Oxford University Press, 2014).
5. Kalsi, P. S. *Stereochemistry, Conformation and Mechanism*, (New Age international Publishers, 2009).
6. Finar, I. L. *Organic Chemistry* (Volume 1), 6thEdn., (Pearson Education, 2002).

Reference Book(s)

1. Sykes, P. *A Guide Book to Mechanism in Organic Chemistry,* 6thEdn., (Longman, 1986).
2. Carey, F. A. and Sundberg, R. J. *Advanced Organic Chemistry, Part B: Reactions and Synthesis,* 5thEdn., (Springer, New York, 2007).
3. Eliel, E. L., Wilen, S. H. and Doyle, M. P. *Basic Organic Stereochemistry*, 1stEdn., (Wiley-Interscience, 2001).
4. Zweifel, G. S., Nantz, M. H. andSomfai, P. *Modern Organic Synthesis: An Introduction*, 2ndEdn.*,* (Wiley, New York, 2017).

CD-409 Laboratory Course in Organic Chemistry L 0 T 0 P 3 CR 3

Unit 1

Separation techniques of organic compounds and their spectroscopic identification.

Experiments involving the separation and purification of organic compounds from a mixture, using chromatographic techniques, steam distillation, fractional crystallization and sublimation.

Unit 2

Synthesis of organic compounds using common reagents: At least eight preparation (involving two or more than two steps) involving the following representative reactions:

(a) Oxidation of alcohol, (b) Reduction of carbonyl group, (c) Nucleophilic substitution, (d) Cycloaddition reaction, (e) Condensation reaction, (f) Aromatic electrophilic substitution, (g) Preparation of dyes, (h) Heterocyclic synthesis, (i) Solid phase synthesis etc.

Unit 3

Natural product extraction: Caffeine, Nicotine, Carotenoides etc.

Unit 4

Estimation of Glucose, acetic acid in vinegar, -OH groups etc.

Unit 5

Determination of acid value and saponification value of fat/ oil.

Unit 6

Green experiments

Text Book(s)

1. Pasto, D. and Johnson, Miller, M. *Experiments and Techniques in Organic Chemistry*, (Prentice Hall, 1992).
2. Williamson, K. L. *Macroscale and Microscale Organic Experiments*, (D. C. Heath & Company, 1999).

Reference Book(s)

1. Furniss, B. S., Ford, A. J. H., Smith, P. W. H. and Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry,* 5thEdn., (Wiley, 1989).

SEMESTER VIII

CD 402 Laboratory Course in Inorganic Chemistry L 0 T 3 P 6 CR 6

Unit 1

Quantitative estimation involving volumetric (redox and complexometry), gravimetric and spectrophotometric methods of analysis of constituents in three component mixtures, alloys and minerals.

Unit 2

Synthesis and characterization of inorganic compounds, including those involving green synthetic methodology: Characterization includes elemental analysis, studies by IR, electronic spectra, magnetic susceptibility, conductance measurements, cyclic voltammetry. TGA, DSC.

Text Book(s)

1. Mendham, J., Denney, R. C., Barnes, J. D., Thomas, M. and Sivasankar, B. *Vogel's Quantitative Chemical Analysis*, 6thEdn.*,* (Pearson Education, 2009).
2. Marr, G. and Rockett, B. W. *Practical Inorganic Chemistry*, (Van Nostrand, 1972).

Reference Book(s)

1. Wollins, J. D. *Inorganic Experiments*, 3rdEdn., (VCH, 1994).
2. Parshall, G. W. (Ed. in Chief). *Inorganic Synthesis*, *Vol. 15*, (McGraw Hill, 1974).

CD 416 History of Chemistry L3 T 0 P 3 CR 3

Course outcome:

On completion of this course, the students will be able to learn:

CO1: Develop understanding of various branches of science during different eras in different parts of the world

CO2: Analyze the role played by the science in different eras in the evolution of modern day science

CO3: Ethics in science

Course content:

Unit 1 **[10 Lectures]**

Old traditions of Chemical sciences in various countries

Ancient Technology

Medicine in the ancient times

Ayurvedic Chemistry

Alchemy

India, Islamic & Chinese Alchemy

Metal extraction in the ancient times

Fiber, cloth and dying chemistry in the ancient times

Paper and ink in ancient times

Unit 2 **[8 Lectures]**

Construction materials in the ancient times

The iron pillar of Delhi

Science & Technology in the West

Medieval and Renaissance Medicine

Unit 3 **[8 Lectures]**

Modern traditions and methods

The Chemical Revolution: From Boyle to Dalton

Priestley's discovery of dephlogisticated air

Lavoisier and oxygen

Unit 4 **[10 Lectures]**

Discoveries and Inventions in the context of state of art and impact

Development of chemistry during the industrial revolution

Development of chemistry during World War

Ethics in science

Text Book(s)

1. Brock, W. H. *The Chemical Tree: A History of Chemistry*, W. W. (Norton & Co.: New York, 2000).
2. Bell, M. S. *Lavoisier in the Year One*, (W. W. Norton & Co.: New York, 2005).

Annexure

The CBCS structure of the programme involves three different types of courses viz. Core Courses, Elective Courses and Ability Enhancement Courses. The significance of each type of course and the details of credit system is given below:

Types of Course:

i) Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

- The Core Course cannot be substituted by any other course.
- It will be offered by the Chemistry department.
- A core course offered in a discipline/subject may be treated as an elective by other discipline/subject/vice versa and such electives may also be referred to as Generic Elective.
- Dissertation/Project: A core course designed to acquire special/advanced knowledge, such as Project work/ Dissertation work is carried out by a candidate on his/her own with an advisory support from the faculty member.

ii) Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure tosome other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

- **Discipline Specific Elective (DSE) Course**: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
- **Generic Elective (GE) Course**: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective. A core course offered in a discipline/subject may be treated as

an elective by other discipline/subject/vice versa and such electives may also be referred to as Generic Elective.

iii) **Ability Enhancement Courses (AEC):** The Ability Enhancement (AE) Courses may be of two kinds

- **Ability Enhancement Compulsory Courses (AECC)**: AECC" courses are the courses based upon the content that leads to Knowledge enhancement viz. Environmental Science, English Communication/MIL Communication etc. AECC should compulsorily be studied by a candidate to complete the requirement of a degree in a said programme/ discipline of study. AECC cannot be substituted by any other course.
- **Skill Enhancement Courses (SEC):** These courses may be chosen from a pool of

  courses designed to provide value-based and/or skill-based knowledge**.**

Credit System:

- Credit defines the quantum of content/syllabus prescribed for the course. It may be a unit prescribed for a course and is determined by the number of hours of instruction required per week. Thus, in each course credits will be assigned on the basis of the number of hours required per week for lectures/tutorials/lab work/field work to complete the course in a single semester.

  1 credit = 1 hour of direct teaching per week

  1 credit = 2 hours of lab work/field work/project work per week
- A course of study may have only lecture (L) component or only practical/practice (P) component or combination of any two or all the three components. The third being Tutorial (T) component.
- The total credits earned by a student at the end of semester upon successfully completing the course is L+T+P.

Credit requirement:

Minimum Credit Requirement: 180
Minimum Duration: 08 Semesters
Maximum Duration: 12 Semesters

Semester	Total Credit	Semester	Total Credit
I	24	V	22
II	21	VI	24
III	25	VII	19
IV	22	VIII	23

The end