Syllabus Based on NEP 2020

Four Year Undergraduate Programme
in Chemistry
(*Effective from Academic Year 2023-2024*)

Bodoland University

Kokrajhar-783370, Assam, India

Four Year Undergraduate Programme (*Chemistry*) (FYUGP-Single Major)

Semester	Major	Minor	IDC	AEC	SEC	VAC	Internship	Dissertation	Total Credits
SEM-I	C-101 (4)	M-101 (4)	IDC-1 (3)	AEC-1 (2) Language/ Regional Language	SEC-1 (3)	VAC-1 (4)			20
SEM-II	C-102 (4)	M-102 (4)	IDC-2 (3)	AEC-2 (2) Language/ Regional Language	SEC-2 (3)	VAC-2 (4)			20
Exit with a Certificate (40 Credits and Internship of 4 Credits)									
SEM-III	C-201 (4) C-202 (4)	M-201 (4)	IDC-1 (3)	AEC-1 (2) Language/ Regional Language	SEC-1 (3) Hands on Training, Soft Skills etc.				20
SEM-IV	C-203 (4) C-204 (4) C-205 (4)	M-202 (4)		AEC-2 (2) Language/ Regional Language			INT-1 (2) Internship		20
Exit with a Diploma (80 Credits and Internship of 4 Credits)									
SEM-V	C-301 (4) C-302 (4) C-303 (4) C-304 (4)	M-301 (4)							20
SEM-VI	C-305 (4) C-306 (4) C-307 (4) C-308 (4)	M-302 (4)							20
Exit with a Bachelor Degree (Major) (120 Credits)									
SEM-VII	C-401 (4) C-402 (4) C-403 (4) C-404 (4)/ REM-401 (4)	M-401 (4)							20
SEM-VIII	C-405 (4)	M-402 (4)						DIS-401 (12)/ ADL-401 (4) ADL-402 (4) ADL-403 (4)	20
	80	**32**	**9**	**8**	**9**	**8**	**2**	**12**	**160**
Exit with a Bachelor Degree (Honours/Research) (160 Credits)									

Four Year Undergraduate Programme (*Chemistry*) (FYUGP-Single Major)

Semester	Major	Minor	IDC	AEC	SEC	VAC	Internship	Dissertation	Total Credits
SEM-I	CHMMAJ101-4: Fundamentals of Chemistry-1	CHMMIN101-4: Chemistry-1	CHMIDC101-3: Chemistry in Everyday Life-1	AEC-1 (2) Language/ Regional Language	CHMSEC101-3: Basic Analytical Chemistry	VAC-1(4)			20
SEM-II	CHMMAJ102-4: Fundamentals of Chemistry-2	CHMMIN102-4: Chemistry-2	CHMIDC102-3: Chemistry in Everyday Life-2	AEC-2 (2) Language/ Regional Language	CHMSEC102-3: Fuel Chemistry	VAC-2(4)			20
Exit with a Certificate (40 Credits and Internship of 4 Credits)									
SEM-III	CHMMAJ201-4: Inorganic Chemistry-1 CHMMAJ202-4: Physical Chemistry-1	CHMMIN201-4: Chemistry-3	CHMIDC201-3: Chemistry in Everyday Life-3	AEC-1 (2) Language/ Regional Language	CHMSEC201-3: Basic Instrumental Techniques in Chemistry				20
SEM-IV	CHMMAJ203-4: Inorganic Chemistry-2 CHMMAJ204-4: Organic Chemistry-1 CHMMAJ205-4: Physical Chemistry-2	CHMMIN202-4: Chemistry-4		AEC-2 (2) Language/ Regional Language			CHMINT201-2: Internship		20
Exit with a Diploma (80 Credits and Internship of 4 Credits)									
SEM-V	CHMMAJ301-4: Inorganic Chemistry-3 CHMMAJ302-4: Organic Chemistry-2	CHMMIN301-4: Chemistry-5							20

	CHMMAJ303-4: Physical Chemistry-3 CHMMAJ304-4: Computers in Chemistry								
SEM-VI	CHMMAJ305-4: Organic Chemistry-3 CHMMAJ306-4: Spectroscopy CHMMAJ307-4: Industrial Chemistry CHMMAJ308-4: Environmental Chemistry	CHMMIN302-4: Chemistry-6							20
Exit with a Bachelor Degree (Major) (120 Credits)									
SEM-VII	CHMMAJ401-4: CHMMAJ402-4: CHMMAJ403-4: CHMMAJ404-4: / CHMREM401-4: Research Methodology	CHMMIN401-4: Chemistry-7							20
SEM-VIII	CHMMAJ405-4:	CHMMIN402-4: Chemistry-8						CHMDIS401-12: Dissertation/ CHMADL401-4: CHMADL402-4: CHMADL403-4:	20
	80	**32**	**9**	**8**	**9**	**8**	**2**	**12**	**160**
Exit with a Bachelor Degree (Honours/Research) (160 Credits)									

Important Points

- ***Theory Classes*:**

  1 Credit = 15 Classes in one semester = 15 Contact hours in one semester.

- ***Tutorial Classes*:**

  1 Credit = 15 Tutorial classes in one semester = 15 Contact hours in one semester.

- ***Practical Classes*:**

  1 Credit (2 h) = 30 Contact hours in one semester.

Abbreviations

MAJ – Major

MIN – Minor

IDC – Inter Disciplinary Course

AEC – Ability Enhancement Course

SEC – Skill Enhancement Course

VAC – Value Added Course

INT – Internship

REM – Research Methodology

DIS – Dissertation

ADL – Advanced Learning

CHEMISTRY
Four Year Undergraduate Programme (FYUGP-Single Major)
Curriculum Structures
Total Credits = 160

SEMESTER-I						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ101-4	Fundamentals of Chemistry-1	3+1+0	4	70	30	100
CHMMIN101-4	Chemistry-1	3+1+0	4	70	30	100
CHMIDC101-3	Chemistry in Everyday Life-1	2+1+0	3	50	-	50
AEC-1 (2)	Language/ Regional Language	2+0+0	2	50	-	50
CHMSEC101-3	Basic Analytical Chemistry	2+1+0	3	50	-	50
VAC1014			4			100
Total		**20**	**20**			**450**

SEMESTER-II						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ102-4	Fundamentals of Chemistry-2	3+1+0	4	70	30	100
CHMMIN102-4	Chemistry-2	3+1+0	4	70	30	100
CHMIDC102-3	Chemistry in Everyday Life-2	2+1+0	3	50	-	50
AEC-1 (2)	Language/ Regional Language	2+0+0	2	50	-	50
CHMSEC102-3	Fuel Chemistry	2+1+0	3	50	-	50
VAC			4			100
Total		**20**	**20**			**450**

SEMESTER-III						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ201-4	Inorganic Chemistry-1	3+0+1	4	50+20(P)	30	100
CHMMAJ202-4	Physical Chemistry-1	3+0+1	4	50+20(P)	30	100
CHMMIN201-4	Chemistry-3	3+0+1	4	50+20(P)	30	100
CHMIDC201-3	Chemistry in Everyday Life-3	2+1+0	3	50	-	50
AEC-1 (2)	Language/ Regional Language	2+0+0	2	50	-	50
CHMSEC201-3	Basic Instrumental Techniques in Chemistry	0+0+3	3	50	-	50
Total		**20**	**20**			450

SEMESTER-IV						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ203-4	Inorganic Chemistry-2	3+0+1	4	50+20(P)	30	100
CHMMAJ204-4	Organic Chemistry-1	3+0+1	4	50+20(P)	30	100
CHMMAJ205-4	Physical Chemistry-2	3+0+1	4	50+20(P)	30	100
CHMMIN202-4	Chemistry-4	3+0+1	4	50+20(P)	30	100
AEC-1 (2)	Language/ Regional Language	2+0+0	2	50	-	50
CHMINT201-2	Internship	2	2	-	-	50
Total			**20**			500

SEMESTER-V						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ301-4	Inorganic Chemistry-3	3+0+1	4	50+20(P)	30	100
CHMMAJ302-4	Organic Chemistry-2	3+0+1	4	50+20(P)	30	100
CHMMAJ303-4	Physical Chemistry-3	3+0+1	4	50+20(P)	30	100
CHMMAJ304-4	Computers in Chemistry	3+0+1	4	50+20(P)	30	100
CHMMIN301-4	Chemistry-5	3+0+1	4	50+20(P)	30	100
Total		**20**	**20**			**500**

SEMESTER-VI						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ305-4	Organic Chemistry-3	3+0+1	4	50+20(P)	30	100
CHMMAJ306-4	Spectroscopy	3+0+1	4	50+20(P)	30	100
CHMMAJ307-4	Industrial Chemistry	3+0+1	4	50+20(P)	30	100
CHMMAJ308-4	Environmental Chemistry	3+0+1	4	50+20(P)	30	100
CHMMIN302-4	Chemistry-6	3+0+1	4	50+20(P)	30	100
Total		**20**	**20**			**500**

SEMESTER-VII						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ401-4	Inorganic Chemistry-4	3+0+1	4	50+20(P)	30	100
CHMMAJ402-4	Organic Chemistry-4	3+0+1	4	50+20(P)	30	100
CHMMAJ403-4	Physical Chemistry-4	3+0+1	4	50+20(P)	30	100
CHMMAJ404-4/ CHMREM401-4	Instrumental Methods of Chemical Analysis/Research Methodology	3+0+1	4	50+20(P)	30	100
CHMMIN401-4	Chemistry-7	3+0+1	4	50+20(P)	30	100
Total		**20**	**20**			**500**

SEMESTER-VIII						
Course Code	**Course Title**	**L+T+P**	**Credit**	**End Sem Marks**	**Internal Marks**	**Total Marks**
CHMMAJ405-4	Advanced Topics in Chemistry	3+1+0	4	70	30	100
CHMDIS401-12	Dissertation	12	12	210	90	300
CHMADL401-4	Inorganic Chemistry-5	3+0+1	4	50+20(P)	30	100
CHMADL402-4	Organic Chemistry-5	3+0+1	4	50+20(P)	30	100
CHMADL403-4	Physical Chemistry-5	3+0+1	4	50+20(P)	30	100
CHMMIN402-4	Chemistry-8	3+0+1	4	50+20(P)	30	100
Total		**20**	**20**			**500**
Students have to select any one of the following groups. **Group A**: CHMMAJ405-4, CHMADL401-4, CHMADL402-4 and CHMADL403-4. **Group B***: CHMMAJ405-4 and CHMDIS401-12 (Dissertation). ***Note:** *Group B will be offered to those students who will opt CHMREM401-4 in* 7th semester.						

SEMESTER I

Course Code: CHMMAJ101-4
Course Title: Fundamentals of Chemistry-1
Credits: 3+1+0
(Theory: 45 Hours, Tutorial: 15 Hours)
Total Marks: 100 (Theory: 70, Internal Assessment: 30)

Course Objectives: This course aims at giving students the theoretical understanding about the basic constituents of matter – atoms, ions and molecules in terms of their electronic structure and reactivity. Structure and bonding in these are to be dealt with basic quantum chemistry treatment. Idea of basic organic chemistry and stereo-chemistry will be discussed. This course also contains states of matter- gaseous, liquid and solid sates along with ionic equilibria. Idea about molecular and crystal symmetry will also be provided.

Course Outcomes: On successful completion, the students would have clear understanding of the concepts related to atomic and molecular structure, chemical bonding, periodic properties. They will learn about basic organic chemistry and stereo-chemistry and states of matter-gaseous, liquid and solid sates along with ionic equilibria. The students will also be able to demonstrate about the molecular and crystal symmetry.

Unit 1: Atomic Structure and Periodicity of Elements 15 Lectures

Atomic structure: Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de-Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

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

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

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

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

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

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

Unit 2: Basics of Organic Chemistry and Stereochemistry 15 Lectures

Basics of Organic Chemistry: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electrometric, resonance and mesomeric effects, hyperconjugation and their applications; Tautomerism; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of carbocations, carbanions, free radicals, carbenes, nitrenes and benzynes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Stereochemistry: Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Diastereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

Unit 3: Gaseous state 15 Lectures

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Recommended Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry.* Oxford, 1970
3. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
4. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
6. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
7. March, J. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. 7th Edition. Willey & Sons.

8. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
9. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
10. Puri, B.R., Sharma, L.R., Pathania, M.S. *Principles of Physical Chemistry*. Vishal Publishing Co.
11. Kapoor, K.L. *Textbook of Physical Chemistry*, (Vol-1). Mc.Graw Hill Education, 6th Edition.

Course Code: CHMMIN101-4
Course Title: Chemistry-1
Credits: 3+1+0
(Theory: 45 Hours, Tutorial: 15 Hours)
Total Marks: 100 (Theory: 70, Internal Assessment: 30)

Course Objectives: This course aims at giving students theoretical understanding about the atomic structure. Idea of basic organic chemistry and aliphatic hydrocarbons. This course contains basics of thermodynamics.

Course Outcomes: On successful completion, students would have clear understanding of the atomic structure, basic organic chemistry and aliphatic hydrocarbons and basics of thermodynamics.

Unit 1: Atomic Structure **15 Lectures**

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

Unit 2: Fundamentals of organic chemistry and aliphatic hydrocarbons
15 Lectures

Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.
Alkenes: Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule). Reactions: cis-addition (alkaline $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis.
Alkynes: Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, oxidation with hot alkaline $KMnO_4$.

Unit 3: Chemical Thermodynamics 15 Lectures

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.
Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.
Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Recommended Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry.* Oxford, 1970
3. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
4. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
6. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
7. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
8. Puri, B.R., Sharma, L.R., Pathania, M.S. *Principles of Physical Chemistry*. Vishal Publishing Co.
9. Kapoor, K.L. *Textbook of Physical Chemistry*, (Vol-2). Mc.Graw Hill Education, 6th Edition.

Course Code: CHMIDC101-3
Course Title: Chemistry in Everyday Life-1
Credits: 2+1+0
(Theory: 30 Hours, Tutorial: 15 Hours)
Total Marks: 50 (Theory: 50)

Course Objectives: This course aims at giving students preliminary ideas of chemistry of medicine, food additives, preservatives and biomolecules.

Course Outcomes: On successful completion, students would have basic ideas of chemistry involved in medicine, sweeteners, flavours, colours and preservatives in food science and different aspects of biomolecules.

Unit 1: Chemistry in medicine **8 Lectures**

Antacid, antipyretics, analgesic, antibacterial, antibiotics, antiallergic, antidiabetic, anti-hypertensives and anaesthetics. (*Structure not necessary*)

Unit 2: Food additives and preservation **8 Lectures**

Artificial sweeteners, food flavours, food colours, food preservation with examples. (*Structure not necessary*)

Unit 3: Biomolecules **14 Lectures**

Carbohydrates: Definition, source and uses of Glucose, Lactose, Sucrose, Starch, Cellulose.
Amino acids: Definition, essential and non-essential amino acids, and their importance.
Vitamin: Definition, classification, sources and their deficiency diseases.
(*Structure not necessary*)

Recommended Books:

1. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's Illustrated Biochemistry.* XXVIII edition. Lange Medical Books/ McGraw-Hill.
2. Sen, M. (2021). Food chemistry: role of additives, preservatives, and adulteration. *Food Chemistry: The Role of Additives, Preservatives and Adulteration*. Willey & Sons.
3. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.
4. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.*, W. H. Freeman.

Course Code: CHMSEC101-3
Course Title: Basic Analytical Chemistry
Credits: 2+1+0
(Theory: 30 Hours, Tutorial: 15 Hours)
Total Marks: 50 (Theory: 50)

Course Objectives: To familiarize students with different micro and semi-micro analytical techniques and help develop the ability to use modern instrumental methods for chemical analysis of food, soil, air and water.
Course Outcomes: Upon completion of this course, students shall be able to explain the basic principles of chemical analysis, design/implement microscale and semi-micro experiments, record, interpret and analyse data following scientific methodology.

Unit 1: Introduction to Analytical Chemistry and its interdisciplinary nature
8 Lectures

Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements (with problem-based examples). Presentation of experimental data and results, from the point of view of significant figures.

Unit 2: Analysis of soil **8 Lectures**

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators. Determination of pH of soil samples.

Unit 3: Analysis of water **14 Lectures**

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. (a) Determination of pH, acidity and alkalinity of a water sample. (b) Determination of dissolved oxygen (DO) of a water sample.
Demonstration of

1. pH meter
2. Conductometer
3. Potentiometer
4. DO meter
5. Flame photometer
6. UV-Vis spectrophotometer

Recommended Books:

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

6. Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India, 1992.
7. Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7thEd.,* Prentice Hall, 1996.
8. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6thEd.,* Pearson, 2009.
9. Robinson, J.W. *Undergraduate Instrumental Analysis 5thEd.*, Marcel Dekker, Inc., New York (1995).
10. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

SEMESTER II

Course Code: CHMMAJ102-4
Course Title: Fundamentals of Chemistry-2
Credits: 3+1+0
(Theory: 45 Hours, Tutorial: 15 Hours)
Total Marks: 100 (Theory: 70, Internal Assessment: 30)

Course Objectives: This course aims at giving students theoretical understanding about the chemical bonding, liquid and solid state and hydrocarbon.
Course Outcomes: On successful completion, students would have clear understanding of the concepts related to Ionic and covalent bond. They will learn about the solid and liquid state of matter and aliphatic and aromatic hydrocarbons.

Unit 1: Chemical Bonding 14 Lectures

(i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.
(ii) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Types of hybridization (involving s, p and d orbitals). Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Unit 2: Liquid and solid-state 14 Lectures

Liquid state: Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing

action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

Unit 3: Hydrocarbon **17 Lectures**

Carbon-Carbon sigma bonds Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Corey-House reaction, Free radical substitutions: Halogenation - relative reactivity and selectivity.

Carbon-Carbon pi bonds: Formation of alkenes by elimination reactions, Wittig reaction, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4-addition reactions in conjugated dienes, and Diels-Alder reaction; Allylic and benzylic bromination by NBS and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Preparation of alkynes. Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, reduction of alkynes. Alkylation of terminal alkynes.

Cycloalkanes and Conformational Analysis: Types of cycloalkanes and their relative stability, Baeyer strain theory. Conformation analysis of alkanes, Relative stability and Energy profile diagrams. Cyclohexane: Chair, Boat and Twist boat forms, relative stability with energy profile diagrams.

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

Recommended Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry.* Oxford, 1970
3. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
4. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
6. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
7. March, J. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. 7th Edition. Willey & Sons.

8. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
9. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
10. Puri, B.R., Sharma, L.R., Pathania, M.S. *Principles of Physical Chemistry*. Vishal Publishing Co.
11. Kapoor, K.L. *Textbook of Physical Chemistry*, (Vol-1). Mc.Graw Hill Education, 6th Edition.

Course Code: CHMMIN102-4
Course Title: Chemistry-2
Credits: 3+1+0
(Theory: 45 Hours, Tutorial: 15 Hours)
Total Marks: 100 (Theory: 70, Internal Assessment: 30)

Course Objectives: This course aims at giving students theoretical understanding about the periodicity of elements, stereochemistry and kinetic theory of gases.
Course Outcomes: On successful completion, students would have clear understanding of the concepts related to periodicity of elements, stereochemistry and kinetic theory of gases.

Unit 1: Periodicity of Elements **14 Lectures**

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s and p-block.
(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
(b) Atomic radii (van der Waals)
(c) Ionic and crystal radii.
(d) Covalent radii (octahedral and tetrahedral)
(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
(f) Electron gain enthalpy, trends of electron gain enthalpy.
(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

Unit 2: Stereochemistry **14 Lectures**

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism, Racemic mixture and Meso compounds). Threo and erythro; D and L; cis-trans nomenclature; CIP Rules: R/S (for upto 2 chiral carbon atoms) and E/Z Nomenclature.

Unit 3: Kinetic Theory of Gases **17 Lectures**

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

Recommended Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry.* Oxford, 1970
3. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
4. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
6. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
7. Puri, B.R., Sharma, L.R., Pathania, M.S. *Principles of Physical Chemistry*. Vishal Publishing Co.
8. Kapoor, K.L. *Textbook of Physical Chemistry*, (Vol-1). Mc.Graw Hill Education, 6th Edition.

Course Code: CHMIDC102-3
Course Title: Chemistry in Everyday Life-2
Credits: 2+1+0
(Theory: 30 Hours, Tutorial: 15 Hours)
Total Marks: 50 (Theory: 50)

Course Objectives: This course aims at giving students preliminary ideas of Chemistry of household materials, polymers and rubbers, chemicals used in agriculture.

Course Outcomes: On successful completion, students would have basic ideas of Household materials, Polymers and rubbers, Chemicals used in Agriculture.

Unit 1: Chemistry of Household materials **15 Lectures**

Soap and detergent – definition, composition and uses. Disinfectants – antiseptic (Dettol, Savlon), hand and surface sanitizer, and surface cleaner.

LPG, CNG, Cooling gases (CFC, HFC), perfumes, deodorant, and talc.

Biogas (Gobar gas) and its production.

Unit 2: Polymers and rubbers **8 Lectures**

Basic definitions and uses of polythene, PVC, nylon, Teflon, Bakelite, melamine, polyester.
Rubber – types, sources and uses.
Biodegradable and non-biodegradable polymers – definition and example.

Unit 3: Chemicals used in Agriculture **7 Lectures**

Chemical Fertilizers – urea, superphosphate, ammonium nitrate, DAP, NPK.
Organic fertilizer – manure, vermicompost.
Definition, examples and uses of pesticides, insecticides, herbicides, and fungicides.

Recommended Books:

1. Handbook on Soaps, Detergents & Acid Slurry (3rd revised edition)
2. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
3. *De, A.K. Environmental Chemistry*; Edition, 8; Publisher, New Age International (P) Limited.
4. Das, B.K., Hoque, M., Dhar, A. *Fuel Chemistry*. Union Book Publication, Pan Bazar, Guwahati-1.

Course Code: CHMSEC102-3
Course Title: Fuel Chemistry
Credits: 2+1+0
(Theory: 30 Hours, Tutorial: 15 Hours)
Total Marks: 50 (Theory: 50)

Course Objectives: This course discusses about the chemistry of various sources of energy. Students are expected to learn about the composition of coal and petroleum products, their extraction, purification methods and usage. A section also covers classification and applications of natural and synthetic lubricants. Students will also learn about the determination and significance of various industrially relevant physical parameters for different fuels and lubricants.

Course Outcomes: At the end of this course students will learn about the classes of renewable and non-renewable energy sources. Students will learn about the composition of coal and crude petroleum, their classification, isolation of coal and petroleum products and their usage in various industries. They will also learn to determine industrially significant physical parameters for fuels and lubricants.

Unit 1: Review of energy sources **6 Lectures**

Renewable and non-renewable. Classification of fuels and their calorific value. Numerical problems based on calorific value.

Unit 2: Coal **10 Lectures**

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

Unit 3: Petroleum, petrochemical industry and lubricants **14 Lectures**

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

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

Recommended Books:

1. Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai& Sons, Delhi.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).
4. Das, B.K., Hoque, M., Dhar, A. *Fuel Chemistry*. Union Book Publication, Pan Bazar, Guwahati-1.

SEMESTER III

Course Code: CHMMAJ201-4
Course Title: Inorganic Chemistry-1
Credits: 3+0+1
(Theory: 45 Hours, Practical: 30 Hours)
Total Marks: 100 (Theory: 50, Practical: 20, Internal Assessment: 30)

***Course Objectives*:** This course starts with the periodic behaviour of s and p block elements related to their electronic structure and their reactivity is included to acquaint students with the principles governing their reactivity. Concepts of protonic and non-protonic acids and bases are introduced for students to appreciate different types of chemical reactions. This course further intends to apprise students about the variety of compounds of the main group elements including oxides, hydrides, nitrides, interhalogens, noble gases and inorganic polymers.

As part of the accompanying lab course, experiments involving acid-base and redox titrations are included for the students to explore other varieties of redox titration.

***Course Outcomes*:** On successful completion of this course, students would be able to identify the variety of s and p block compounds and comprehend their preparation, structure, bonding, properties and uses. They will also be able to apply the concept of acids and bases in inorganic applications. Students will also be equipped with noble gases and inorganic polymer.
Experiments in this course will boost their quantitative estimation skills and precautions involved in titrations.

Unit 1: Chemistry of *s* and *p* Block Elements 15 Lectures

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Unit 2: Acids and Bases 6 Lectures

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB). Application of HSAB principle.

Unit 3: Noble Gases 6 Lectures

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

Unit 4: Inorganic Polymers 6 Lectures

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

Recommended Books:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of*
3. *Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
4. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*,
5. Butterworth-Heinemann. 1997.
6. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
7. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India
8. Edition, 2002.
9. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010.

10. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).
11. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
12. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed., Pearson Education India, 2006.

Inorganic Chemistry-1 LAB – CHMMAJ201-4, 30 Hours

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

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

(B) Acid-Base Titrations

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

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

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

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe (II) and oxalic acid using standardized $KMnO_4$ solution.

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

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

Recommended Books:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Pearson, 2009
2. Baruah, S. Practical Chemistry. Kalyani Publishers.

Course Code: CHMMAJ202-4
Course Title: Physical Chemistry-1
Credits: 3+0+1
(Theory: 45 Hours, Practical: 30 Hours)
Total Marks: 100 (Theory: 50, Practical: 20, Internal Assessment: 30)

***Course Objectives*:** In this course, chemical thermodynamics, and chemical equilibrium will be taught to the students. Experiment-based knowledge of properties of solutions like surface tension, viscosity, and pH-metry will be provided.

***Course Outcomes*:** In this course, the students will learn laws of thermodynamics, thermochemistry, thermodynamic functions, relations between thermodynamic properties, Gibbs Helmholtz equation, Maxwell relations, etc. Moreover, the students are expected to learn ionic equilibria, the acidic and basic nature of the solution, pH measurement, buffer solution, their applications, and related numerical calculation. They will also learn about the quantitative

estimation of solutions. Students are expected to gather experimental knowledge of properties of solutions like surface tension, viscosity, and pH-metry.

Unit 1: Chemical Thermodynamics 1 **15 Lectures**

Definition of thermodynamic terms, closed, open and isolated system; surroundings, energy, heat, work, internal energy. The first law, calculation of work done during expansion of gas, thermodynamic reversibility, heat capacity, enthalpy and its significance, significance of heat and work. State functions and differentials; variation of internal energy and enthalpy with temperature, Joule-Thomson experiment and liquefaction of gases; relation between Cp and C_V; Calculation of work done on adiabatic expansion; relation between P, V and T in adiabatic processes. Thermochemistry- standard enthalpy changes, derivation of Hess's law and Kirchhoff's law. Relation of reaction enthalpy with changes in internal energy. Calculation of bond dissociation energies from thermochemical data.

Unit 2: Chemical Thermodynamics 2 **15 Lectures**

The second law, entropy changes in reversible and irreversible processes. Clausius inequality, calculation of entropy changes during various processes. Helmholtz function and Gibb's function and the direction of spontaneous change. Thermodynamics of chemical reactions - Equilibrium constant of a reaction in terms of standard Gibb's function, dependence of equilibrium constant of temperature and pressure. Standard entropy of a reaction and standard Gibbs function of formation. Maxwell's relations and derivation of thermodynamic equation of state; Gibb's-Helmholtz equation, variation of Gibb's function with pressure and temperature. A brief idea of partial molar quantity, chemical potential, and Gibb's-Duhem equation. Third law of thermodynamics – Nernst heat theorem.

Unit 3: Ionic equilibria **15 Lectures**

Strong, moderate, and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids.

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

Recommended Books:

1. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
2. Puri, B.R., Sharma, L.R., Pathania, M.S. *Principles of Physical Chemistry*. Vishal Publishing Co.
3. Kapoor, K.L. *Textbook of Physical Chemistry*. Mc.Graw Hill Education, 6th Edition.
4. Negi, A. S. Anand, S. C. A Textbook of Physical Chemistry. New Age International.

Physical Chemistry-1 LAB – CHMMAJ202-4, 30 Hours

1. **Surface tension measurements**
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
   b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer**
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
   b. Study the variation of viscosity of sucrose solution with the concentration of solute.

3. pH metry

   a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   b. Preparation of buffer solutions of different pH
      i. Sodium acetate-acetic acid
      ii. Ammonium chloride-ammonium hydroxide
   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
   d. Determination of dissociation constant of a weak acid.

Recommended Books:

1. Yadav, J.B. Advanced Practical Physical Chemistry. Krishna Publication.
2. Baruah, S. Practical Chemistry. Kalyani Publishers

Course Code: CHMMIN201-4
Course Title: Chemistry-3
Credits: 3+0+1
(Theory: 45 Hours, Practical: 30 Hours)
Total Marks: 100 (Theory: 50, Practical: 20, Internal Assessment: 30)

Course Objectives: This course aims at giving students theoretical understanding about the chemical bonding and aromatic hydrocarbon. This course contains also basics concept of liquid and solid.

Course Outcomes: On successful completion, students would have clear understanding of the chemical bonding of compounds, electrophilic aromatic substitution, properties of liquid and structure of solid. The students will also get idea of volumetric analysis.

Unit 1: Chemical Bonding **15 Lectures**

(i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Lattice energy. Born-Haber cycle and its application, Solvation energy.

(ii) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Types of hybridization (involving s, p and d orbitals). Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, F_2, CO, and HCl. Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Unite 2: Aromaticity and Aromatic Hydrocarbons 15 Lectures

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

Directive influence of activating and deactivating groups in aromatic electrophilic substitution reaction.

Unit 3: Liquids and Solids 15 Lectures

Liquid state: Physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of soap and detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Solid state: Nature of the solid state, classification of crystalline solid, crystal lattice and unit cell, Miller indices, seven crystal systems and fourteen Bravais lattices; closed packed structure and packing efficiency, X-ray diffraction, Bragg's law. Defects in crystalline solids.

Recommended Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry.* Oxford, 1970
3. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
4. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
6. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
7. March, J. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. 7th Edition. Willey & Sons.
8. Kalsi, P. S. *Stereochemistry Conformation and Mechanism,* New Age International, 2005.
9. Atkins, P.W. & Paula, J. *Physical Chemistry,* 10th Ed., Oxford University Press, 2014.

10. Puri, B.R., Sharma, L.R., Pathania, M.S. *Principles of Physical Chemistry*. Vishal Publishing Co.
11. Kapoor, K.L. *Textbook of Physical Chemistry*, (Vol-1). Mc.Graw Hill Education, 6th Edition.

Chemistry-3 LAB – CHMMIN201-4, 30 Hours

Inorganic Chemistry - Volumetric Analysis

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

Recommended Books:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Pearson, 2009
2. Baruah, S. Practical Chemistry. Kalyani Publishers.

Course Code: CHMIDC201-3
Course Title: Chemistry in Everyday Life-3
Credits: 2+1+0
(Theory: 30 Hours, Tutorial: 15 Hours)
Total Marks: 50

Course Objectives: This course aims at giving students preliminary ideas of Chemistry of environmental pollution and related issues including health impacts of metals on human health.
Course Outcomes: On successful completion, students would have basic ideas of the chemicals responsible for environmental pollution, dos and dons for protection of environmental related issues. They will also have the basic idea of the importance and impact of metals on human health.

Unit 1: Environmental Pollution 12 Lectures

Definition, Causes, effects and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution, and thermal pollution.
Role of an individual in prevention of pollution. Pollution case studies. Disaster management – floods, earthquake, cyclone and landslides.

Unit 2: Issues related to Environment 12 Lectures

From Unsustainable to Sustainable development. Urban problems related to energy. Water conservation. Rain water harvesting, watershed management, Environmental ethics: issues and possible solutions. Climate change – global warming, acid rain, ozone layer depletion. nuclear accidents - case studies. Wasteland reclamation.

Unit 3: Impacts of some elements in human health 6 Lectures

Role of sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), iron (Fe), cobalt (Co), copper (Cu), and zinc (Zn) in human health.

Toxicity due to mercury (Hg), lead (Pb), cadmium (Cd), arsenic (As) and fluoride.

Importance of metal salts in diet.

Recommended Books:

1. *De, A.K. Environmental Chemistry*; Edition, 8; Publisher, New Age International (P) Limited.
2. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
3. S.E. Manahan, Environmental Chemistry, CRC Press (2005).

Course Code: CHMSEC201-3

Course Title: Basic Instrumental Techniques in Chemistry

Credits: 0+0+3

(Practical: 90 Hours)

Total Marks: 50

Course Objectives: This course introduces the basic ideas about the various equipment in common chemistry laboratory. The course will also discuss about the electronic equipment's used in chemistry and as well as handling of sophisticated equipment's.

Course Outcomes: At the end of this course, students will learn about the different equipment's used in common chemistry laboratories. They will also be equipped with the knowledge of electronic equipment's used in chemistry for chemical analysis. The students will also learn about handling of sophisticated equipment's and software's used in chemistry.

Unit 1: Common Laboratory Equipment 30 Hours

Melting point apparatus, electronic balance, viscometer, stalagmometer, pycnometer, separating funnel, distillation apparatus, Soxhlet apparatus, Kipps apparatus, centrifuge Machin, suction apparatus.

Unit 2: Basic Electronic Equipment 30 Hours

Conductometer, pH meter, potentiometer, polarimeter, magnetic stirrer, calorimeter, hot plate, hot air oven, muffle furnace, DO meter.

Unit 3: Handling of sophisticated Equipment 30 Hours

Flame photometer, UV-Vis spectrophotometer, IR spectrophotometer, Dean stark apparatus, Vacuum Rotary Evaporator, colorimeter, computer software (Chemdraw, origin, excel, etc.)

Recommended Books:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Pearson, 2009
2. Baruah, S. Practical Chemistry. Kalyani Publishers.
3. Yadav, J.B. Advanced Practical Physical Chemistry. Krishna Publication.

SEMESTER IV

Course Code: CHMMAJ203-4
Course Title: Inorganic Chemistry-2
Credits: 3+0+1
(Theory: 45 Hours, Practical: 30 Hours)
Total Marks: 100 (Theory: 50, Practical: 20, Internal Assessment: 30)

***Course Objectives*:** This course introduces students to transition elements, metallurgy of transition elements and coordination chemistry. Various aspects like nomenclature, structure, bonding, variety and reactivity of the coordination compounds are included for the students to learn.

As part of the accompanying lab course, experiments involving iodo- and iodi-metric titrations are included for the students to explore other varieties of redox titration. Preparation of simple inorganic compounds is incorporated to give hands-on experience of inorganic synthesis.

***Course Outcomes*:** On successful completion, students will be able to gain the idea of general trends in the properties of transition elements in the periodic table and identify differences among the rows. The students will also learn about various aspects of metallurgy. Students will be able to name coordination compounds according to IUPAC, explain bonding in this class of compounds, understand their various properties in terms of CFSE and predict reactivity.

Through the experiments, students not only will be able to estimate and prepare inorganic compounds but also will be able to design experiments independently which they would be able to apply if and when required.

Unit 1: Transition Elements **15 Lectures**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Frost diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co (Chemistry of first -row transition elements) in various oxidation states as halides, oxides, hydroxides.

Unit 2: Metallurgy of elements of First Transition Series **8 Lectures**

Chief modes of occurrence of metals based on standard electrode potentials. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

Unit 3: Coordination Chemistry-1 **7 Lectures**

Coordination compounds, types of ligands, Werner's theory, IUPAC nomenclature and isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers.

Unit 3: Coordination Chemistry-2 **15 Lectures**

Valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δ_o, Δ_t). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspects of ligand field and MO Theory. Chelate effect, polynuclear complexes, labile and inert complexes.

Recommended Books

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of*
3. *Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
4. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*,
5. Butterworth-Heinemann. 1997.
6. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
7. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
8. Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
9. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010.
10. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).
11. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
12. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed., Pearson Education India, 2006.

Inorganic Chemistry-2 LAB - CHMMAJ203-4, 30 Hours

(A) Iodo / Iodimetric Titrations

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

(ii) Estimation of (i) arsenic and (ii) antimony in tartar-emetic iodimetrically

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

(B) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2

(ii) Preparation of Manganese (III) phosphate, $MnPO_4.H_2O$

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

Recommended Books:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6thEd.,* Pearson, 2009.
2. Baruah, S. Practical Chemistry. Kalyani Publishers.
3. Raj, G. Advance Practical Inorganic Chemistry. Goel Publishing House.

Course Code: CHMMAJ204-4
Course Title: Organic Chemistry-1
Credits: 3+0+1
(Theory: 45 Hours, Practical: 30 Hours)
Total Marks: 100 (Theory: 50, Practical: 20, Internal Assessment: 30)

***Course Objectives*:** The aim of this course is to teach students the important aspects of halogenated hydrocarbons, alcohols, phenols, ethers, epoxides, carbonyl compounds and carboxylic acids.

***Course Outcomes*:** The students are expected to learn preparation, properties and reactions of halogenated hydrocarbons, alcohols, phenols, ethers and epoxides, carbonyl compounds and carboxylic acids. They will also learn certain name reactions and reaction mechanisms. After attending this course, the students will be able to understand and demonstrate the concepts of organic chemistry and reactions of organic compounds. After studying the lab course of this paper, students will be able to detect of extra elements present in organic compounds, perform functional group test for nitro, amine and amide groups, and further, they will be able to perform qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds).

Unit 1: Chemistry of Halogenated Hydrocarbons 10 Lectures

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unite 2: Alcohols, Phenols, Ethers and Epoxides 10 Lectures

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. *Phenols:* Preparation and properties; Acidity

and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

Unit 3: Carbonyl Compounds 15 Lectures

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, Meerwein-Ponndorf-Verley Reduction, oxidations and reductions (Zn-Hg/HCl, Hydrazine /NaOH, $LiAlH_4$, $NaBH_4$, SeO_2, PDC and PCC). Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Unit4: Carboxylic Acids and their Derivatives 10 Lectures

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

Recommended Books:

1. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
2. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
3. March, J. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. 7th Edition. Willey & Sons.
4. Bruice, P.Y. Organic Chemistry. Pearson. 8th Edition.
5. Caruthers, W, Coldham, I. Modern Method of Organic Synthesis. Cambridge University Press; 4th edition.

Organic Chemistry-1 LAB – CHMMAJ204-4, 30 Hours

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)
4. Determination of melting/boiling of organic sample.
5. Preparation of derivatives of simple organic functional group and determination of melting point.

Recommended Books:

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

Course Code: CHMMAJ205-4
Course Title: Physical Chemistry-2
Credits: 3+0+1
(Theory: 45 Hours, Practical: 30 Hours)
Total Marks: 100 (Theory: 50, Practical: 20, Internal Assessment: 30)

***Course Objectives*:** In this course, the chemical equilibrium, conductance, and phase equilibria will be taught to the students. Experiment based knowledge of thermochemistry will be taught in the lab course.

***Course Outcomes*:** In this course, the students are expected to learn about chemical thermodynamics, conducting properties of solution, transference number, their determination, application of conductance measurement and conductometric titrations, and hydrolysis of salts. They will also learn about phase transition and phase equilibria, the derivation of various relations related to phase equilibria, and their applications. It is also expected that the students will learn about lab-based knowledge of thermochemistry.

Unit 1: Chemical Equilibrium **15 Lectures**

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

Unit 2: Conductance **15 Lectures**

Conductance Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar

conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

Unit 4: Phase Equilibria **15 Lectures**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

Physical Chemistry-2 LAB – CHMMAJ205-4, 30 Hours

Thermochemistry

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

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

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

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

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

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

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

Recommended Books

1. Khosla, B. D.; Garg, V. C. &Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).
3. Yadav, J.B. Advanced Practical Physical Chemistry. Krishna Publication.
4. Baruah, S. Practical Chemistry. Kalyani Publishers.

Course Code: CHMMIN202-4
Course Title: Chemistry-4
Credits: 3+0+1
(Theory: 45 Hours, Practical: 30 Hours)
Total Marks: 100 (Theory: 50, Practical: 20, Internal Assessment: 30)

Course Objectives: This course aims at giving the students theoretical knowledge about the chemistry of *s* and *p* block elements, alkyl and aryl halide, chemical kinetics and catalyst.
Course Outcomes: On successful completion, students would have clear understanding of the properties of s- and p block elements present in periodic table, halogenated hydrocarbons and kinetics of reaction and catalysis. The students will get idea on the analysis of organic compounds.

Unit 1: Chemistry of *s* and *p* Block Elements 15 Lectures
Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements. Hydrides and their classification ionic, covalent and interstitial. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Unit 2: Chemistry of Halogenated Hydrocarbons 15 Lectures
Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.
Aryl halides: Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit 3: Chemical Kinetics and catalysis 15 Lectures
Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, derivation of zero and first order rate law equation, Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates.
Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Homogenous and heterogenous catalysis reactions, Enzyme catalysis, acid-base catalysis.

Recommended Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry.* Oxford, 1970
3. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
4. Puri, B.R., Sharma, L.R., Kalia, K.C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
6. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
7. March, J. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. 7th Edition. Willey & Sons.
8. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
9. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
10. Puri, B.R., Sharma, L.R., Pathania, M.S. *Principles of Physical Chemistry*. Vishal Publishing Co.
11. Kapoor, K.L. *Textbook of Physical Chemistry,* (Vol-1). Mc.Graw Hill Education, 6th Edition.

Chemistry-4 LAB – CHMMIN202-4, 30 Hours

1. Qualitative analysis of organic sample-

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

b. Identification of functional group.

2. Purification of organic compounds by crystallization (from water and alcohol) and distillation.

Recommended Books:

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

CHMINT201-2 (Internship)
Credit: 2
Total Marks: 50

Syllabi of the remaining semesters will be incorporated in the coming days.

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