SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

(Deemed to be University)

Syllabus for

B.Sc (Hons.) in Chemistry

Prasanthi Nilayam – 515134

Anantapur District, Andhra Pradesh

Ph: +91 8555 287239 Fax: +91 855 286919

Website: www.sssihl.edu.in Email: registrar@sssihl.edu.in

Syllabus for Three Year B.Sc. (Hons.) in Chemistry

Programme Objectives:

- In the first two years of study, two combinations such as (Biosciences and Chemistry) OR Mathematics, Physics and Chemistry are taught
- In the third year, the subject (students will take courses in only that subject) of specialization will determine the final degree awarded: B.Sc. (Hons.) in Chemistry

Honours in Chemistry (Year 3): The emphasis is on teaching the fundamental principles of Chemistry that cover topics under each of the major branches of Chemistry such as Inorganic, Organic and Physical, and giving training in appropriate experimental methods. Electives (including interdepartmental) are being introduced for Chemistry Honours students that enable the incorporation of emerging fields into the syllabus as and when the need arises. The graduating student will be exposed to almost every aspect of the subject - Theoretical, Applied, Instrumental, Computational and Experimental.

Programme Specific Objectives:

The three-year course leading to a B.Sc (Hons.) degree in Chemistry will consist of fourteen papers in chemistry spread over three years. During the first two years, that is, the first four semesters, chemistry will be one of a combination of three subjects (Physics, Mathematics and Chemistry or Botany, Zoology and Chemistry) of equal weightage with regard to number of credits. During this period all aspects of different branches of Chemistry will be covered in a manner so that the students get as complete a picture as possible of the range and depth of the subject without going too much into details. After four semesters students can choose one of the specific area of specialization such as Mathematics, Physics, Chemistry, Biosciences etc. Students who opt for chemistry specialization will be exposed to advanced papers in organic, inorganic and physical chemistry, in the fifth and sixth semesters. The emphasis is on teaching the fundamental principles and giving training in appropriate experimental methods. The objective is to bring under one cover related topics conventionally treated under each of the major branches of chemistry such as Inorganic, Organic and Physical, so that the students realize that the subject is one and governing principles are the same. In the fifth and sixth semesters electives are being introduced in order to enable the incorporation of emerging fields into the syllabus. Also a project has been introduced in the fifth and sixth semester to introduce students to the nuances of scientific research. A student graduating with Honours degree in chemistry would have been exposed to almost every aspect of the subject - Theoretical, Applied, Instrumental, Computational and Experimental.

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DEPARTMENT OF CHEMISTRY

Undergraduate Honours Programme Structure consists of Three Parts.

PART-I: LANGUAGES #

(a) General English (four papers offered, one each in the first four semesters)
(b) Another Language (four papers offered, one each in the first four semesters – Any one out of: HINDI / SANSKRIT / TELUGU / ADDITIONAL ENGLISH)

PART-II: CORE SUBJECTS

(Offered in all the six semesters) – Title of the papers are given below in the Scheme of Instruction & Evaluation and the syllabus contents are enclosed.

Part-II consists of three-subject-combination during the first four semesters, which, each student has to study. Three Subject combinations that are offered in the Honours Programme are Mathematics/Physics/Chemistry and Biosciences/Chemistry). During the fifth and sixth semesters the students will choose one of the three subjects from the three-subject-combination as subject of exclusive study for Honours. (i.e., either MATHEMATICS or PHYSICS or CHEMISTRY or BIOSCINCES).

PART-III: AWARENESS COURSE and ENVIRONMENTAL COURSE ##

a) Awareness Courses – (six papers offered, one each in all the six semesters)
b) Environmental Courses – (two papers offered, one each in the first two semesters)

NOTE: The title of the papers and the syllabus contents of Part-I and Part-III are provided separately.

SCHEME OF INSTRUCTION AND EVALUATION

B.Sc. (HONOURS) in CHEMISTRY

(Effective 2018 batch onwards)

PART-I: LANGUAGES

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UGEN-101	General English-I #	**5**	5	IE1	T	100
	Another Language-I #	**4**	4	IE1	T	100
Semester II						
UGEN-201	General English-II #	**5**	5	IE1	T	100
	Another Language-II #	**4**	4	IE1	T	100
Semester III						
UGEN-301	General English-III #	**5**	5	IE1	T	100
	Another Language-III #	**4**	4	IE1	T	100
Semester IV						
UGEN-401	General English-IV #	**5**	5	IE1	T	100
	Another Language-IV #	**4**	4	IE1	T	100
	PART-I TOTAL	**36** credits	**36** hours			**800** Marks

PART-II: CORE SUBJECT (Honours in Chemistry)

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Types of Papers	Maximum Marks
Semester I						
UCHM-101	Principles of Structure and Bonding	**3**	3	IE1	T	100
UCHM-102	Laboratory Course in General Chemistry	**1**	3	I	P	50
		4 credits	**6** hours			**150** Marks
Semester II						
UCHM-201	Chemical Thermodynamics	**3**	3	IE1	T	100
UCHM-202	Laboratory Course on Titrimetry and Thermodynamics	**1**	3	I	P	50
		4 credits	**6** hours			**150** Marks
Semester III						
UCHM-301	Chemical Kinetics and Equilibria	**4**	4	IE1	T	100
UCHM-302	Laboratory Course on Chemical Kinetics and Equilibria	**1**	3	I	P	50
		5 Credits	**7** hours			**150** Marks
Semester IV						
UCHM-401	Chemistry of Organic Functional Groups	**4**	4	IE1	T	100
UCHM-402	Laboratory Course on Methods and Synthesis in Organic Chemistry	**1**	3	I	P	50
		5 credits	**7** hours			**150** Marks
Semester V						
UCHM-501	Chemistry of Elements	**3**	3	IE1	T	100
UCHM-502	Applications of Thermodynamics and Surface Chemistry	**3**	3	IE1	T	100
UCHM-503	Dynamic Aspects of Organic Chemistry	**3**	3	IE1	T	100
UCHM-504	Chemistry of Biological Molecules	**3**	3	IE1	T	100
UCHM-505 (E-I) (OR)	Quantum Chemistry (OR)	**2**	2	IE1	T	50
UCHM-505 (E-II)	Environmental and Green Chemistry	**2**	2	IE1	T	50
UCHM-506	Laboratory Course in Inorganic and Physical Chemistry	**2**	6	I	P	50
UCHM-507	Laboratory Course in Organic Chemistry and Biochemistry	**2**	6	I	P	50
UCHM-508	Project / Laboratory Course in Computer Applications – I	**2**	4	I	PW/P	50
		20 credits	**30** hours			**600** Marks
Semester VI						
UCHM-601	Advanced Inorganic Chemistry	**3**	3	IE1	T	100
UCHM-602	Analytical Chemistry	**3**	3	IE1	T	100
UCHM-603	Synthetic Organic Chemistry	**3**	3	IE1	T	100
UCHM-604	Applications of Spectroscopy	**3**	3	IE1	T	100
UCHM-605 (E-I) (OR)	Theoretical Aspects of Spectroscopy	**2**	2	IE1	T	50

UCHM-605 (E-II)	Materials of Industrial Importance	**2**	2	IE1	T	50
UCHM-606	Laboratory Course in Inorganic and Analytical Chemistry	**2**	6	I	P	50
UCHM-607	Laboratory Course in Synthetic Organic Chemistry and Spectroscopic Techniques	**2**	6	I	P	50
UCHM-608	Project / Laboratory Course in Computer Applications – II	**2**	4	I	PW/P	50
		20 credits	**30** hours			**600** Marks

PART-II TOTAL (Honours in Chemistry)	**58** credits	**86** hours		**1800** Marks

NOTE:
Nature of project: An exploratory study on a topic of any branch of chemistry which involves experimentation or computational work.
Mode of evaluation of project work: Internal evaluation as other practicals, evaluation will be done by the project guide. Marks distribution consists of viva voice for 10 marks and project report for 40 marks.

PART-II: CORE SUBJECT (Mathematics)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UMAT-101	Multivariable Calculus	**3**	3	IE1	T	100
UMAT-102	Ordinary Differential Equations	**3**	3	IE1	T	100
		6 credits	**6** hours			**200** Marks
Semester II						
UMAT-201A	Probability	**3**	3	IE1	T	100
UMAT-202	Vector Analysis	**3**	3	IE1	T	100
		6 credits	**6** hours			**200** Marks
Semester III						
UMAT-301	Real Analysis-I	**3**	3	IE1	T	100
UMAT-302	Boundary Value Problems	**3**	3	IE1	T	100
		6 credits	**6** hours			**200** Marks
Semester IV						
UMAT-401	Real Analysis II	**3**	3	IE1	T	100
UMAT-402	Linear Algebra	**3**	3	IE1	T	100
		6 credits	**6** hours			**200** Marks

PART-II TOTAL (Mathematics)	**24** credits	**24** hours		**800** Marks

Notes: The Choice of Electives and Streams of Specialization offered shall be decided by the Head of the Department.

PART-II: CORE SUBJECT (Physics)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UPHY-101	Electronics-I: Analog and Digital	**3**	3	IE1	T	100
UPHY-102	Practical (Electronics-I)	**1**	3	I	P	50
		4 credits	**6** hours			**150** Marks
Semester II						
UPHY-201	Optics	**3**	3	IE1	T	100
UPHY-202	Practical (Optics)	**1**	3	I	P	50
		4 credits	**6** hours			**150** Marks
Semester III						
UPHY-301	Classical Mechanics	**4**	4	IE1	T	100
UPHY-302	Practical (Mechanics and Waves)	**1**	3	I	P	50
		5 credits	**7** hours			**150** Marks
Semester IV						
UPHY-401	Electromagnetism	**4**	4	IE1	T	100
UPHY-402	Practical (Electromagnetism)	**1**	3	I	P	50
		5 credits	**7** hours			**150** Marks
	PART II TOTAL (Physics)	**18** credits	**26** hours			**600** Marks

PART-II: CORE SUBJECTS (Biosciences)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UBIO-101	Plant Diversity – I (Algae, Fungi and Bryophytes)	**3**	3	IE1	T	100
UBIO-102	Animal Diversity – I (Invertebrata)	**3**	3	IE1	T	100
UBIO-103	Practical Course on Plant Diversity-I	**1**	3	I	P	50
UBIO-104	Practical Course on Animal Diversity-I	**1**	3	I	P	50
		8 credits	**12** hours			**300** Marks
Semester II						
UBIO-201	Plant Diversity-II (Pteridophytes, Gymnosperms and Morphology of Angiosperms)	**3**	3	IE1	T	100
UBIO-202	Animal Diversity-II (Chordata)	**3**	3	IE1	T	100
UBIO-203	Practical Course on Plant Diversity-II	**1**	3	I	P	50
UBIO-204	Practical Course on Animal Diversity-II	**1**	3	I	P	50
		8 credits	**12** hours			**300** Marks

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Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester III						
UBIO-301	Plant Diversity-III (Taxonomy, Anatomy and Embryology of Angiosperms)	**4**	4	IE1	T	100
UBIO-302	Developmental Biology (Embryology of Animals)	**4**	4	IE1	T	100
UBIO-303	Practical Course on Plant Diversity-III	**1**	3	I	P	50
UBIO-304	Practical Course on Developmental Biology	**1**	3	I	P	50
		10 credits	**14** hours			**300** Marks
Semester IV						
UBIO-401	Biostatistics	**4**	4	IE1	T	100
UBIO-402	Bacteriology and Virology	**4**	4	IE1	T	100
UBIO-403	Practical Course on Biostatistics	**1**	3	I	P	50
UBIO-404	Practical Course on Bacteriology and Virology	**1**	3	I	P	50
		10 Credits	**14** hours			**300** Marks
	PART II TOTAL (Biosciences)	**36** credits	**52** hours			**1200** Marks

Modes of Evaluation

Indicator	Legend
IE1	CIE and ESE ; ESE single evaluation
IE2	CIE and ESE ; ESE double evaluation
I	Continuous Internal Evaluation **(CIE)** only Note: 'I' does not connote 'Internal Examiner'
E	End Semester Examination **(ESE)** only Note: 'E' does not connote 'External Examiner'
E1	ESE single evaluation
E2	ESE double evaluation

Continuous Internal Evaluation (CIE) & End Semester Examination (ESE)

Types of Papers

Indicator	Legend
T	Theory
P	Practical
V	Viva voce
PW	Project Work
D	Dissertation

PS: Please refer to guidelines for 'Modes of Evaluation for various types of papers', and 'Viva voce nomenclature & scope and constitution of the Viva-voce Boards'.

PART-III: AWARENESS and ENVIRONMENTAL COURSES

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UAWR-100	Awareness Course-1: Sai Education for Transformation (Based on Life and Teachings of Bhagawan Baba)	**2**	2	I	T	50
UENT-101	Environment-I: Environmental Studies and Human Values	**2**	2	I	T	75
Semester II						
UAWR-200	Awareness Course-2: Unity of Religions	**2**	2	I	T	50
UENT-201	Environment-II: Environmental Studies and Human Values	**2**	2	I	T	75

Semester III						
UAWR-300	Awareness Course-3: Study of Classics-I: Ramakatha Rasavahini	**2**	2	I	T	50
Semester IV						
UAWR-400	Awareness Course-4: Study of Classics-II: Bhagawatha Vahini	**2**	2	I	T	50
Semester V						
UAWR-500	Awareness Course-5: Eternal Values for the changing World	**2**	2	I	T	50
Semester VI						
UAWR-600	Awareness Course-6: Life and its Quest	**2**	2	I	T	50
	PART-III TOTAL	**16** credits	**16** hours			**450** Marks

SUMMARY

for B.Sc.(Hons.) in Chemistry with MPC combination

	Credits	Hours	Maximum Marks
PART-I: LANGUAGES			
PART-I TOTAL	**36** credits	**36** hours	**800** Marks
PART-II: CORE SUBJECTS			
PART-II TOTAL (Honours in Chemistry)	**58** credits	**86** Hours	**1800** Marks
PART-II TOTAL (Mathematics)	**24** credits	**24** Hours	**800** Marks
PART-II TOTAL (Physics)	**18** credits	**26** Hours	**600** Marks
PART-III: AWARENESS and ENVIRONMENTAL COURSES			
PART-III TOTAL	**16** credits	**16** Hours	**450** Marks
GRAND TOTAL (B.Sc.(Hons.) in Chemistry)	**152** credits	**186** Hours	**4450** Marks

SUMMARY

for B.Sc.(Hons.) in Chemistry with Biosciences & Chemistry combination

	Credits	Hours	Maximum Marks
PART-I: LANGUAGES			
PART-I TOTAL	**36** credits	**36** Hours	**800** Marks
PART-II: CORE SUBJECTS			
PART-II TOTAL (Honours in Chemistry)	**58** credits	**86** Hours	**1800** Marks
PART-II TOTAL (Biosciences)	**36** credits	**52** Hours	**1200** Marks
PART-III: AWARENESS and ENVIRONMENTAL COURSES			
PART-III TOTAL	**16** credits	**16** Hours	**450** Marks
GRAND TOTAL (B.Sc.(Hons.) in Chemistry)	**146** credits	**190** Hours	**4250** Marks

UCHM-101: Principles of Structure and Bonding

3 Credits

Course Objectives:

1. Provide a brief introduction to atomic structure using quantum mechanics
2. Understanding of the different atomic properties and their variation in a periodic table
3. Understand the nature of bonding and structure in molecules
4. Provide a brief understanding of the relationship between the physical and chemical properties of molecules and the nature of bonding

Course Outcomes:

1. Deduce the arrangement of electrons in multielectron atoms
2. Ability to predict the atomic properties in the periodic table
3. Predict the nature and strength of bonding based on the species involved.
4. Deduce a relationship between the nature of bonding and the properties of a molecule

Syllabus:

Atomic Structure: 10 hours

Atomic spectra of hydrogen atom – Bohr's explanation.
Dual nature of electron, wave mechanical model: de Broglie principle, Heisenberg's uncertainty principle, Schrodinger wave equation, significance of ψ and ψ^2, Solutions of Schrodinger equation to a particle in 1-D box; quantum numbers, radial and angular wave functions, probability distribution curves for the hydrogen atom, shapes of s, p and d orbitals; Aufbau principle, Pauli exclusion principle, Hund's rule of maximum multiplicity.

Chemical Periodicity: 9 hours

Modern periodic law, arrangement and classification of elements.
Effective nuclear charge, screening effect, Slater's rules, atomic radii (van der Waals), ionic radii (Pauling's method), covalent radii; Ionization potential, electron affinity, electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales) – factors influencing these properties, inert pair effect; Group trends and periodic trends with respect to s, p and d block elements.

Chemical Bonding and Structure: 20 hours

Chemical bonds: classification, octet rule, 18-electron rule, electronic theory of valency.

Ionic bonding: size effects, radius ratio rules and their limitations; packing of ions in crystals, lattice energy, Born-Lande equation and its applications, Born-Haber cycle and its application; solvation energy; Fazan's rules.

Covalent bonding: electronic structure, Lewis structures, formal charge; VSEPR theory: shapes of molecules and ions (examples: NH_3, H_3O^+, SF_4, ClF_3, ICl_2^-, H_2O, $SnCl_2$, XeF_2, XeF_4, IF_5); Valence bond theory: directional nature of covalent bonds, hybridization (examples: $BeCl_2$, CO_2, BCl_3, SO_2, CO_3^{2-}, CH_4, NH_3, H_2O, SO_4^{2-}, PCl_5, ClF_3, SF_4, XeF_2, SF_6, BrF_5, XeF_4, IF_7, XeF_6), equivalent and non-equivalent hybrid orbitals, Bent's rule, partial ionic character of covalent bonds, dipole moment and electronegativity differences, percentage ionic character; inductive effect, concept of resonance, resonance energy, resonance structures, hyperconjugation; MO theory: LCAO, MO treatment of simple diatomic molecules (N_2, O_2, CO, NO, HF, HCl); coordinate covalent bond.

Band theory: bonding in metals based on MO approach, classification of substances as insulators, semiconductors and conductors.

Hydrogen bond: nature, classification, consequences; van der Waal's forces: Debye, Keesom and London forces; molecular solids – ice, dry ice.

Concept of Symmetry: 6 hours

Symmetry elements and operations. Symmetry properties of simple organic and inorganic molecules (SiBrClFI, H_2O, SO_2Cl_2, C_2H_6, XeF_4, NH_3, BCl_3, C_6H_6, CO_2, $CHCl_3$, CH_4, HCl, CO, cis and trans isomers of ClCH=CHCl).

Prescribed Books:

1. Concise Inorganic Chemistry, 5th ed. by J D Lee; Blackwell Science Ltd., 1996.
2. Inorganic Chemistry, 3rd ed. by Alan G Sharpe; Pearson Education Ltd., 1992.
3. Principles of Inorganic Chemistry, 2nd ed. by G S Sodhi; Viva Books Pvt. Ltd., 2015.
4. Theoretical Principles of Inorganic Chemistry by G S Manku; Tata McGraw-Hill Publishing Company Ltd., 1980.

Reference Books:

1. Concepts and Models of Inorganic Chemistry, 3rd ed. by Bodie Douglas, Darl McDaniel and John Alexander; Wiley India Pvt. Ltd., 1994.
2. Shriver and Atkin's Inorganic Chemistry, 5th ed. by Atkins, Overton, Rourke, Weller and Armstrong; Oxford University Press, 2010.
3. Chemical Principles: The Quest for Insight, 6th ed. by P Atkins, L Jones and L Laverman; W H Freeman and Company, New York, 2013.
4. A Simple Approach to Group Theory in Chemistry by S Swarnalakshmi, T. Saroja and R M Ezhilarasi; University Press, 2008.
5. Chemistry of the Elements, 2nd ed. by Greenwood and Earnshaw, Elsevier Butterworth- Heinemann, 1997.
6. Atomic Structure and Chemical Bond: Including Molecular Spectroscopy by Manas Chanda, Tata McGraw-Hill, 1979.
7. Theoretical Inorganic Chemistry by M C Day and J Selbin, ACS Publications, 1962.
8. Physical Chemistry, 9th ed. by P Atkins and J Paula, Oxford University Press India, 2010.

UCHM-102: Laboratory Course in General Chemistry

1 Credit

Course Objectives:

1. To have hand on experience with different minor equipment for the determination of different physical properties
2. To gain knowledge on the different types of symmetry elements existing in molecules.
3. To get knowledge of the shapes of molecules by using different types of hybridization.
4. To gain knowledge in using software for scientific calculations

Course Outcomes:

1. Ability to measure the physical properties of organic and inorganic compounds
2. Experience in using different minor equipments.
3. The concepts of hybridization and symmetry elements will make the students, appreciate the arrangement of different atoms in the molecules to give a particular shape.
4. Should be in a position to do scientific calculations with the help of specialized computer software.

Syllabus:

1. Determination of density of liquids using a pyknometer.
2. Determination of density of solids by buoyancy method.
3. Determination of viscosity of a liquid using Ostwald's viscometer.
4. Determination of surface tension of a liquid using stalagmometer.
5. Determination of melting point of pure solids and mixtures.
6. Determination of refractive indices of given liquids by Abbe's refractometer.
7. Determination of boiling point of pure liquids and mixtures.
8. Determination of energy band gap of a semiconductor.
9. Determination of the length of a conjugated polyene based on the concept of the particle in a 1D box.
10. Plotting of radial and angular wave functions and probability distribution curves for hydrogen atom.
11. Plotting of hybrid orbitals.
12. Plotting of wave functions and energy of a particle in a 1D box.
13. To study VSEPR theory by modelling the chemical compounds: NH_3, H_3O^+, SF_4, ClF_3, ICl_2^-, H_2O, $SnCl_2$, XeF_2, XeF_4, IF_5 and so on.
14. Modelling on hybridization, geometry of some organic & inorganic compounds.
15. To study symmetry elements and operations by modelling of chemical compounds: H_2O, $SOCl_2$, C_2H_6, XeF_4, NH_3, BCl_3, C_6H_6, CO_2, $CHCl_3$, CH_4, HCl, CH_2=CHCl, cis & trans isomers of ClCH=CHCl and so on.

***Note**: A minimum of eight experiments from the above list are to be carried out.*

References:

1. B.Sc. Chemistry Experiments by Vasudev Bhatt, B.Srikant and M.S.Hegde, Talent Development Centre, Indian Institute of Science, Challakere, Karnataka, 2016.
2. College Practical Chemistry by V.K. Ahluwalia, Sunita Dhingra and Adarsh Gulati, Orient BlackswanPvt Ltd., 2005.
3. Concise Inorganic Chemistry by J. D. Lee, 5^{th} Ed., Blackwell Science, 1996.
4. A Simple Approach to Group Theory in Chemistry**,** by S Swarnalakshmi, T. Saroja and R M Ezhilarasi, University Press, 2008
5. Experimental Physical Chemistry by G.P. Matthews, Clarendon Press, 1985.

UCHM-201: Chemical Thermodynamics

3 Credits

Course Objectives:

1. Introduce laws that describe the behaviour of a gas
2. Understand the basic concepts of chemical thermodynamics, the laws of thermodynamics and their applications in chemistry

Course Outcomes:

1. Should be in a position to understand and apply laws that describe the behaviour of gases
2. A fundamental understanding of the first and second laws of thermodynamics and their applications to a wide range of systems in chemistry.
3. An understanding of the interrelationship between thermodynamic functions and an ability to use such relations to solve practical problems.

Syllabus:

Gaseous state — 6 hours

Postulates of kinetic theory of gases; deviation from ideal behaviour: van der Waals equation of state, compressibility factor (Z), variation with pressure for different gases.
Critical phenomena: PV isotherms of real gases, continuity of states, isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, law of corresponding states, reduced equation of states.
Molecular velocities: root mean square, average, probable velocities; qualitative discussions of Maxwell's distribution of molecular velocities, collision frequency of binary collisions, mean free path, collision diameter, collisions of gas molecules.

Basic concepts in Chemical thermodynamics — 2 hours

Types of systems (open, closed and isolated); thermodynamic processes: reversible, irreversible, isothermal, adiabatic, isobaric, isochoric; extensive and intensive properties, state and path functions, exact and inexact differentials, dynamic equilibrium – chemical, thermal, mechanical; zeroth law of thermodynamics.

First law of thermodynamics — 15 hours

Work, heat and internal energy; first law of thermodynamics, expansion work – reversible, irreversible, free expansion; isothermal reversible expansion of perfect and van der Waals gases, enthalpy, heat changes at constant volume and pressure; variation of internal energy with volume (π_T); relation between C_p and C_v, work of adiabatic expansion for a perfect gas; calculation of w, q, ΔU, ΔH for expansion of perfect gas under isothermal and adiabatic conditions for reversible, irreversible, free expansion; Joules-Thomson effect, inversion temperature.

Thermochemistry — 6 hours

Standard enthalpy, enthalpies of physical and chemical changes, Hess's law of heat summation, bond dissociation energy – its calculation from thermo-chemical data, standard enthalpies of formation, Kirchhoff's law.

Second law of thermodynamics — 8 hours

Direction of spontaneous change – entropy, Carnot cycle, thermodynamic scale of temperature, entropy as a state function; statements of the second law of thermodynamics, Clausius inequality; entropy changes in reversible and irreversible processes (isothermal and adiabatic), variation of entropy with volume and temperature; entropy changes accompanying phase transitions; calculation of entropy for reversible and irreversible processes.

Fundamental equations of thermodynamics — 3 hours

Helmholtz and Gibb's energies, Gibb's energy as a criterion for spontaneity; standard Gibb's energy of reaction, variation of Gibb's energy with temperature and pressure; fundamental equations of thermodynamics in terms of U, H, A, G; Maxwell's relations – significance and applications.

Third law of thermodynamics — 3 hours

Nernst heat theorem, statement of third law of thermodynamics- molecular interpretation, calculation of absolute entropy and standard reaction entropy; technique to attain low temperature – Adiabatic demagnetization – principle and method.

Statistical Thermodynamics 2 hours

The distribution of molecular states: Configurations and weights, Boltzmann distribution; the molecular partition function – interpretation.

Prescribed Books:

1. Physical Chemistry, 9th ed. by P Atkins and J Paula, Oxford University Press India, 2010.
2. A Textbook of Physical Chemistry – Volume 2, 5th ed. by K L Kapoor, McGraw Hill Education (India) Pvt. Ltd., 2015.

Reference Books:

1. Chemical Thermodynamics – Classical, Statistical and Irreversible by J Rajaram and J C Kuriacose, Dorling Kindersley (India) Pvt. Ltd. (Pearson education), 2013.
2. Chemical Thermodynamics by Peter A Rock, University Science Books, 1983.
3. Chemical Principles: The Quest for Insight, 6th ed. by P Atkins, L Jones and L Laverman; W H Freeman and Company, New York, 2013.

UCHM-202: Laboratory Course on Titrimetry And Thermodynamics

1 Credit

Course Objectives:

1. To gain knowledge of different types of titrations and their importance in quantitative estimations.
2. To analyze various fertilizers being used for the agriculture purpose.
3. To determine different thermodynamic parameters.
4. To determine the universal gas constant.

Course Outcomes:

1. The students should be in a position to design their own methodology to determine the concentration of a given sample
2. Ability to estimate the exact concentration using titrimetric methods
3. Should be able to determine various thermodynamic parameters of samples
4. Ability to determine the universal gas constant
5. Should be able to determine the composition of different fertilizers and the active component present in them.

Syllabus:

1. Titrimetry:
    a. **Neutralization titrations**
    b. Standardization of HCl with Borax.
    c. Estimation of carbonate and bicarbonate in a mixture.
    d. Estimation of carbonate and hydroxide in a mixture.
    e. Standardization of NaOH with potassium hydrogen phthalate
    f. Estimation of ammonia in a fertilizer.
    g. Standardization of NaOH with Oxalic acid and determining the strength of HCl with standardized NaOH.
    h. Standardization of NaOH with Oxalic acid and determining the strength of acetic acid with standardized NaOH.
    i. Redox titrations
    j. Standardization of $KMnO_4$ with oxalic acid.
    k. Estimation of mixture of Fe(III) and Fe(II) with $KMnO_4$.
    l. Estimation of Fe(II) with $K_2Cr_2O_7$
2. Determination of universal gas constant R.
3. Determination of enthalpy of neutralisation.
4. Specific heat of metals
5. Specific heat of liquids.
6. Latent heat of fusion of ice.
7. Linear thermal expansion coefficient.
8. Volume expansion coefficient of water.

***Note**: A minimum of eight experiments from the above list are to be carried out.*

References

1. B.Sc. Chemistry Experiments by Vasudev Bhatt, B. Srikant and M.S. Hegde, Talent Development Centre, Indian Institute of Science, Challakere, Karnataka, 2016.
2. College Practical Chemistry by V.K. Ahluwalia, Sunita Dhingra and Adarsh Gulati, Orient Blackswan Pvt Ltd., 2005.
3. Experimental Physical Chemistry by G.P. Matthews, Clarendon Press, 1985.

UCHM-301: Chemical Kinetics and Equilibria

4 Credits

Course Objectives:

1. Introduce the empirical and theoretical principles of rates of chemical reactions.
2. Understand the concept of equilibrium as an application of thermodynamic principles.
3. Introduce the concepts of aqueous ionic equilibria
4. Introduce the concepts of electrochemical equilibria

Course Outcomes:

1. Understand the concept of reaction rates, order of reaction and rate constant.
2. Determine the rate law from initial rate data and recognize integrated rate laws
3. Understand the theoretical rate aspects of reactions at molecular level
4. Calculation of equilibrium constant from thermodynamic parameters
5. Should be able to apply the concepts of aqueous ionic equilibria in various applications
6. Understand essential features of electrochemical cells and calculate cell potentials.

Syllabus:

Empirical Chemical Kinetics — 10 hours

Rate of reactions – rate laws and rate constants, order and molecularity; differential and integrated form of rate equations for simple chemical reactions – zero, first, second order, pseudo first order and n^{th} order reactions; equations for half-life; radioactive decay as first order phenomenon.

Methods of determining reaction orders and rate laws – integrated rate law method, isolation and initial rate method, half-life method.

Theoretical Chemical Kinetics — 7 hours

Arrhenius concept of activation energy, kinetic energy of molecules – Boltzmann and Maxwell interpretation, Arrhenius equation; collision theory and reaction kinetics.

Transition state theory: assumptions, expression for rate of reaction in presence of activated complex, Eyring's equation for rate (elementary treatment); factors affecting rate of a reaction – concentration, pressure, temperature, catalyst, surface area and nature of solvent.

Chemical Equilibrium — 4 hours

Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient; Relationship between ΔG and equilibrium constant of a reaction; temperature dependence of equilibrium constant – van't Hoff equation.

Ionic Equilibria — 25 hours

Theories of acids and bases: Arrhenius, Lowry-Brønsted and Lewis, modern interpretation. Pearsons classification – HSAB principle.

Arrhenius concept of electrolytic dissociation, degree of dissociation and factors affecting; strong and weak electrolytes; limitations of Arrhenius theory; Ostwald's mathematical interpretation – Ostwald's dilution law.

Chemical interactions in the solution, mechanism of solvation; concept of activity, activity coefficient, ionic strength; factors affecting activity and ionic strength.

Acid-base equilibria in water, hydrogen ion exponent (pH), ionic product of water, concept of neutralization, formation of salt, types of salts and their solubility; sparingly soluble salts and their behaviour in the presence of interfering substances – common ion effect and salt effect. Solubility product principle and application.

Hydrolysis of salts – interaction of salt with water, hydrolysis constant, degree of hydrolysis. Derivation for expressions for pH of aqueous solution of different types of salts and their applications.

Buffer solutions – concept, components of a buffer, types of buffers, mechanism of action, buffer capacity; Henderson's equation and its applications (preparation of buffer solutions); Importance and applications of buffers.

Titrimetry: Primary and secondary standard substances – criteria with examples, standard solutions. Basic principles of titrimetry – rule of titre, equivalence point, end point, types of reactions in titrimetry with examples; theory and concept of an indicator, role of indicators and their selection in titrimetry.

Electrochemical cells — 14 hours

Introduction – electrolytic and galvanic cell; reversible and irreversible cells; cell potential and its measurement; formulation of a galvanic cell – half-cells, cell diagram, cell notation; sign conventions for electrodes; Electrode types – metal-metal ion electrode, gas electrode, metal-metal insoluble salt electrode, redox electrode and amalgam electrode.

Determination of standard potentials of electrodes; reference electrode, significance of standard half-cell potentials, electrochemical series; secondary reference electrodes; Nernst equation – EMF of a cell and its cell reaction. Cell reactions and its relation with cell potential

Applications of electrochemical cells – Determination of thermodynamic data, equilibrium constant, accurate value of dissociation constant of a weak acid, ionic product of water, pH of a solution, potentiometric titrations.

Battery – primary and secondary; fuel cells – introduction.

Prescribed Books:

1. A Textbook of Physical Chemistry – Volume 1, 5th ed. by K L Kapoor, McGraw Hill Education (India) Pvt. Ltd., 2014.
2. A Textbook of Physical Chemistry – Volume 3, 4th ed. by K L Kapoor, McGraw Hill Education (India) Pvt. Ltd., 2014.
3. A Textbook of Physical Chemistry – Volume 5, 3rd ed. by K L Kapoor, McGraw Hill Education (India) Pvt. Ltd., 2014.
4. Physical Chemistry, 9th ed. by P Atkins and J Paula, Oxford University Press India, 2010
5. Vogel's Text Book of Quantitative Inorganic Analysis, 5th ed., ELBS, 1994.

Reference Books:

1. Chemical Principles: The Quest for Insight, 6th ed. by P Atkins, L Jones and L Laverman; W H Freeman and Company, New York, 2013.
2. Basic Reaction Kinetics and Mechanism by H E Avery, Mcmillan Publishers Ltd., 1974.
3. Principles of Physical Chemistry by Samuel Maron and Carl Prutton, 4th edition, Oxford and IBH Publishing Co. Pvt. Ltd., 1951.
4. Exploring Chemical Analysis, 2nd ed. by Daniel C. Harris, W. H. Freeman and Company, 2001.
5. Quantitative Chemical Analysis, 8th ed. by Daniel C. Harris, W. H. Freeman and Company, 2010

UCHM-302: Laboratory Course on Chemical Kinetics and Equilibria

1 Credit

Course Objectives:

1. To equip the students with the ability to determine reaction mechanisms using chemical kinetics and also to determine the order of different types of chemical reactions.
2. To understand the concept of common ion effect and ionic strength influence.
3. To understand the concept of buffer action and preparation of different buffer solutions.
4. To familiarize the students with the usage of pH meter and conductivity meter for different analytical measurements.

Course Outcomes:

1. The students must equip themselves to determine the order of the reaction and propose a suitable mechanism for the same.
2. The importance of maintenance of constant pH, common ion effect, ionic strength effect in chemical processes and biological processes should be known to students.
3. Should be able to understand the concept of buffer action and must be in a position to prepare different buffer solutions.
4. Students should be in a position to determine the analyte content in a given sample by carrying out pH and conductivity measurements.

Syllabus:

1. Determination of solubility product of a sparingly soluble salt and calculation of entropy & enthalpy
2. Determination of pK_a of following compounds by pH titration: Phenol, aniline, ammonia, acetic acid and oxalic acid.
3. Determination of Avogadro number.
4. Determination of electrode potentials and application of Nernst equation.
5. Determination of K_{sp} using concentration cell.
6. Simulation of redox titrations using Nernst equation.
7. Kinetics of hydrolysis of methyl acetate - acid and base catalysed using integrated rate law method.
8. Kinetics of iodination of acetone using isolation method.
9. To study the principle of solubility product and common ion effect by undertaking group separation studies of single salts and double salts.
10. Determination of relative viscosity of given liquids by Ostwald's viscometer.
11. Determination of pH of different salt solutions using pH meter.
12. Preparation of buffer solutions: sodium acetate-acetic acid and ammonium chloride-aqueous ammonia.
13. Measurement of pH of buffer solutions and comparison of the values with theoretical values.
14. Determination of dissociation constant of CH_3COOH by pH metry.
15. Conductometric titration of:
    a. strong acid vs strong base
    b. weak acid vs strong base
    c. mixture of strong acid and weak base vs strong base.
16. ***Note**: A minimum of eight experiments from the above list are to be carried out.*

References:

1. B.Sc. Chemistry Experiments by Vasudev Bhatt, B.Srikant and M.S.Hegde, Talent Development Centre, Indian Institute of Science, Challakere, Karnataka, 2016.
2. College Practical Chemistry by V.K. Ahluwalia, Sunita Dhingra and Adarsh Gulati, Orient BlackswanPvt Ltd., 2005.
3. Vogel's Text Book of Quantitative Inorganic Analysis, 5th Ed., ELBS, 1994.
4. Experimental Physical Chemistry by G.P. Matthews, Clarendon Press, 1985
5. Experimental Physical Chemistry by V.D. Athawale, ParulMathur, New Age International Publishers, 2001.

UCHM-401: Chemistry of Organic Functional Groups

4 Credits

Course Objectives:

1. Introduce the fundamental concepts of organic chemistry.
2. Provide an overview of the chemistry of organic functional groups.
3. To give a mechanistic understanding of various elementary organic reactions

Course Outcomes:

1. Must be familiar with the fundamental concepts of organic chemistry
2. Understand nature and reactivity of various functional groups.
3. Deduce the mechanism of various elementary organic reactions.

Syllabus:

Review of Basic Concepts 4 hours

Electronic displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation, hydrogen bonding; oxidation and reduction; electrophiles and nucleophiles; curly arrow rules to represent reaction mechanisms; types of reactions.

Hydrocarbons 6 hours

Cycloalkanes: General methods of preparation, ring size, stability and nomenclature.

Alkenes: electrophilic addition reactions in presence of hydrogen, water, alcohols, halogens, hydrogen halides, boranes, peroxy acids and ozone.

Alkynes: electrophilic addition reactions in presence of hydrogen, water, hydrogen halides, halogens. Reactivity of 'sp' carbon.

Isomerism in Organic compounds 7 hours

Fischer, Newmann and Sawhorse projection formulae and their interconversions.

Geometric isomerism: Cis-trans, syn-anti and E/Z notations with CIP rules.

Conformational analysis of alkanes: relative stability and energy diagrams; conformers of n-butane, cyclohexane and their relative stability, conformers of mono- and di- substituted cyclohexane.

Chirality – asymmetric and stereocenters, enantiomers, optical activity, enantiomeric excess and purity of a compound, erythro-threo enantiomers, meso compounds, isomers with more than one asymmetric center, racemic mixture and their resolution; relative and absolute configuration, separation of enantiomers.

Alkyl Halides 8 hours

Preparation of alkyl halides, substitution (S_N2 and S_N1) and elimination (E2 and E1) reactions Hoffmann and Saytzeff products – mechanisms with stereochemical aspects, factors governing these reactions, competitions between these reactions.

Applications of alkyl halides as Grignard reagents with carbonyl compounds, acid chlorides, esters, epoxides, cyanides and alkynes.

Alcohols, Ethers and Epoxides 5 hours

Preparation of alcohols, reactions of alcohols: substitution (with PCl_3, PCl_5 and $SOCl_2$), elimination and oxidation; reactivity of different classes of alcohols.

Ethers: preparation of ethers and reactions with acids.

Epoxides: preparation and ring opening reactions of epoxides.

Aromatic hydrocarbons 8 hours

Aromaticity and criteria, MO interpretation of cyclic systems; Electrophilic substitution reactions of aromatic compounds – halogenation, nitration, sulphonation, Friedel-Craft's alkylation and acylation (with mechanism); directing effects of the groups; polyaromatic hydrocarbons – electrophilic reactions of napthalene, anthracene and phenanthrene .

Phenols 4 hours

Preparation of phenols; ring substitution reactions, Reimer-Tiemann and Kolbe's-Schmidt reactions, Fries and Claisen rearrangements with mechanism; comparison of acidity of phenols and alcohols with respect to inductive and mesomeric effects.

Amines — 6 hours

Preparation of amines; basicity of amines, reactions: carbylamines reaction, Hoffmann's exhaustive methylation, Diazotization and applications, Hofmann elimination reaction; distinction between 1^o, 2^o and 3^o amines with Hinsberg test and nitrous acid.

Carbonyl Compounds — 7 hours

Structure and reactivity, properties and preparation of carbonyl compounds; keto-enol tautomerism; nucleophilic additions, nucleophilic addition-elimination reactions with ammonia derivatives with mechanism - Schiff's bases; mechanisms of aldol reaction, cross-aldol (acid and base catalysed), Cannizzaro reaction and Benzoin condensation

Carboxylic acids and their Derivatives — 5 hours

Physical properties and preparation of carboxylic acids, separation of a mixture of carboxylic acid and phenol, reactions – Fischers esterification reaction, typical reactions of dicarboxylic acids.

Properties, preparation and reactions of acid chlorides, anhydrides, esters and amides; mechanism of acidic and basic hydrolysis of esters ($A_{ac}2$ and $B_{ac}2$ mechanisms).

Prescribed Books:

1. Organic Chemistry, 11th ed. by T W Solomons and Craig B Fryhle, International Student Edition, Wiley, 2015.
2. Organic Chemistry, 8th ed. by Leroy G Wade, Pearson, 2016.
3. Organic Chemistry, Vol. 1-3, 2nd ed. by S M Mukherji, S P Singh, R P Kapoor and R Das, New Age International Publishers, 2017.

Reference Books:

1. Organic Chemistry, 7th ed. by Paula Y Bruice, Pearson Education India.
2. Organic Chemistry, 4th ed. by Pine, Hendrickson, Cram, Hammond; McGraw-Hill Education, 1987.
3. Organic Chemistry, 5th ed. by Ralph J Fessenden and Joah S. Fessenden, Brookscole, 1994.

UCHM-402: Laboratory Course on Methods and Synthesis in Organic Chemistry

1 Credit

Course Objectives:

1. To identify the different functional groups present in a given organic molecule.
2. To learn different synthetic strategies by preparing various organic compounds of general interest.
3. To learn various basic laboratory purification techniques.
4. To familiarize the student to draw chemical structures using computer software and examine their stereochemistry

Course Outcomes:

1. Should be in a position to identify the functional group in a given organic compound
2. Should be in a position to synthesize organic compounds using the methods learnt
3. Should be in a position to purify organic compounds
4. Students should be in a position to draw chemical structures using computer software and deduce their stereochemistry.

Syllabus:

1. Qualitative organic functional group analysis - tests for alcohols, phenols, amines, carbonyls, carboxylic acids and nitro compounds.
2. Preparation of organic compounds: Dibenzylidene acetone, Aromatic sulphonation, Nitration of acetanilide, Bromination of acetanilide(Green Synthesis)
3. Purification techniques: recrystallization, sublimation, distillation and steam distillation.
4. Thin layer chromatography, column chromatography& paper chromatography.
5. Preparation of soap - saponification.
6. Preparation of methyl orange and aspirin.
7. Specific rotation of chiral compounds (sugars) using a polarimeter.
8. Plotting of molecular orbitals of aromatic compounds and conjugated systems.
9. Conformational analysis – butane and substituted butanes, cyclohexane and di-substituted cyclohexane with stress on cis and trans isomerism.
10. Molecular modelling:
    a. Stereo-chemistry: R-S configuration.
    b. Stereochemistry of E_2 mechanism.
    c. Modelling on hybridization, geometry of some organic & inorganic compounds.

Note*: A minimum of eight experiments from the above list are to be carried out.*

References:

1. Introduction to Organic Laboratory Techniques by D.L. Pavia, G.M. Lampman, and G.S. Kriz, 2nd Ed., Saunders College Publishing, 1982.
2. Experimental Organic Chemistry by P.R. Singh ,D.S. Gupta and K.S. Bajpai, Vols I & II, Tata McGraw Hill, 1980.
3. Vogel's Text Book of Qualitative organic Analysis, 5th Ed., ELBS, 1994.
4. Experimental Physical Chemistry by V.D. Athawale, Parul Mathur, New Age International Publishers, 2001.

UCHM-501: Chemistry of Elements

3 Credits

Course Objectives:

1. Understand the importance of the periodic table of the elements and its role in organizing chemical information
2. Understanding the varying chemical reactivities of elements in the periodic table with emphasis on inorganic materials
3. Introduction to the chemistry of coordination compounds
4. Introduction to nuclear reactions and nuclear chemistry

Course Outcomes:

1. Understanding the chemistry of elements in the periodic table and their compounds
2. Understanding the nature of compounds formed by various elements based on their position in the periodic table (s, p, d and f blocks)
3. Should be familiar with the chemistry of coordination compounds
4. Should predict the outcome of a nuclear reaction

Syllabus:

Chemistry of s-block elements: 5 hours

Diagonal relationship between Lithium and Magnesium, Beryllium and Aluminium.
Difference between Lithium and the other group I elements; alkali metals in liquid ammonia, alkali metal complexes of acetylacetone, salicylaldehyde, crown ethers and cryptands.
Difference between beryllium and other group II elements; covalency and stereochemistry of beryllium compounds e.g. $BeCl_2$, and BeH_2; EDTA complexes of calcium and magnesium.

Chemistry of p-block elements: 9 hours

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: diborane, boron-nitrogen compounds, graphitic compounds, carbides, silanes, silicones, hydrazine, hydroxyl amine, phosphazene oxides, hydrogen peroxide, oxoacids of nitrogen, phosphorous, sulphur and chlorine; structural aspects of interhalogen compounds and polyhalides; pseudohalogens and pseudohalides; structure and bonding of fluorides of xenon – clathrates.

Chemistry of d-block elements 6 hours

Characteristics of d-block elements with respect to electronic configuration, variable oxidation states, magnetic properties, colour, catalytic properties and ability to form complexes; stability of different oxidation states and standard electrode potential; comparative treatment of second and third row transition elements with their first row analogues; study of Ti, Cr and Cu triads with respect to electronic configuration and reactivity of different oxidation states.

Chemistry of f-block elements 7 hours

Lanthanides – electronic structure, oxidation states, lanthanide contraction, consequences of lanthanide contraction, magnetic properties, spectral properties and separation of lanthanides; Actinides – electronic configuration, oxidation states, actinide contraction, position of actinides in the periodic table, comparison with lanthanides in terms of magnetic properties, spectral properties and complex formation.

Coordination Chemistry 15 hours

IUPAC nomenclature, bonding theories – review of Werner's theory and Sidgwick's concept of coordination (EAN rule), shapes of d-orbitals, Valence Bond Theory: tetrahedral, square planar and octahedral geometries, limitations of VBT; Crystal Field Theory: splitting of d-orbitals (t_{2g} and e_g) in octahedral, square planar and tetrahedral complexes – low spin and high spin complexes – factors affecting crystal-field stabilization energy (delta value), merits and demerits of crystal-field theory, Applications of CFT, Tetragonal distortion of octahedral complexes (Jahn -Teller Distortion); qualitative aspects of MO theory
Isomerism in coordination compounds.

Nuclear chemistry 3 hours

Composition of the nucleus, stability, radioactive decay modes – law of radioactivity, half life; natural and artificial disintegration series; nuclear reactions; carbon dating.

Prescribed Books:

1. Concise Inorganic Chemistry, 5th ed. by J D Lee; Blackwell Science Ltd., 1996.
2. Principles of Inorganic Chemistry, 2nd ed. by G S Sodhi; Viva Books Pvt. Ltd., 2015.
3. Essentials of Nuclear Chemistry, 2nd ed. by H J Arnikar, Wiley-Eastern, 1982.

Reference Books:

1. Inorganic Chemistry, 3rd ed. by Alan G Sharpe; Pearson Education Ltd., 1992.
2. Chemistry of the Elements, 2nd ed. by Greenwood and Earnshaw, Elsevier Butterworth- Heinemann, 1997.
3. Inorganic Chemistry: Principles of Structure and Reactivity by Huheey, Keiter, Keiter and Medhi, Pearson Education India, 2006.
4. Inorganic Chemistry, 3rd ed. by Miessler and Tarr, Pearson Education, 2008.
5. Advanced Inorganic Chemistry by Cotton, F.A. and Wilkinson, G., Wiley Publishers, New York, 1988.

UCHM-502: Applications of Thermodynamics and Surface Chemistry

3 Credits

Course Objectives:

1. Apply the principles of thermodynamics to understand the behavior of solutions
2. Study electrochemical and phase equilibria starting from thermodynamic principles
3. Relate ideal thermodynamic system models to corresponding real systems
4. Introduction to the principles of surface chemistry

Course Outcomes:

1. Should be able to describe and apply basic thermodynamic principles to analyse ideal and real thermodynamic systems
2. Should be familiar with electrochemical and phase equilibria
3. Should be in a positon to relate ideal thermodynamic system models to corresponding real systems
4. To be able to understand and apply the principles of surface chemistry

Syllabus:

Thermodynamics of Open Systems — 3 hours

Dependence of various extensive variables on composition – partial molar properties, partial molar volume – determination by intercept method; chemical potential and its determination, variation of chemical potential (van't Hoff isotherm and isochore); Gibb's-Duhem equation and applications, expression for chemical potential in terms of U, H, G and A.

Expression for chemical potential of an ideal gas and a real gas; fugacity, fugacity coefficient, derivation of expression for fugacity (effective pressure) in terms of true pressure, derivation of expression for fugacity of a van der Waals gas in terms of true pressure when a is dominant and when b is dominant.

Binary solutions of liquids — 6 hours

Chemical potential of a liquid, Raoult's law – solvent activity and Henry's law – solute activity; real solutions: non-electrolytes – activity and activity coefficients; electrolytes – activity, activity coefficient, mean activity coefficients; expressions for activity in terms of molality and mean activity coefficient.

Gibbs-Duhem-Margules equation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule.

Thermodynamics of mixing — 3 hours

Binary systems-expressions for $\Delta_{mix}G$, $\Delta_{mix}S$, $\Delta_{mix}H$ and $\Delta_{mix}V$ for mixtures of ideal gases, ideal solutions; real solutions – Excess thermodynamic functions, regular solution.

Colligative properties — 6 hours

Thermodynamic derivation of colligative properties using chemical potential – relative lowering of vapour pressure, elevation of boiling point, depression in freezing point, osmotic pressure; applications in calculating molar mass, dissociated and associated solutes in solution, abnormal colligative properties – van't Hoff factor.

Nernst distribution law — 4 hours

Definition, limitations and applications: determination of equilibrium constant and solvent extraction.

Phase equilibrium: — 9 hours

Concept of phases, components and degrees of freedom. Derivation of Gibb's phase rule for non-reactive and reactive systems.

Clausius-Clapeyron equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria.

Phase equilibria for one component system – water system and sulphur system.

Phase equilibria for two component system – solid-liquid equilibria, simple eutectic phase diagram; solid solutions – compound formation with congruent melting point system and incongruent melting point system. Freezing mixtures.

Electrochemistry — 10 hours

Ionics: true electrolytes and potential electrolytes.

Electrolytic conduction: conductance, cell constant, specific conductance (conductivity); equivalent conductance, molar conductivity, variation of conductivity and molar conductivity with dilution for weak and strong electrolytes; molar conductivity at infinite dilution, Kohlrausch law of independent migration of ions and its applications.

Debye-Huckel ionic cloud model (physical idea only). Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only) – molar conductivity & ion-ion interactions – relaxation and electrophoretic effect. Mobility of ions and hydrodynamics, conductivity of H^+ and OH^- ions – chain transfer mechanism.
Transport number, determination by Hittorf method and moving boundary method. Effect of concentration on transport number, abnormal transport number.

Electrodics: Concentration cells with and without transference, liquid junction potential (Ej) for a cell reversible to cation/anion.

Surface chemistry 4 hours

Adsorption – physisorption, chemisorption; adsorption isotherms - Langmuir adsorption isotherm, multilayer adsorption & BET isotherm (derivation excluded).
Heterogeneous catalysis – Langmuir-Hinshelwood and Eley-Rideal mechanism; surface catalysis – steps, terrace, kinks.
Catalytic activity and applications of catalysis – catalytic hydrogenation, catalytic oxidation, catalytic cracking and reforming.

Prescribed Books:

1. Physical Chemistry, 9th ed. by P Atkins and J Paula, Oxford University Press India, 2010
2. A Textbook of Physical Chemistry – Volume 3, 5th ed. by K L Kapoor, McGraw Hill Education (India) Pvt. Ltd., 2015.

Reference Books:

1. Principles of Physical Chemistry by Samuel Maron and Carl Prutton, 4th edition, Oxford and IBH Publishing Co. Pvt. Ltd., 1951.
2. Chemical Thermodynamics by Peter A Rock, University Science Books, 1983.
3. Introduction to Electrochemistry by Samuel Glasstone, East-West Press Pvt. Ltd., 1999.
4. Modern Electrochemistry - Volume 1, 2nd ed. by J O M Bockris and A K N Reddy, Kluwer Academic Publishers, 2002.

UCHM-503: Dynamic Aspects of Organic Chemistry

3 Credits

Course Objectives:

1. To obtain the knowledge of various reactive intermediates and their properties
2. To understand different types of organic reactions and their mechanisms

Course Outcomes:

1. Should be familiar with various reaction intermediates and their generation, structure and reactivity
2. Develop an insight into the mechanistic aspects of pericyclic reactions, molecular rearrangements etc

Syllabus:

Types of organic reactions — 4 hours

Ionic, free radical, concerted and non-concerted reactions - kinetic and thermodynamic control; Experimental methods used for determining the mechanism of organic reactions.

Reactive intermediates — 8 hours

Generation, detection, structure, stability and reactions of Carbocations, Nitrenes, Carbanions, Carbenes, and Arynes.

Pericyclic reactions — 6 hours

Introduction, illustrative examples of electrocyclic reactions, cycloadditions and sigmatropic rearrangements; Frontier molecular orbital approach for understanding pericyclic reactions; an introduction to the principle of conservation of orbital symmetry (Woodward-Hoffman rules).

Mechanisms — 8 hours

Acetal and ketal formation. mechanisms of Perkin, Knoevenagel reactions and Darzen's condensation, Enamines – synthetic applications, Umplong effect – its applications in different synthetic reactions; mechanisms of ester hydrolysis – $A_{Ac}1$, $A_{Ac}2$, $A_{Al}1$, $A_{Al}2$, $B_{Ac}1$, $B_{Ac}2$, $B_{Al}1$, $B_{Al}2$.

Addition to double bond — 2 hours

Mechanism and stereochemistry, nucleophilic addition to conjugated double bonds – Michael reaction.

Reactive methylene compounds — 2 hours

Diethylmalonate and ethylacetoacetate – keto-enol tautomerism, mechanism of Claisen condensation, synthetic applications of diethylmalonate and ethylacetoacetate.

Elimination reactions — 2 hours

E_1, E_2 and E_{1cb} mechanisms.

Linear Free energy relationship — 2 hours

Quantitative approach – Hammett equation – reaction constant and substituent constant.

Molecular rearrangements — 4 hours

Beckmann, Hoffmann, Schidmt, Lossen, Wagner-Meerwin, Pinacol-Pinacolone and Baeyer-Villiger (mechanisms and applications)

Hetero Aromatic compounds — 4 hours

General characteristics and substitution reactions of furan, pyrrole, thiophene and pyridine.

Organosulphur compounds — 3 hours

Nomenclature, structural features, methods of formation and chemical reactions of thiols, thioethers, sulphonic acids and sulphonamides.

Prescribed Books:

1. A Guide book to mechanisms in organic chemistry, 6th ed. by Peter Sykes, Orient Longman, 1981.
2. Advanced Organic Chemistry, 4rd ed. by J. March, Wiley India Pvt. Ltd., 2010.
3. Pericyclic Reactions, 2nd ed. by Ian Fleming, Oxford Chemistry Primers, 2015.
4. Heterocyclic Chemistry, 5th ed. by Raj K Bansal, New Age International Publishers, 2017.
5. Organic Reaction Mechanisms, 4th ed. by V K Ahluwalia and Rakesh K Parashar, Narosa Publications, 2010.

Reference Books:

1. Principles of Organic Synthesis, 3rd ed. by R O C Norman and James M Coxon, CRC Press, 1993.
2. Organic Chemistry, 2nd ed. by Clayden, Greeves, Warren and Wothers, Oxford, 2015.
3. Heterocyclic Chemistry, 2nd ed., J.A. Joule and G.F. Smith, ELBS,1986
4. Advanced Organic Chemistry Part-B, 5th ed. by F Carey and R J Sundberg, Springer, 2007.
5. Organic Chemistry, 5th ed. by Ralph J Fessenden and Joah S Fessenden, Brookscole, 1994.

UCHM-504: Chemistry of Biological Molecules

3 Credits

Course Objectives:

1. Understanding the structure and functional roles of biological macromolecules from a chemistry perspective

Course Outcomes:

1. Gain knowledge about the chemical structure and role of biological molecules (carbohydrates, proteins, lipids and nucleic acids)
2. Should be familiar with mechanism and kinetics of enzyme action
3. Understanding the major role of nucleic acids as a storehouse of information and its role in protein synthesis.

Syllabus:

Carbohydrates — 10 hours

Introduction ; classification, nomenclature of monosaccharides; structure of monosaccharides deduced by Emil-Fisher using glucose as an illustration; reactions of carbonyl, alcoholic groups and anomeric carbon as applicable to sugars; configurations of sugars – determination ascending and descending of series of aldoses – interconversion of sugars; ring structure – evidences, mutarotation – mechanism (acid catalyzed); determination of ring size – Haworth and HIO_4 method – glycosidations, permethylation, periodate oxidation and lead tetra acetate oxidation – limitations of the above methods.

Disaccharides: classification, characteristics and nomenclature; general methods of determination of structure – deduction of structure of sucrose (synthesis not required).

Polysaccharides: classification – brief account of naturally occurring polysaccharides, general methods of determination of structure, deduction of structure of cellulose and starch.

Amino acids, Peptides and Proteins — 10 hours

Introduction to proteins – constituents of proteins, alpha amino acids – structures, classification and important characteristics; acid-base characteristics, reactions of NH_2 and COOH groups important in protein chemistry, colour reactions of R groups – importance in qualitative identification and quantitative analysis; general methods of synthesis of amino acids.

Peptides: peptide linkage – characteristics – evidences in favour of its existence; nomenclature, examples of naturally occurring peptides; structure of peptides – general methods of determination of sequence of amino acids – strategies and applications, identification of N- and C- terminal amino acids; properties of peptides.

Proteins: subunit structure – methods of determination; composition – complete hydrolysis; primary structure of proteins – determination of sequence of amino acids – partial hydrolysis, use of enzymes and related strategies; secondary structure – conformation – helix, pleats, turns, etc.; characteristics and conditions for their stability – determination of helical content, prediction of secondary structures (qualitative account); tertiary structure – characteristics, classifications based on structures – stability; quaternary structures – characteristics.

Enzymes — 10 hours

Definition, general characteristics, comparison with industrial catalysts, specificity – types, origin of specificity – lock and key hypothesis, induced fit theory and Ogstons theory (qualitative account); classification and nomenclature – rules, trivial and systematic name, suitable illustration, enzyme commission number; effect of substrate concentration – Michaelis-Menton equation (deduction for steady state condition); V_{max}, K_m – their determination and importance – Lineweaver-Burke plots; efficiency of enzyme catalysis –qualitative description of factors; holoenzymes – cofactors – metal ions and coenzymes – prosthetic groups; metal activated enzymes and metalloenzymes – examples; roles of metal ions in enzyme catalysis; coenzymes – role in enzyme catalysis – mechanisms; enzyme inhibitors – types – characteristics, biological importance (qualitative treatment only); regulation of enzyme activity (qualitative treatment).
Effect of temperature and pH (qualitative treatment).

Vitamins — 2 hours

Classification of vitamins, examples; structure (determination not required), biological roles – deficiency symptoms.

Lipids 4 hours

Definition, distribution in nature, classification (fatty acids, lipids containing glycerol, lipids not containing glycerol, derived lipids); aggregation of lipids – micelles, bilayers – conditions for their formation; fatty acids – general characteristics and examples of naturally occurring fatty acids, biological roles; lipids containing glycerol – Glycerides – characteristics, oil and fats, characterization of fats (Iodine number, saponification value, RM value, acetyl value), importance of glycerides; phospholipids – types, structures, general characteristics and biological roles – derivatives of phosphatidic acid; sphingo lipids – structures, general characteristics, biological roles.

Nucleic acids 9 hours

Introduction, components, location, types and differences; complete hydrolysis – acid and base hydrolysis; ribonucleosides: determination of structure (no synthesis) of purine and pyrimidine nucleosides, properties, nomenclature; ribonucleotides: types, nomenclature, structure of nucleotides – position of attachment of phosphate (no synthesis).

Polynucleotides: base composition and relationships, Chargaff's rule for 'DNA' – mode of attachment of nucleotides, characteristics, primary structure – Determination – Maxam Gilbert – partial hydrolysis, chemical methods and Sanger's di-deoxy method – DNA polymerase synthesis.

Secondary structure of DNA: double helical structure – evidences which lead to it; success of the double helical structure, important feature of secondary structure; biological role.

RNA types – biological roles, essential structural characteristics, brief description of the base composition, secondary (clover-leaf) structure and tertiary structure of t-RNA. RNA – biosynthesis (transcription) – post transcriptional modifications.

Ribosomes – gross description, essential features, constituents; genetic code, translation – protein synthesis – post translational modifications.

Prescribed Books:

1. Organic Chemistry - Volume II, 5th ed. by I L Finar, ELBS, 1973.
2. Biochemistry by Zubay, Addision-Wesley publishing Company, 1983.
3. Principles of Bio-chemistry, 2nd ed. by A.L. Lehninger, D.C.Nelson and M.M.Cox, Worth Publishers, 1993.
4. Biochemistry, 4th ed. by C. Stryer, W.H. Freeman and company, 1995.

Reference Books:

1. Biochemistry by J D Rawn, Neil Patterson Publishers, International edition, 1989.
2. Principles of Biochemistry Volume I, 7th ed. by A White, P Handler and Smith E L, McGraw Hill, 1978.
3. Principles of Biochemistry, 4th ed. by Conn and Stump F, Wiley Eastern Ltd., 1983.
4. A Text book of Biochemistry, 2nd ed. by Ranganatha Rao K, Prentice Hall, India, 1980.

UCHM-505 (E-I): Quantum Chemistry

2 Credits

Course Objectives:

1. Introduce the elements of quantum chemistry starting from the Schrodinger equation
2. Setting up and solving Schrodinger equation for simple systems
3. Provide a qualitative understanding of the solutions of the Schrodinger equation for hydrogen atom

Course Outcomes:

1. Ability to set up time-independent Schrodinger equation
2. Understanding the concept of operators
3. Calculate the energy levels and transition frequencies for the model problems under study (particle in a box, harmonic oscillator and rigid rotor)
4. Calculate the expectation values for different model problems
5. Plot the radial and angular parts of the wave function for hydrogen atom

Syllabus:

Historical Background to Quantum Mechanics — 8 hours

Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Heisenberg uncertainty principle; Schrodinger wave theory – Schrodinger time-independent equation, nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function.

Operators — 3 hours

Elementary concepts of operators, Eigen functions and Eigenvalues. Linear operators. Commutation of operators; expectation and average value; Hermitian operators, Orthogonality.

Particle in a box — 5 hours

Setting up of Schrodinger equation for one-dimensional box and its solution. Comparison with free particle eigen functions and eigenvalues. Properties of particle in a box wave functions (normalisation, orthogonality, probability distribution). Expectation values of x, x^2, p_x and p_x^2 and their significance in relation to the uncertainty principle. Extension of the problem to two and three dimensions and the concept of degenerate energy levels; Tunnelling.

One dimensional Harmonic Oscillator — 5 hours

Classical harmonic oscillator, conservation of energy of a classical harmonic oscillator, Harmonic oscillator model of a diatomic molecule, Numerical solution of the 1D time-independent Schrodinger equation, The energy levels of a quantum mechanical HO.

Rigid Rotator — 4 hours

The energy levels of a rigid rotator, rigid rotator as a model of a diatomic molecule, wave functions of the rigid rotator – spherical harmonics.

The Hydrogen Atom — 5 hours

Stationary Schrodinger equation for the H-atom in polar coordinates, separation of radial and angular (θ, ϕ) parts; solution of the radial and angular parts, emergence of quantum numbers 'n', 'l' and 'm'; energy expression (without derivation), degeneracy; hydrogenic wave functions (expression only); real wave function; concept of orbitals and shapes of orbitals.

Prescribed Books:

1. Quantum Chemistry, 2nd ed. by Donald A McQuarrie; University Science Books.
2. Quantum Chemistry, 7th ed. by Ira N Levine; Pearson Education India.
3. A Textbook of Physical Chemistry – Volume 5, 5th ed. by K L Kapoor, McGraw Hill Education (India) Pvt. Ltd., 2015.

Reference Books:

1. Quantum Chemistry and Spectroscopy, 3rd ed. by Thomas Engel, Pearson Education.
2. Physical Chemistry, 9th ed. by P Atkins and J Paula, Oxford University Press India, 2010

UCHM-505 (E-II): Environmental and Green Chemistry

2 Credits

Course Objectives:

1. Understand how crucial environment is for the sustenance of life on earth.

Course Outcomes:

1. Knowing the composition of atmosphere and different reaction pathways for environmentally relevant chemical processes.
2. Learning the mitigation strategies for the pollution problems.
3. Realizing the importance of green chemistry and sustainability

Syllabus:

Introduction — 1 hour

Environmental science, technology and chemistry- inter relationship, problems and related solutions.

Air pollutants — 6 hours

(CO_2, SO_2, CO, NOx), acid rain-cause and consequences, Green-house effect-causes and consequences-abatement of green-house effect, Photochemical smog-mechanism of formation-harmful effects- measures to control photochemical smog, Ozone depletion: mechanism and abatement of ozone depletion.

Water pollution — 3 hours

Alkalinity and acidity of water, water pollutants (trace elements, heavy metals, inorganic species, metalloids, organic pollutants, pesticides and radionuclides, Eutrophication- BOD and COD.

Sewage treatment — 5 hours

Primary waste treatment –secondary waste treatment by biological processes- tertiary waste treatment - Photochemical degradation: an eco-friendly approach of waste water treatment – Photochemical principles, Heterogeneous photo-catalysis, homogeneous photo degradation, photo-oxidation, direct photo degradation. Application-removal of hazardous metal ions from water. Water disinfectants – Cl_2, ClO_2 and O_3

Atmospheric analysis — 2 hours

Analysis of particulates-sampling methods, analytical methods involving sample dissolution, direct analysis of Solids.

Water analysis — 7 hours

Trace pollutants-Introduction, Organic Trace Pollutants, Extraction Techniques for Chromatographic Analysis, Gas Chromatography, Liquid Chromatography, Metal ions- Storage of Samples for Metal Ion Analysis, Pretreatment, Atomic Spectrometry, Visible Spectrometry, Anodic Stripping Voltammetry, Liquid Chromatography. Pesticides as water pollutants and analysis, radionuclides in water. Water pollution laws and standards.

Green Chemistry — 6 hours

Introduction and the need for green chemistry and eco-efficiency, Twelve principles of green chemistry - Green chemistry in daily life- examples- dry-cleaning and versatile bleaching agents, green reagents, green catalysts, phase transfer catalysis. Synthesis involving basic principles of green chemistry: Green techniques for synthesis - Ultra sound assisted green synthesis, Microwave mediated green synthesis, Solid state synthesis- examples – synthesis of adipic acid, methyl methacrylate, halide-free synthesis of aromatic amines.

Prescribed Books:

1. Fundamental Concepts of Environmental Chemistry, 3rd ed. by G. S. Sodhi; Narosa Publishing house, 2013.
2. Environmental Chemistry, 2nd ed. by A.K. De, Wiley-Eastern, 1989.
3. New trends in Green chemistry by V.K. Ahluwalia, M. Kidwai, Springer, 2004.

Reference Books:

1. Environmental Pollution by H.M. Dix, John-Wiley, 1981.

2. Environmental Chemistry by Stanley .E. Manahan, 5th Ed., Lewis Publishers, 1991.
3. Chemical and process technology encyclopedia by D.M. Considine, Mc Graw – Hill book company, New York, 1974.
4. Green Chemistry – Theory and Practice by Paul T. Anastas, John C. Warner, Oxford University Press, 2000.
5. Chemistry for green environment by M M Srivastava, Rashmi Sanghi, Narosa publishing house, 2005.

UCHM-506: Laboratory Course in Inorganic and Physical Chemistry

2 Credits

Course Objectives:

1. To perform qualitative analysis of various inorganic cations and anions in the presence of interfering substances
2. To prepare metal complexes
3. Verifications of different laws and theories in physical chemistry
4. To construct phase diagrams and measurements of various physical properties such as optical activity, molar refractivity etc

Course Outcomes:

1. Should be able to perform qualitative analysis of different inorganic cations and anions in a mixture in the presence of interfering substances
2. Should possess the skill to prepare metal complexes
3. Should be able to verify different laws and theories in physical chemistry
4. Should be able to experimentally construct phase diagrams and measure various physical properties of solutions

Syllabus:

1. Qualitative analysis with interfering anions, Systematic semi-micro qualitative inorganic analysis of a mixture containing two anions and two cations and one interfering anion.
   Non-interfering anions: Chloride, Bromide, Iodide, Nitrate, Sulphate and Carbonate
   Interfering anions: Oxalate, Tartarate, Citrate, Acetate, Borate and Phosphate.
   Interfering cations: Pb^{+2} ,Cu^{+2}, Cd^{+2}, Bi^{+3} ,Sn^{+2}, Sb^{+3}, Sn^{+4} ,Fe^{+2}, Fe^{+3}, Al^{+3}, Cr^{+3} ,Ni^{+2}, Co^{+2}, Mn^{+2}, Zn^{+2} ,Ba^{+2}, Ca^{+2}, Sr^{+2} ,Mg^{+2}, Na^+, K^+, NH_4^+
2. Preparation of metal complexes.
3. Phase diagram of a three component system: CH_3COOH-$CHCl_3$-H_2O.
4. Construction of two component phase diagram of simple eutectic and congruently melting systems using cooling curves.
5. Determination of partial molar volume of ethanol in dilute aqueous solution.
6. Polarimetry:
   i. Kinetics of inversion of cane sugar.
   ii. Determination of specific rotation of sucrose.
7. Verification of Nernst distribution law for distribution of benzoic acid/acetic acid/iodine in H_2O and an immiscible organic solvent. Determination of molecular state of the solute in the given phases.
8. Verification of Debye-Huckel-Onsager equation for true electrolyte.
9. Conductometric titration of a mixture of H_2SO_4 - $CuSO_4$ - CH_3COOH against NaOH.
10. Potentiometric titration of a dibasic and a tribasic acid.
11. Determination of molar refractivity of given liquids and calculation of the refractive equivalence of C, H, Cl and O atoms.
12. Determination of molecular weight of Polystyrene by viscosity measurements.
13. Preparation of lyophobic colloids and verification of Hardy-Schulze rule for coagulation of these colloids by the addition of electrolytes.
14. To study the kinetics of base hydrolysis of ester using conductometry (integrated rate law method).
15. Determination of rate law of iodination of acetone using photometry.
16. Determination of the keto-enol ratio of acetoacetic ester by bromination method and calculation of the corresponding equilibrium constant.

***Note**: A minimum of ten experiments from the above list are to be carried out. Any similar experiment conforming to the Syllabus: content of UCHM 501 and UCHM 502 may be considered.*

Prescribed Books:

1. Experimental Physical Chemistry by G.P. Matthews, Clarendon Press, 1985.
2. Experimental Physical Chemistry by V D Athawale, Parul Mathur, New Age International Publishers, 2001.
3. Vogel's Text book of macro and semimicro qualitative inorganic analysis 5th Ed. Revised by G Snehla, Longman, 1979.

UCHM-507: Laboratory Course in Organic Chemistry and Biochemistry

2 Credits

Course Objectives:

1. Introduction to basic synthetic methods and biochemical experiments

Course Outcomes:

1. Should acquire the skills to prepare different organic compounds and familiarity with various biochemical estimations

Syllabus:

1. Preparation of 9, 10-Dihydroanthracene- 9, 10 endo-α,β succinic anhydride.
2. An experiment involving Beckmann rearrangement - rearrangement of benzophenoneoxime.
3. Preparation of enamines and their reaction - preparation of 2- acetyl cyclohexanone.
4. Michael addition reaction - Aniline and maleic anhydride.
5. Hoffmann rearrangement experiment -synthesis of benzanilide.
6. Preparation of a ketal using Dean-Stark apparatus.
7. Phase transfer catalysis : Addition of dichlorocarbene to cylcohexene
8. Kinetic and thermodynamic control of reaction pathways : study of the competitive semicarbazone formation from cyclohexanone and furfural.
9. Preparation of 7-hydroxy 4-methyl-coumarin.using sulphamic acid as a solid catalyst.
10. Claisen Schmidt condensation : Green synthesis of chalcones by grinding
11. Preparation of allyl caproate (pineapple essence).
12. Construction of models to observe the symmetry of reactants and products of electrocyclic reactions.
13. To estimate the percentage of reducing sugar and total reducing sugar in jaggery by Fehlind - Soxhlet method.
14. Isolation of RNA from yeast and estimation of RNA by Orcinol method.
15. To estimate the protein content in peanuts by determination of nitrogen using micro-Kjeldahl method.
16. Qualitative study of sugars, Polysaccharides, Amino acids, Proteins, Lipids
17. Estimation of a protein by Biuret method.(Colorimetry)
18. Studies on the activities of potato acid phosphatase with reference to: a) temperature b) substrate concentration c) pH.
19. To estimate the ascorbic acid content in tomato by modified titrimetric method of Bessay.

***Note**: A minimum of ten experiments from the above list are to be carried out. Any similar experiment conforming to the syllabus content of UCHM 503 and UCHM 504 may be considered.*

References:

1. Techniques and experiments for organic chemistry by Ault, Allyn and Bacon Inc., 4th Ed., 1983.
2. Experimental organic chemistry, Principles and Practice by Laurence M Harwood and Christopher Moody, Blackwell Scientific Publications, 1989.
3. Introduction to organic laboratory techniques a Contemporary approach by Donald Pavia, Gary M. Lampman and George S. Kriz Jr. 2nd Ed., 1982.
4. Reactions and synthesis in the Organic Chemistry Laboratory by L.F. Tietze and T H. Eicher, University Science Books, 1989.
5. Solvent –free Organic Synthesis, Koichi Tanaka, Wiley-VCH, 2003.
6. Natural Products -A Laboratory Guide by Raphael Ikan, 2nd Ed., Academic Press Inc., 1991.
7. Intoduction to Practical Biochemistry by Plummer, David. T. Tata McGraw-Hill Publishing Co., 2006.
8. Qualitative tests and quantitative procedures in biochemistry by Pushpa Sundararaj and Anupama Siddhu, 2nd Ed., Phoenix publishing House Pvt Ltd., 2002.
9. Experimental biochemistry-A student companion by B Sashidhar Rao and V. Deshpande 2nd Ed., Phoenix publishing House Pvt Ltd., 2002.
10. Biochemical methods by S. Sadasivam and A. Manickam, 2nd Ed., New Age International Pvt Ltd., 2005.

UCHM-508: Project / Laboratory Course in Computer Applications-I

2 Credits

Project

Objectives:

1. Learn to carry out Literature survey
2. Identifying and designing a problem

Outcomes:

1. Should acquire the experience to do literature survey
2. Should be able to identify and design research problems

OR

Laboratory Course in Computer Applications-II

Course Objectives:

1. General awareness of computer hardware and operating systems.
2. Introduction to writing programs in C/Java/Python
3. Introduction to molecular modelling using Gaussian software

Course Outcomes:

1. Should have learnt different variable constructs in programming languages
2. Should acquire the skill to write programs to solve small problems in chemistry
3. Ability to apply various computational tools for various applications in chemistry

Syllabus:

a) Introduction to Computers, History of development of computer, Mainframe, mini, micro and super computer systems.
b) General awareness of computer hardware i.e. CPU and other peripheral devices (I/O and auxiliary storage devices).
c) Basic knowledge of computer systems software and programming language. Introduction and functioning of operating systems. Types of operating systems.
d) General awareness of popular commercial software packages for office productivity, chemistry drawing software's, and other scientific applications packages.
e) Introduction to programming: Introduction to programming using Python / C / Java.
f) To develop programs that are useful in solving problems in various fields of chemistry.
g) Gaussian -03 or Gaussian-09
h) Modelling the molecules using Gaussview.
i) Optimization and frequency calculations.
j) Introduction to various ab initio and DFT levels of theory.
k) Conformational analysis of ethane, n-butane and cyclohexane.
l) Calculation of HOMO-LUMO energies, chemical hardness, chemical softness, ionization potential, electron affinity values of a given compound.

References:

1. Exploring 'C' by Yashavant Kanetikar, BPB Publications, 1993.
2. Python for Informatics: Exploring Information by Charles Severance, E-book, www.pythonlearn.org
3. Mastering 'C' by Craig Blon, BPB Publications, 1988.

UCHM-601: Advanced Inorganic Chemistry
3 Credits

Course Objectives:

1. Understanding the chemistry of inorganic and organometallic materials.
2. Understanding crystal structures by applying basic concepts of crystallography

Course Outcomes:

1. Should heave gained knowledge of key concepts of inorganic and organometallic chemistry including those related to synthesis, structure and bonding and reactivity
2. Should be in a position to describe specific crystal structures by applying basic crystallographic concepts

Syllabus:

Solid state chemistry — 20 hours

Solids and their classification, isotropic and anisotropic properties.
Types of crystals – Ionic, covalent, molecular, metallic and hydrogen bonding; crystal lattice and unit cell, crystal systems – BCC, FCC, ECC, Bravais lattices- cubic, orthorhombic, tetragonal, monoclinic, triclinic, hexagonal, trigonal types.
Lattice planes: Lattice planes and their designations - law of rational indices, Weiss indices, Miller indices; Lattice planes in cubic crystals – inter planar spacing and its significance; arrangement in a cubic lattice - assigning atoms.
Diffraction properties: diffraction of X-rays by crystals, the Bragg equation and its significance.
Experimental methods: Bragg X-ray spectrometer and the powder methods; Indexing of lattice planes – structure of NaCl and KCl; density determination from cubic lattice.
Packing: closest packing types – hexagonal and cubical, vacant sites; Ionic solids – Zinc blende, fluorite and rutile.
Radius ratio: definition, effect of ion size, radius ratio for three, four, six and eight coordinate systems.
Crystal defects: Schottky and Frenkel defects, colour centers – metal deficiency, interstitial ions and electrons.

Mechanistic Inorganic chemistry — 9 hours

Substitution reaction mechanism in octahedral and square planar complexes; trans effect (square planar complex), cis-effect (octahedral complex), insertion reaction, oxidative addition and reductive elimination reactions; mechanism of typical industrially important reactions (symmetric and asymmetric hydrogenation, hydroformylation reaction, Wacker's process, Monsanto acetic acid process).

Organometallic chemistry — 6 hours

Introduction, classification based on hapticity and M-C bond connectivity, the 18 electron rule and its application to metal carbonyl complexes e.g. $Cr(CO)_6$, $Ni(CO)_4$,$Fe(CO)_5$, $Fe_2(CO)_9$, $Mn_2(CO)_{10}$, $Fe_3(CO)_{12}$. Schematic molecular energy level diagram of CO. π-acceptor behaviour of CO, synergistic effect (schematic representation of the orbital overlaps leading to M-CO bonding).
Metal nitrosyl complexes – $Fe(CO)_2(NO)_2$ and $Co(CO)_3(NO)$; metal carbene complexes –$(OC)_5W{=}C(R)$ (OMe); Metallocenes – ferrocene – structure, synthesis and its reactions.

Bioinorganic chemistry — 10 hours

Essential and trace elements of life; basic reactions in biological systems and the role of metal ions e.g. Fe^{2+}, Fe^{3}+, Cu^{2+}, Zn^{2+}; structure and function of haemoglobin and myoglobin and carbonic anhydrase. Chlorophyll, structure and role in photosynthesis.

Prescribed Books:

1. Basic Solid State Chemistry by A R West, John Wiley & Sons Inc., 1999
2. Inorganic Chemistry, 4th ed. by J E Hueey, E A Keiter and R L Keiter, Harper Collins College Publishers, 1993.
3. Inorganic Chemistry, 3rd ed. by Miessler and Tarr, Pearson Education, 2008.

Reference Books:

1. A Textbook of Physical Chemistry by A S Negi and S C Anand, New Age International, 1985.
2. Advanced Inorganic Chemistry, 5th ed. by F A Cotton and G Wilkinson, Wiley New York, 1988.
3. Inorganic Chemistry, Gary Wulfsberg, Viva Books Private Limited, 2016.
4. Inorganic Substances, Derek W Smith, Cambridge University Press, 1990.

UCHM-602: Analytical Chemistry

3 Credits

Course Objectives:

1. To understand various quantitative methods of estimation using wet chemical methods such as gravimetry, titrimetry etc and analytical instrumentation such as electroanalytical techniques etc

Course Outcomes:

1. Should have the knowledge of various quantitative methods of analysis including wet chemical and instrumental methods
2. Interpretation of analytical data and its significance.
3. Insight of analytical signals as indicative of analyte presence, analyte concentration and chemical reactions happening.

Syllabus:

Introduction — 3 hours

Evaluation of analytical data-types of errors in analytical results; Determinate and indeterminate errors and their effect on precision; significant figures and computation.

Gravimetry — 6 hours

Theory of gravimetric analysis – precipitation methods - colloidal state - super saturation and precipitate formation, purity of the precipitate - co-precipitation, post precipitation-conditions of precipitation, washing of the precipitate and ignition of the precipitate, precipitation from homogenous solution, selective and specific precipitating agents including organic precipitants.

Titrimetric Analysis — 2 hours

Theory of precipitation and complexometric titrations (including their theory of indicators)-Types of EDTA titrations, Masking and demasking agents.

Separation Techniques — 7 hours

Principles and practice of partition and adsorption chromatography, Gas-liquid chromatography – HPLC - gel chromatography – affinity, Ion exchange and molecular sieve chromatography.

Thermal analysis — 4 hours

Thermogravimetry – introduction, experimental factors and applications. Differential thermal analysis (DTA) and differential scanning calorimetry (DSC) – introduction, experimental and instrumental factors, applications, and determination of the degree of conversion of high alumina cement. Thermometric titrations – introduction, theory, instrumentation and applications.

Electroanalytical techniques — 10 hours

Voltammetry – principle involved, voltammogram, half-wave potential equation of the voltammographic wave – limiting current, migration current, residual current; supporting electrolytes to eliminate migration current.
Polarography – principle involved, polarogram, factors affecting diffuse current - migration current, residual current, supporting electrolyte to eliminate migration current.
Ilkovic equation, salient features of a polarogram – polarographic wave, wave height, half wave potential, polarographic maxima. Advantages and disadvantages of dropping mercury electrode.
Pulse voltammetry – Normal, differential and square wave voltammetry.
Amperometry: Amperometric titration's - principle involved and advantages.

Electrogravimetric and Coulometric methods — 6 hours

Effects of current on cell potentials, Ohmic potential -polarization effects - potential selectivity of electrolytic methods, Electrogravimetry methods of analysis - types of electrogravimetry, instrumentation, application of electrogravimetry.
Coulometric methods of analysis - quantity of electricity - types of coulometric methods, controlled potential coulometry - application of controlled potential coulometry, Coulometric titrations - application of coulometric titrations.

Kinetic methods — 3 hours

Catalyzed reactions -experimental methods - types of kinetic methods applications of kinetic methods, Non-catalyzed reactions - the kinetic determination of components in a mixture, Enzymatic reactions-single substrate processes.

Nuclear methods	4 hours
Applications of radioisotopes as tracers (chemical, analytical, medicinal, agricultural, industrial and archaeological), Counting statistics-Counting techniques such as GM, ionization scintillation and proportional counters.	

Prescribed Books:

1. Principles of Instrumental Analysis, 5th ed. by D A Skoog, F J Holler and T A Nieman, Saunders College Publishing, 1998.
2. Fundamentals of Analytical Chemistry, 5th ed. by D A Skoog, D M West and F U Holler, Saunders, 1988.
3. Vogel's Text Book of Quantitative Inorganic Analysis by J. Bassett, et.al; ELBS 1978.

Reference Books:

1. Contemporary Chemical Analysis by R F Robinson and K A Robinson, Prentice Hall, 1998.
2. Analytical Chemistry, 5th ed. by G D Christian, Wiley. 1986.

UCHM-603: Synthetic Organic Chemistry

3 Credits

Course Objectives:

1. Understanding of various organic synthetic reactions used in multistep synthesis
2. Understanding of the usage of various specialized reagents and their applications in organic synthesis
3. Introduction to retrosynthesis and various techniques in total synthesis
4. Introduction to supramolecular chemistry

Course Outcomes:

1. Should have gained knowledge of useful reactions and reagents and their applications in multistep organic synthesis
2. Use of retrosynthetic approach and its application in designing total synthesis of organic compounds
3. Should be familiar with supramolecular chemistry

Syllabus:

Introduction — 9 hours

Scope and objectives, facets of multi-step synthesis, diminishing yields – region- and stereo-control - illustrative examples; strategies in multistep synthesis - protection and deprotection of sensitive functional groups such as hydroxyl, amino, carboxyl and carbonyl functions.

Important reactions of synthetic value — 10 hours

Different methods of catalytic hydrogenation; use of complex metal hydrides ($LiAlH_4$, $NaBH_4$ and DIBAL-H), Birch reduction, hydroboration; oxidation using CrO_3, silver carbonate - Oppenauer oxidation; Robinson annulation reaction.

Special reagents in organic synthesis — 12 hours

Organometallic reagents (organo- lithium, zinc, copper); use of DCC and dimethyl sulphoxide; reactions of phosphorous and sulphur ylides; polymer supported reagents – Merrifield solid phase peptide synthesis; Oxidizing agents like selenium dioxide, osmium tetroxide, lead tetraacetate, periodic acid.

Photochemical organic synthesis — 4 hours

Photochemical reactions - quantum yield - primary quantum yield, over all quantum yields; photosensitization; Jablonski diagram; Paterno - Buchi reaction.

Designing of organic synthesis — 5 hours

A programmed introduction to disconnection approach, use of synthons - types of transform; examples: saccharine, limonene, paracetamol, salbutamol and dimedone.

Total synthesis — 3 hours

Total synthesis of the natural products: Z-Jasmone, Pencillin V and (-) Khusimone.

Supramolecular chemistry — 2 hours

Introduction, host guest chemistry, cation, anion and neutral molecules binding hosts.

Prescribed Books:

1. Guidebook to Organic Synthesis, 3rd ed. by R K Mackie, D M Smith and R A Aitken, Longman group, 2000.
2. Principles of Organic Synthesis, 3rd ed. by R O C Norman and James M Coxon, CRC Press, 1993.
3. Organic Reaction Mechanisms, 4th ed. by V K Ahluwalia and Rakesh K Parashar, Narosa Publications, 2010.
4. Introduction to Organic Photochemistry by J D Coyle, John-Wiley, 1986.
5. Organic Synthesis - The Disconnection Approach, 3rd ed. by Stuart Warren and Paul Wyatt, Wiley, 2008.

Reference Books:

1. Organic Chemistry, 5th ed. by S H Pine, McGraw-Hill International Ed., 1988.
2. Organic Synthesis, 2nd ed. by J Fuhrhop and G Penzhir, VCH, 1994.
3. Organic Chemistry, 2nd ed. by Clayden, Greeves, Warren and Wothers, Oxford, 2015.
4. Modern Methods of Organic Synthesis 3rd ed. by W Carruthers, Cambridge University, 1996.

UCHM-604: Applications of Spectroscopy

3 Credits

Course Objectives:

1. Understand the instrumentation and principles of UV-Vis, IR, NMR and mass spectrometry
2. Interpretation of spectra of organic molecules

Course Outcomes:

1. Should be familiar with the instrumentation and principles of UV-Vis, IR, NMR and mass spectrometry
2. Solve problems related to the structure, purity and concentration of compounds
3. Deduce the structure of organic compound using UV-Vis, IR, NMR and mass spectrometric data

Syllabus:

Introduction — 3 hours

Energy and electromagnetic spectrum; absorption and emission spectroscopy – a comparison; molecular formula and structural correlation.

Elemental analysis: molecular mass and formula determination; Index of hydrogen deficiency – rule of thirteen.

Ultraviolet – Visible spectroscopy — 8 hours

The nature of electronic excitations – type of radiation absorbed and its effect on the molecule; Electronic energy levels – orbitals involved in electronic transitions – chromophore concept; Laws of light absorption: Beer – Lambert's law and its quantitative application and limitations; Sources of UV radiation – sample and reference cells used – solvents and solutions – solvent effects – vacuum UV Region; bathochromic, hypsochromic, hyperchromic and hypochromic shifts; effect of conjugation.

Woodward - Fieser rules for calculation of λ_{max} of dienes (excluding polar group substituents) – Woodward rules for enones (polar substituents –OH, $–OCH_3$, –Cl, –Br); Fieser – Kuhn rules for determining λ_{max} and ε_{max} of polyenes.

Infra-Red spectroscopy — 11 hours

Theory: IR absorption process, IR spectrum – complexities; Fundamental absorptions, overtones, combination bands, difference bands, Fermi resonance bands; IR spectrum as a molecular finger print; modes of stretching and bending – calculation of vibrational frequencies – Hooke's law; Sampling techniques – infrared sources, monochromators, detectors used; factors influencing vibrational frequency – hydrogen bonding, electronic effects, inductive and mesomeric effects – bond angles and field effects.

Application of IR spectroscopy: Analysis of IR spectral data, identification of the following functional groups: alkanes, alkenes, alkynes, aromatic compounds, carbonyl compounds – (amides, carboxylic acids, ketones, aldehydes, esters, anhydrides, acid chlorides), hydroxy compounds (alcohols, phenols), ethers, nitrogen compounds (amines, nitriles).

Nuclear Magnetic Resonance — 11 hours

Theory of NMR – nuclear spin states, nuclear magnetic moment, mechanism of absorption of energy (resonance), population density of nuclear spin states – precessional (Larmor) frequency.

Chemical shift and its measurement: Internal standards in NMR, NMR spectrometer, units used in NMR spectroscopy; factors influencing chemical shift – electronegativity, shielding and de-shielding – van der Waals de-shielding, magnetic anisotropic effects in alkene, alkynes, carbonyl compounds (ketones and aldehydes) – ring protons.

Choice of solvents for PMR, position, intensity, multiplicity of peaks, integrals in PMR; theory of spin-spin coupling, spin-spin splitting tree (proton only); coupling constants – importance; Pascal's triangle; first-order spectra – AX, AX_2 and AX_3 coupling cases; magnetically equivalent protons – coupling constants in aliphatic, aromatic and alkene systems; detailed analysis of PMR spectral data of organic compounds; Illustration by means of solving problems.

Mass spectrometry — 8 hours

Theory, utility of technique, basic principles, isotope abundance, base peak, nitrogen rule, recognition of molecular ion; meta stable ions – calculation of apparent mass – significance –mass spectrometer; fragmentation: general rules for predicting prominent peaks in mass spectra; McLafferty rearrangement in the case of carbonyl compounds; mass spectra and fragmentation pattern of the following classes of organic compounds: Aliphatic hydrocarbons, aromatic hydrocarbons, alcohols, phenols, ethers, ketones, aldehydes, carboxylic acids, esters, anhydrides, amines, amides, nitriles, nitro compounds, and halides; Illustrations of mass spectral analysis with the help of problems.

Spectrometric identification of organic compounds — 4 hours

Application of UV-VIS, IR, NMR and Mass spectroscopic techniques in the determination of structure of organic compounds (solving combined problems).

Prescribed Books:

1. Organic Spectroscopy, 3rd ed. by William Kemp, Macmillan, 1991.
2. Introduction to Spectroscopy, 2nd ed. by Donald Pavia, Gary M Lampman, George S Kriz, Saunders college publishing, 1996.
3. Spectrometric Identification of Organic Compounds, 6th ed. by R M Silvenstein, Francis X Webster, John Wiley and sons, 2002.
4. Structural Methods in Inorganic Chemistry, 2nd ed. by E A V Ebsworth, D W H Rankin and S Cradock, Blackwell Publishing, 1991.

Reference Books:

1. Principles of Instrumental Analysis, 5th ed. by Douglas A Skoog, James Holler and Timothy A Niemen, Saunders college publishing, 1998.
2. Physical Methods in Inorganic chemistry by R. S. Drago, East-West, 1968.
3. Spectroscopic Techniques for Organic Chemistry by Cooper, Wiley - Interscience, 1980.

UCHM-605 (E-I): Theoretical Aspects of Spectroscopy

2 Credits

Course Objectives:

1. Introduce molecular spectroscopy through an account of the interaction of radiation with matter
2. Present a theoretical description of the principles of spectroscopy

Course Outcomes:

1. Understand the elementary theoretical principles of vibrational, rotational, electronic and magnetic resonance spectroscopy
2. Calculate electronic transitions in specific molecules

Syllabus:

Introduction — 2 hours

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

Rotational spectroscopy — 4 hours

Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy — 5 hours

Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Vibration-rotation spectroscopy — 2 hours

diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy — 3 hours

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

Electronic spectroscopy — 4 hours

Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance spectroscopy — 6 hours

Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales (δ and τ), spin-spin coupling and high resolution spectra, Applications of NMR.

Electron Spin Resonance spectroscopy — 4 hours

Principle of ESR spectroscopy, hyperfine structure, ESR of simple radicals.

Prescribed Books:

1. Fundamentals of Molecular Spectroscopy, 4th ed. by C N Banwell and E M McCash, Tata McGraw-Hill, New Delhi, 2006.
2. Introductory Quantum Chemistry by A K Chandra, Tata McGraw-Hill, 2001.

Reference Books:

1. Fundamentals of Quantum Chemistry, 2nd ed. by J E House, Elsevier, USA, 2004.
2. Quantum Chemistry by J P Lowe and K Peterson, Academic Press, 2005.
3. Atomic & Molecular Spectroscopy by R Kakkar, Cambridge University Press, 2015.

UCHM-605 (E-II): Materials of Industrial Importance

2 Credits

Course Objectives:

1. Introduction to Nanotechnology
2. Emphasize on the fact that chemical science is the fulcrum for all materials and their use in various industrial applications

Course Outcomes:

1. Should be introduced to nanotechnology and its applications
2. Should be familiar with the preparation and applications of materials important in industrial and agriculture sectors.

Syllabus:

Nanotechnology and applications — 3 hours

Introduction to carbon nanotubes, forces acting at nanoscale, nano-bio interface-nano medicine, nanotoxicology, nanofabrication, photomedicine: Introduction to DNA damage by UV radiation – photodynamic therapy of tumor, Nano devices.

Glass — 5 hours

Raw materials (glass forming substances, fluxes and stabilizers) and secondary components (refining agent, decolorants, colorants, opacifiers) - Classification of glasses - fused silica, alkali silicates, sodalime glass, lead glass, borosilicate, alumina silica ,fiber glass, special glasses (colored ,opal, translucent, safety, photo form, optical and photo chromic silica glass -

Properties of glass influenced by glass composition – applications - glass fibers and glass wool.

Ceramics — 5 hours

Classification-silicate, oxide and non-oxide ceramics-basic and secondary components of ceramics - Classification of clay minerals-structure of Kaolinite and montmorillonite silica - and its role in ceramics - Refractories: classification – acid, neutral and basic refractories – properties governing the use of refractories.

Polymers — 8 hours

Importance of polymers-basic concepts-monomers-repeat units-degree of polymerization-linear, branched and network polymers, Types of polymers-classification based on Thermoset and Thermoplastics.

Structure and properties: Crystalline polymers – crystallization and melting. Polymer structure and physical properties – crystalline melting point Tm - effect of chain flexibility and other stearic factors, entropy and heat of fusion. Glass transition temperature, T_g - relationship between T_m & T_g

Polymer processing — 4 hours

Classification based on methods of preparation and properties - elastomers, fiber forming , thermoplastics and thermosetting – typical examples – synthesis and applications of alkeneic polymers, rubbers , phenol - formaldehyde & urea - formaldehyde resins, polyurethanes - processing of polymers (chemical additives and methods) extrusion and molding- concepts

Fertilizers — 5 hours

Classification- organic fertilizers, inorganic/commercial fertilizers.

Inorganic fertilizers- phosphorous containing fertilisers -superphosphate –triple superphosphate-ammonium phosphate-nitro phosphate -Nitrogen containing fertilisers-ammonium sulphate- urea. Potassium containing fertilisers -potassium chloride- potassium sulphate –potassium nitrate.

Organic fertilizers- Benefits of organic fertilizers-disadvantages of complex fertilizers-comparison with inorganic fertilizers-examples of organic fertilizers-organic fertilizers sources (animal, plant and mineral).

References:

1. Chemical Process Industries by Shreve & Brink, 4th Ed., Mc Graw Hill, 1977.
2. Organic Chemistry, Vol-I by I.L. Finar, 6th Ed., ELBS 1969.
3. Organic Chemistry by J.D. Roberts and M.C. Caserio, 3rd Ed., W.A. Benjamin Inc., 1965.
4. Industrial Chemistry by E. Stocchi, Ellis Horwood series, 1990.

5. Industrial Inorganic chemistry, Buchner, Schlieb, Winter, Buchel, VCH series, 1989.

UCHM-606: Laboratory Course in Inorganic and Analytical Chemistry

2 Credits

Course Objectives:

1. Different types of estimations using gravimetry, titrimetry and electrochemical methods
2. Study of inorganic complexes using UV-Vis and IR spectroscopy
3. Separation and estimation of inorganic mixtures

Course Outcomes:

1. Should be able to perform different types estimations using gravimetric, titrimetric and electrochemical methods
2. Should be able to record and interpret UV-Vis and IR spectra of inorganic complexes
3. Should be able to separate and estimate various inorganic mixtures

Syllabus:

1. Determination of Chromium (III) and Iron (III) with EDTA.
2. Determination of Cadmium Polarographically.
3. Preparation of an octahedral complex - $[Cu(NH_3)_4(H_2O)_2]SO_4$
4. Determination of fluoride in water with the aid of cation exchanger.
5. Simultaneous spectrophotometric determination of chromium and manganese.
6. Estimation of Manganese in steel spectrophotometrically.
7. Analysis of solder by complexometric titrations.
8. Estimation of aluminum by homogenous precipitation technique using Oxine reagent.
9. Gravimetric estimation of Nickel by DMG.
10. Separation and estimation of Copper and Nickel (complexometry /gravimetry).
11. Separation of Inorganic mixture by column chromatography.
12. Analysis of haemetite.
13. To determine the amount of copper in a given solution using standard sodium thiosulphate iodometrically.
14. Standardization of hypo with standard potassium dichromate solution.
15. Determination of temporary and permanent hardness of water with EDTA.
16. Estimation of iodine in an iodized common salt with iodometry.
17. Estimation of the amount of calcium in milk powder complexometrically using EDTA.
18. Study of Fe(III)/Fe(II) redox system using cyclic, differential pulse and square wave voltammetry.
19. Study of inorganic complexes using Fourier-Transform Infra-red spectroscopy.
20. Study of inorganic complexes using UV-VIS spectroscopy.
21. EDTA Titrations for determination of
22. Nickel (II) by EDTA direct titration.
23. Aluminium (III) by EDTA back titration.
24. Calcium (II) by EDTA titration based on indicator for an added metal ion.
25. Determination of fluoride in selected samples by potentiometric method using fluoride ion selective electrode (Tea, salt, tooth paste and samples from living systems)..
26. To study the effect of concentration and scan rate on the Fe(III)/Fe(II) redox system by cyclic voltammetry using electrochemical workstation.

***Note**: A minimum of ten experiments from the above list are to be carried out. Any similar experiment conforming to the syllabus content of UCHM 601 and UCHM 602 may be considered.*

References:

1. Vogel's Text Book of Quantitative Inorganic Analysis, 5^{th} Ed., ELBS, 1994.
2. B.Sc. Chemistry Experiments by Vasudev Bhatt, B.Srikant and M.S.Hegde, Talent Development Centre, Indian Institute of Science, Challakere, Karnataka, 2016.
3. Practical Inorganic Chemistry: Preparations, reactions and instrumental methods by G. Pass, 2^{nd} Ed., Springer, 2013.

UCHM-607: Laboratory Course in Synthetic Organic Chemistry and Spectroscopic Techniques

2 Credits

Course Objectives:

1. Introduction to spectrophotometric estimations and recording UV and IR spectra of organic compounds
2. Familiarize students with various organic preparations and some green chemistry methods

Course Outcomes:

1. Should gain knowledge about spectrophotometric estimations and recording UV and IR spectra
2. Students should be able to synthesize simple organic compounds and understand green chemistry principles

Syllabus:

1. To test the validity of Lambert- Beer's law for $K_2Cr_2O_7$ system and determination of concentration of the given solution.
2. Determination of leaching of aluminum from low quality aluminum vessels by spectrophotometric technique i.e., Eriochrome cyanine R method.
3. Determination of pK values of indicators using spectroscopy
2. Structural characterization of organic compounds by Infra-red spectroscopy
3. To record UV-VIS spectra of a compound: Plot of transmittance vs wavelength and plot of absorbance vs wavelength.
4. Preparation of the following compounds:
   a) Luminol
   b) Dimedone (5,5 Dimethyl-1,3- cyclohexanedione).
   c) 1,3: 4,6- D- O-benzylidene-O-mannitol
   d) Benzyltrimethylammonium chloride and its use to prepare Mandelic acid
   e) 2-Amino 4,6- diarylbenzene-1,3-dicarbonitrile under solvent free conditions.
   f) Biodiesel from waste oil
   g) Dialkoxypropanes in simple ammonium ionic liquids
   h) m-nitroacetophenone and chemoselectivity in its reduction.
   i) Calix[4]resorcinarence
   j) Malachite green
5. Synthesis of a ketone by solvent free oxidation of an alcohol using solid support MnO_2 under microwave irradiation.
6. Reduction of Camphor by Sonication.
7. Synthesis of a flavone
8. Photo reduction of benzophenone.

***Note**: A minimum of ten experiments from the above list are to be carried out. Any similar experiment conforming to the syllabus content of UCHM 603 and UCHM 604 may be considered*

References:

1. Introduction to organic laboratory techniques a Contemporary approach, Donald Pavia , Gary M. Lampman and George S. Kriz Jr. 2nd Ed., 1982
2. Techniques and experiments for organic chemistry 4thEd., Addition Ault, Allyn and Bacon Inc. 1983.
3. Experimental organic chemistry , Principles and Practice, Laurence M Harwood and Christopher Moody, Blackwell Scientific Publications, 1989.
4. J W Huffman, W Liao and R H Wallace, Terahedron Lett., 28, 3315(1987).
5. Organic synthesis, Special techniques, 2nd Ed., V K Ahluwalia and Renu Aggarwal, Narosa Publishing House, 2007.
6. Don Bladt et al., Journal of Chemical Education, 88(2), 203 (2010).
7. Hui Jiang et al., Green Chemistry, 8, 1076-1079 (2006).
8. L Ropel et al., Green Chemistry, 7, 83 (2005).
9. Intermediate for Organic Synthesis, V K Ahuwalia, Pooja Bhajat, Renu Aggarwal and Ramesh Chandra, I K International, 2005.

10. Solvent –free Organic Synthesis, Koichi Tanaka, Wiley-VCH, 2003.
11. Experimental Organic Chemistry by P.R. Singh, D.S. Gupta and K.S. Bajpai, Vols I & II, Tata McGraw Hill, 1980.
12. Introduction to Organic Laboratory Techniques by D.L. Pavia, G.M. Lampman, and G.S. Kriz, 3rd ed., Saunders College Publishing, 1999.

UCHM-608: Project / Laboratory Course in Computer Applications-II

2 Credits

Project

Objectives:

1. Planning and performing experiments independently
2. Scientific approach to working on a research problem

Outcomes:

1. Should possess the ability to plan and perform experiments
2. Should have the ability to think independently and have gained experimental skills
3. Should have the learnt the scientific approach of working towards a research problem

OR

Laboratory Course in Computer Applications-II

Course Objectives:

1. Exposure to computer based productivity tools
2. Introduction to writing programs in C/Java/Python
3. Introduction to molecular modelling using Gaussian software

Course Outcomes:

1. Ability to use spreadsheet software to calculate and plot problems in chemistry
2. Should have learnt various variable constructs in programming languages
3. Should be in a position to write programs to solve small problems in chemistry
4. Ability to apply studied computational tools for various applications in chemistry

Syllabus:

1. Exposure to computer based productivity tools
   a. Introduction to Presentation software
   b. Introduction to Spreadsheet software
   c. Introduction to database management software.
2. Introduction to programming languages: C / Python / Java. To develop programs for solving problems in chemical kinetics, thermodynamic, electrochemistry, distribution law, etc.
3. Gaussian-03 or Gaussian-09:
   a. Transition state calculations for various reactions.
   b. Intrinsic reaction coordinate (IRC) calculations to understand the reaction
   c. Calculation of the vibrational frequencies and comparing the computationally
   d. Calculation of the strength of hydrogen bonding between the donor and acceptor
   e. Mini project on the reaction mechanisms and the effect of various substituents on the reaction path using experimental FTIR results and Natural Bond Orbital (NBO) analysis.

References:

1. Exploring 'C' by Yashavant Kanetikar, BPB Publications, 1993.
2. Python for Informatics: Exploring Information by Charles Severance, E-book, www.pythonlearn.org
3. Mastering 'C' by Craig Blon, BPB Publications, 1988.