SOMAIYA VIDYAVIHAR

K J Somaiya College of Science & Commerce

Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

Learning Outcomes based Curriculum Framework

(LOCF)

For

T.Y.B.Sc. Chemistry

Undergraduate Programme

From

Academic year

2023-24

SOMAIYA VIDYAVIHAR
K J Somaiya College of Science & Commerce
Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

Board of studies in Chemistry

Undergraduate and Post graduate

	Name	Designation	Institute/Industry
Head of the Department			
1	Dr. Bright O. Philip	HOD and Chairman	K J Somaiya college of science and commerce
Subject Expert nominated by Vice-Chancellor			
1	Prof. B. M. Bhanage (Inorganic chemistry)	Professor, Industrial and Engineering chemistry	ICT, Mumbai
Subject experts			
1	Prof. Suresh Pawar	Professor, Chemistry	University of Mumbai
2	Dr. Brijesh Singh	HOD and Associate Professor, Chemistry	Jai Hind College, Mumbai
3	Dr. Kalpana Jain	HOD and Associate Professor, Chemistry	B.N.N. College, Bhiwandi
4	Dr. P.A. Hassan	Scientist	BARC
Representative from Industry/corporate sector/allied area			
1	Dr. Ajit Datar	Advisor	Shimadzu Analytical (I) Pvt. Ltd, Mumbai
2	Dr. Ranjan Mogre	MD	Avtos Life Sciences Pvt. Ltd, Mumbai
Meritorious Alumnus			
1	Dr. Druman Utekar	Assistant Professor	K J Somaiya College of Engineering, Vidyavihar
2	Dr. Rajesh Rajshrike	Technical Manager	BASF
3	Dr. Rikhil Shah	Lead Analyst- Intellectual Property	Avient Corporation

Faculty of the specialisation			
1	Dr. Pradnya. J. Prabhu	Principal	K J Somaiya college of science and commerce
2	Dr. Sugandha Shetye	Associate Professor	K J Somaiya college of science and commerce
3	Dr. Chitra Kamath	Associate Professor	K J Somaiya college of science and commerce
4	Dr. Veena Khilnani	Associate Professor	K J Somaiya college of science and commerce
5	Dr. Nishamol Kanat	Associate Professor	K J Somaiya college of science and commerce
6	Dr. Yogesh Ghalsasi	Associate Professor	K J Somaiya college of science and commerce
7	Dr. Vanita Kulkarni	Associate Professor	K J Somaiya college of science and commerce
8	Dr. Saurabh Shete	Assistant Professor	K J Somaiya college of science and commerce
9	Dr. Trupti Tawde	Assistant Professor	K J Somaiya college of science and commerce
10	Dr. Rohit S. Chauhan	Assistant Professor	K J Somaiya college of science and commerce
11	Dr. Aniket Pawanoji	Assistant Professor	K J Somaiya college of science and commerce
12	Dr. Nanabhau Karanjule	Assistant Professor	K J Somaiya college of science and commerce
13	Dr. Dilip Kumar Yadav	Assistant Professor	K J Somaiya college of science and commerce

14	Dr. Afsar Ali Siddiki	Assistant Professor	K J Somaiya college of science and commerce
15	Dr. Mithun Mondal	Assistant Professor	K J Somaiya college of science and commerce
16	Mr. Jaidip Wable	Assistant Professor	K J Somaiya college of science and commerce
17	Dr. Amol Pawar	Assistant Professor	K J Somaiya college of science and commerce
18	Mrs. Meenakshi Wagh	Assistant Professor	K J Somaiya college of science and commerce
19	Mr. Sarang Gujar	Assistant Professor	K J Somaiya college of science and commerce

7.3 T. Y. B.Sc. Syllabus [6 Units] with effect from the Academic year 2023–2024

Syllabus – T. Y. B.Sc. Chemistry [6 Units]

Course No.	Course Title	Course code	Credits	Hour	Periods (50 min)	Module	Lectures per module (50 minutes)	Examination		
								Internal Marks	External Marks	Total Marks
SEMESTER V										
Core courses THEORY										
I	Physical Chemistry III	23US5 CHCCI PHC3	2	30	36	3	12	40	60	100
II	Inorganic Chemistry III	23US5 CHCC 2INC3	2	30	36	3	12	40	60	100
III	Organic Chemistry III	23US5 CHCC 3ORC3	2	30	36	3	12	40	60	100
IV	Analytical Chemistry I	23US5 CHCC 4ANCI	2	30	36	3	12	40	60	100
Core courses PRACTICAL										
CCP I	Based on CC I and CC IV	23US 5CHC CP1	2	4	48			40	60	100
CC P II	Based on CC II and CC III	23US5 CHCC P2	2	4	48			40	60	100

Discipline Specific Electives THEORY										
I/II	Fundaments of drug chemistry OR Essentials of radiation chemistry	23US5CHDS1FDC Or 23US5CHDS2ERC	2	30	36	3	12	40	60	100
III/IV	Research methodology in chemistry OR Environmental chemistry	23US5CHDS3RMC Or 23US5CHDS4ENC	2	30	36	3	12	40	60	100
Discipline Specific Electives PRACTICAL										
DSE P	Practical Based on DSE Courses	23US5CHDSP	2	4	48			40	60	100
Skill Enhancement Course										
I/II	Business skills for Chemists OR Food Chemistry	23US5CHSE1BSC Or 23US5CHSE2FOC	2					40	60	100

SEMESTER VI										
Core courses THEORY										
I	Physical Chemistry IV	23US6CHCCIPHC4	2	30	36	3	12	40	60	100
II	Inorganic Chemistry IV	23US6CHCC2INC4	2	30	36	3	12	40	60	100
III	Organic Chemistry IV	23US6CHCC3ORC4	2	30	36	3	12	40	60	100
IV	Analytical Chemistry II	23US6CHCC4ANC2	2	30	36	3	12	40	60	100
Core courses PRACTICAL										
CC P I	Based on CC I and CC IV	23US6CHCCPI	2	4	48			40	60	100
CC P II	Based on CC II and CC III	23US6CHCCP2	2	4	48			40	60	100
Discipline Specific Electives THEORY										
I/II	Introduction to dyestuff chemistry OR Pesticide chemistry	23US6CHDSIIDC or 23US6CHDS2PSC	2	30	36	3	12	40	60	100
III/IV	Polymer OR	23US6CHDS3PLC	2	30	36	3	12	40	60	100

	Industrial Chemistry	Or 23US6 CHDS4 INC								
Discipline Specific Electives PRACTICAL										
DSE P	Practical Based on DSE Courses	23US6 CHDSP	2	4	48			40	60	100
Skill Enhancement Course										
I/II	Chemistry of Cosmetics OR Dairy Chemistry	23US6 CHSE1 COC Or 23US6 CHSE2 DAC	2					40	60	100

** Skill enhancement courses may have theory or may have only practical component.

Credit distribution for T.Y.B.Sc. Chemistry

Semester	Course number	Course title	Credits		
			Theory	Practical	Total
V 6 Units	CC I	Physical Chemistry III	2	1	3
	CC II	Inorganic Chemistry III	2	1	3
	CC III	Organic Chemistry III	2	1	3
	CC IV	Analytical Chemistry I	2	1	3
	DSE I/II	Fundaments of drug chemistry or Essentials of radiation chemistry	2	1	3
	DSE III/IV	Research methodology in chemistry or Environmental chemistry	2	1	3
	AECC I	Environmental science	2		2
	SEC I/II	Business skills for chemist or Food Chemistry	2		2
Total Credits					**22**
VI 6 Units	CC I	Physical Chemistry IV	2	1	3
	CC II	Inorganic Chemistry IV	2	1	3
	CC III	Organic Chemistry IV	2	1	3
	CC IV	Analytical Chemistry II	2	1	3
	DSE I/II	Introduction to dyestuff chemistry or Pesticides chemistry	2	1	3
	DSE III/IV	Polymer or Industrial Chemistry	2	1	3
	AECC I	Environmental science	2		2

	SEC I/II	Chemistry of cosmetics or Dairy chemistry	2		2
Total Credits					**22**
V 3 Units	CC I	Physical-Analytical Chemistry	2	1	3
	CC II	Inorganic-Organic Chemistry	2	1	3
	CC III	Biochemistry Courses	2	1	3
	CC IV		2	1	3
	DSE I/II		2	1	3
	DSE III/IV		2	1	3
	AECC I	Environmental science	2		2
	SEC I/II	Business skills for chemist or Food Chemistry	2		2
VI 3 Units	CC I	Physical-Analytical Chemistry	2	1	3
	CC II	Inorganic-Organic Chemistry	2	1	3
	CC III	Biochemistry Courses	2	1	3
	CC IV		2	1	3
	DSE I/II		2	1	3
	DSE III/IV		2	1	3
	AECC I	Environmental science	2		2
	SEC I/II	Chemistry of cosmetics or Dairy chemistry	2		2

Evaluation pattern

Evaluation pattern: Theory

For each core course I, II, III, IV and DSE I and II and SEC I and II

External (60 M) + Internal (40 M)

External: End Semester Examination

Paper Pattern: T. Y. B.Sc. Semester V/VI

External : 60 Marks Duration: 2 hrs

Question No.	Module	Marks (with option)	Marks (Without option)
Q1	I	5 M X 6 Q = 30 M	5 M X 4 Q = 20 M
Q2	II	5 M X 6 Q = 30 M	5 M X 4 Q = 20 M
Q3	III	5 M X 6 Q = 30 M	5 M X 4 Q = 20 M

- Each question will have sub questions a, b, c, d, e, f out of which any 4 should be answered.
- Internal: 40 Marks:
  - i) 25 marks – MCQ type test using ICT technique
  - ii) 15 marks – assignment/workshop/Project/industrial visit
- Evaluation pattern: Practical
- Practical Evaluation:
  - i) 30 Marks practical examination at the end of each semester per paper.
  - ii) 20 Marks Continuous internal Evaluation

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Core Course- I

COURSE TITLE: Physical Chemistry III

COURSE CODE: 23US5CHCCIPHC3 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Describe the concepts of Thermodynamics and Chemical Kinetics. 2. Recognize the different types of Electrochemical cells and their applications. 3. Illustrate the concepts of Nuclear chemistry and reactions.

Module 1	Chemical Thermodynamics and Chemical Kinetics	[12L]

Learning Objectives:

The module is intended to

1. Discuss different concepts like Gibb's and Helmholtz's free energy, chemical potential and their significance.
2. Describe the basic theories and effect of temperature on rate of chemical reactions.
3. Calculate of different and kinetic parameters using numericals.
4. Illustrate fundamental principles of radioactivity and Nuclear fission for power generation

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Describe the concepts like free energy and chemical potential in Thermodynamics in detail.
2. Explain the kinetic theories through chemical reactions.
3. Solve different numerical based on the concepts of thermodynamics and kinetics.

1.1	**Chemical Thermodynamics**	**8L**
1.1.1	Gibbs free energy and Helmholtz free energy, variation of Gibbs free energy with temperature and pressure, Gibbs-Helmholtz equation	
1.1.2	Physical equilibria involving pure substances, Clapeyron equation and variation of vapour pressure with temperature, Clausius- Clapeyron equation and its application. Partial molal properties, partial molal volume and chemical potential, Gibbs- Duhem equation	
1.1.3	Variation of chemical potential with temperature and pressure, fugacity, activity and their relationship with chemical potential, activity and activity coefficient	
1.2	**Chemical Kinetics**	**4L**
1.2.1	Effect of temperature on rate of a reaction, temperature coefficient, Arrhenius equation, energy of activation and its experimental determination (Numerical expected)	
1.2.2	Collision theory of reaction rates, application of collision theory to 1) Biomolecular reaction and 2) Unimolecular reaction, Lindemann theory (derivation expected), merits and drawbacks of collision theory.	
1.2.3	Activated complex theory of bimolecular reactions, expression for rate constant of bimolecular reactions (derivation not expected), comparison of collision theory and activated complex theory.	

References:

- Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).
- Chemical Kinetics, Keith J Laidler, Third Edition, Pearson Education.

Module 2	Electrochemical Cells and Their Applications	[12L]

Learning Objectives:

This module is intended to

1. Discuss different types of Electrochemical cells
2. Illustrate the applications of EMF Measurements
3. Describe the concepts of Decomposition potential and Over voltage

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Compare between Chemical and concentration cells
2. Classify different types of Concentration cells.
3. Describe the Applications of EMF Measurements.
4. Recognize the concepts of Decomposition potential and Over voltage

2.1	Lewis concept of activity and activity coefficient, ionic strength of a solution, Debye- Huckel limiting law (derivation not expected)	
2.2	Classification of cells: Comparison between chemical and concentration cell 1) Concentration cells with and without transference (derivation of expression for concentration cell EMF are expected), 2) Chemical cells without transference. Origin of liquid-liquid junction potential and its elimination using a salt bridge.	

2.3	Faradaic and Non-Faradaic processes. Batteries and Superconductors	
2.4	Polarization, concentration polarization and its elimination, Decomposition potential, experimental determination of decomposition potential, factors affecting decomposition potential (nature of electrolyte, nature of electrodes and temperature), overvoltage, experimental determination of overvoltage, Tafel's theory and Tafel's equation for hydrogen overvoltage, simultaneous deposition of metal. Corrosion and its prevention	

References:

- Electrochemical Methods: Fundamentals and Applications, Allen J. Bard and Larry R. Faulkner, 2006, wiley Student Edition.
- An Introduction to Electrochemistry, Samuel Glasstone, 10th edition, An East-West Edition

Module 3	Nuclear Chemistry	[12L]

Learning Objectives:

The module is intended to

1. Describe the detection and measurement of nuclear radiation using GM counter and scintillation counter
2. Determine half-life of radioactive elements
3. Illustrate the working of a nuclear power and breeder reactor

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Illustrate the principle and working of detectors used for detection and measurement of nuclear radiations

2. Solve numerical problems on determination of half-life, decay constants, Q value, threshold energy 3. Explain the important terms and factors controlling fission reaction while designing a nuclear reactor		
3.1	Types of nuclear radiations and their characteristics, behaviour of ion-pairs in electric field, detection and measurement of nuclear radiations using – G.M counter and scintillation counter.	
3.2	Kinetics of radioactive decay, units of radioactivity (Curie, Becquerel, Rutherford).	
3.3	Radioactive equilibrium (secular and transient), determination of radioactive constants for radio-elements having 1) Moderate half-life 2) Long half-life 3) Extremely long or short half-life.	
3.4	Use of radioisotopes as tracers in: 1) Chemical investigations-reaction mechanism 2) Age determination - dating by tritium content and by carbon-14.	
3.5	Nuclear Reactions: nuclear transmutation, artificial radioactivity (suitable examples using different projectiles are expected), Q-value of nuclear reaction, threshold energy.	
3.6	Fissile and fertile materials, nuclear fission, chain reactions, factors controlling fission Process (multiplication factor and critical size or mass of fissionable material), nuclear power reactor and breeder reactor	

References:

- Essentials of Nuclear Chemistry, H.J. Arnicker, New Age International Publishers.
- Source Book on Atomic Energy, S. Glasstone, Macmillon Co Ltd, 2016.

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Core Course- II

COURSE TITLE: Inorganic Chemistry III

COURSE CODE: 23US5CHCC2INC3 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the concept of molecular symmetry and chemical bonding. 2. Recognize the modern theories of bonding in coordination compounds. 3. Discuss the chemistry of f- block elements.

Module 1	Molecular Symmetry and Chemical bonding	[12L]
Learning Objectives: The module is intended to 1. Discuss different symmetry elements, symmetry operations, concept of point group in molecule. 2. Explain molecular orbital theory in simple polyatomic molecules. 3. Describe band theory of metallic bonding.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Describe the basic concept of symmetry like symmetry elements, symmetry operations and point group. 2. Illustrate molecular orbital approach for bonding in simple polyatomic molecules and draw MOT diagrams for these molecules. 3. Use molecular orbital approach / band theory to explain bonding in metals and properties of conductors, insulators and semiconductors.		
1.1	Molecular Symmetry	6L
1.1.1	Introduction and Importance.	

1.1.2	Symmetry elements and Symmetry operations.	
1.1.3	Concept of a Point Group with illustrations using the following point groups: (i) $C_{\infty v}$ (HCl), (ii) $D_{\infty h}$ (H_2), (iii) C_{2v} (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h} (trans dichloroethylene), (vi) D_{3h} (BCl_3) (vii) C_2H_4 (D_2h)	
1.2	**Molecular Orbital Theory for polyatomic species**	**3L**
1.2.1	Simple triatomic species H_3^+ and H_3 (correlation between bond angle and molecular orbitals)	
1.2.2	Other molecules (considering only σ bonding): (i) BeH_2 (ii) H_2O (with reference to Walsh diagram)	
1.3	**Metallic Bond**	**3L**
1.3.1	Band theory	
1.3.2	Explanation of electric properties of conductors, insulators and semiconductors (n- and p- types) on the basis of Band theory.	

References:

- Chemical Applications of Group Theory by F A Cotton, 3rd Edition
- Chemistry Inorganic - B.R. Puri, L.R. Sharma and K.C. Kallia - Vallabh Publications (2003).

Module 2	Bonding in Coordination Compounds	[12L]

Learning Objectives:

This module is intended to

1. Discuss two theories of bonding in coordination compounds – Crystal field theory and molecular orbital theory.
2. Describe concepts of electronic states, term symbols, micro states.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Describe the nature of bond between metal and ligand.
2. Discuss thermodynamic, kinetic, spectral and stereo chemical properties of coordination compounds.
3. Interpret different electronic states, term symbols and microstates for d^1, d^4, d^6, d^9 electronic configurations.

2.1	**Crystal Field Theory (CFT) of co–ordination complexes**	**6L**
2.1.1	Basic tenets of Crystal Field Theory (CFT) and effect of Crystal Field on central metal valence orbitals	
2.1.2	Splitting of d orbitals in octahedral, tetrahedral and square planar complexes; Jahn Teller Effect	
2.1.3	Crystal field splitting energy (10Dq/Δo) for octahedral complexes and factors affecting the magnitude of Δo	
2.1.4	Crystal field stabilization energy (CFSE), calculation of CFSE for octahedral and tetrahedral complexes with d^1 to d^{10} metal ion configurations, high spin and low spin complexes.	
2.1.5	Effect of Crystal field splitting on (i) Ionic radius (ii) Lattice energy	
2.1.6	Experimental evidence for co-valence in coordination compounds: (i)ESR spectrum of $[IrCl_6]^{-2}$ (ii)Nephelauxetic effect.	
2.1.7	Merits and Demerits of CFT	
2.2	**Molecular Orbital Theory (MOT) of co –ordination complexes**	**3L**

2.2.1	Application to octahedral complexes in case of (i)$[Ti(H_2O)_6]^{+3}$ (ii) Fluoro complexes of Fe(II) and Fe(III) (iii) Cyano complexes of Fe(II) and Fe(III) (iv) Fluoro and amino complexes of Co(III)	
2.2.2	Effect of π- bonding on ligand field splitting parameter in MLπ and LMπ interactions	
2.3	**Electronic states and Terms for Polyelectronic Atoms**	**3L**
2.3.1	Introduction, electronic configuration and electronic states, Term symbols, coupling of spin momenta (MS), orbital momenta (ML) and spin orbit coupling or Russell -Saunders coupling.	
2.3.2	Determination of Terms for p^2 electronic configuration (as in a carbon atom).	
2.3.3	Terms and micro-stats for transition metal atoms/ions.	

References:

- Inorganic Chemistry - J.E. Huheey, Harper and Collins - NY IV edition (12011).
- Chemistry Inorganic - B.R. Puri, L.R. Sharma and K.C. Kallia - Vallabh Publications (2016).

Module 3	Chemistry of Lanthanides	[12L]

Learning Objectives:

The module is intended to discuss the study of f-block elements

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Discuss the position of f-block elements in the periodic table.
2. Relate the electronic configuration of 4f and 5f block elements and their comparison.

3. Describe chemistry of lanthanides with respect to occurrence, extraction, separation, physical & chemical properties and applications.		
3.1	**Introduction**	**3L**
3.1.1	The shapes of f-orbitals	
3.1.2	The position of f-block elements in the periodic table	
3.1.3	Electronic configuration of 4f and 5f block	
3.1.4	Comparison between lanthanides and actinides	
3.2	**Chemistry of lanthanides with reference to**	**9L**
3.2.1	(i) lanthanide contraction, (ii) oxidation states, (iii) magnetic properties, (iv) colour and spectra (f-f transition spectra) and (v) complex formation (types and stereochemistry of the complexes).	
3.2.2	Occurrence, extraction and separation of lanthanides by (i) ion- exchange (ii) solvent extraction methods	
3.2.3	Application of lanthanides.	

References:

- Selected Topics in Inorganic Chemistry - W.U. Malik, G.D. Tuli and R.D. Madan - S. Chand Publications (2016).
- Advanced Inorganic Chemistry - Cotton and Wilkinson - V Edition - Wiley and Sons (2011).

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Core Course- III

COURSE TITLE: Organic Chemistry III

COURSE CODE: 23US5CHCC3ORC3 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the reaction mechanism of carbonyl compounds and assign the IUPAC nomenclature to bicyclic, biphenyl, cumulene and heterocyclic compounds. 2. Synthesize heterocyclic compounds by Paal Knor method and design the synthesis using retrosynthetic approach 3. Elucidate the structure and design multistep synthesis of polysubstituted aromatic compounds. 4. Discuss the concepts of stereochemistry.

Module 1	Mechanism of Organic Reactions and IUPAC	[12L]

Learning Objectives:

The module is intended to

1. Discuss mechanism of reactions of carbonyl compounds.
2. Explain the mechanism of rearrangement involving migration to electron deficient Carbon and nitrogen.
3. Illustrate the concept of thermodynamic and kinetic control of organic reactions.
4. Assign IUPAC nomenclature to bicyclic, biphenyl, cumulene and heterocyclic compounds.

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Predict and account for the most commonly encountered reaction mechanisms in carbonyl compounds.
2. Explain the mechanism of rearrangement involving migration to electron deficient Carbon and nitrogen.
3. Discuss the concept of thermodynamic and kinetic control of organic reactions
4. Name the bicyclic compounds, biphenyls, cummulenes upto 3 double bonds, heterocyclic compounds containing a maximum of two hetero atom among N, O, S.
5. Draw the structure of above compounds if IUPAC names are given.

1.1	**Mechanism of Organic Reactions**	9L
1.1.1	Thermodynamic and Kinetic control of organic reactions: Concept with mechanisms of the following reactions: addition of HX to butadiene; sulfonation of naphthalene. Nucleophilicity / electrophilicity Vs Basicity / acidity.	
1.1.2	Mechanism of reactions of carbonyl compounds with nucleophiles.	
1.1.2.1	Reaction of aldehydes and ketones with primary and secondary amines	
1.1.2.2	Acyl nucleophilic substitution (tetrahedral mechanism): Acid catalysed esterification of carboxylic acids and base promoted hydrolysis of esters.	
1.1.3	Mechanism of rearrangements with examples and stereochemistry wherever applicable.	
1.1.3.1	Migration to electron deficient carbon: Pinacol, Benzilic acid.	

1.1.3.2	Migration to electron deficient nitrogen: Beckmann, Hofmann.	
1.2	IUPAC IUPAC systematic and accepted trivial nomenclature of the following classes of compounds, including substituted ones (up to 2 substituents/functional groups):	3L
1.2.1	Bicyclic compounds- spiro, fused, and bridged (up to 11 carbon atoms)-saturated and unsaturated compound.	
1.2.2	Biphenyls.	
1.2.3	Cummulenes upto 3 double bonds, Monocyclic (5 and 6 membered) aromatic and nonaromatic heterocyclic compounds containing a maximum of two hetero atom among N, O, S.	

References:

- Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
- Carey, F. A. & Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
- Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.
- Nomenclature of organic compounds, S C Pal, Alpha science, 2nd edition,
- Organic Nomenclature, James G Traynham, 6th Edition.

Module 2	Organic Synthesis, Retrosynthesis and Multistep synthesis	[12L]

Learning Objectives:

This module is intended to

1. Discuss the synthesis of some important heterocycles
2. Describe the different terms and strategies involved in synthesizing organic compounds using the retrosynthetic approach.
3. Illustrate the synthesis of some simple target molecules.
4. Explain structure determination and multistep synthesis of polyfunctional aromatic compounds.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Illustrate the synthesis of N,O,S containing heterocycles.
2. Predict synthesis of simple organic compounds of different classes using the retrosynthetic approach
3. Elucidate the structure of simple organic compounds based on organic reactions.
4. Design the synthesis of bifunctional aromatic compounds using multiple steps.

2.1	**Organic Synthesis**	**4L**
2.1.1	Introduction: Criteria for ideal organic synthesis. Yield and selectivity	
2.1.2	Synthesis of furans, pyrroles, and thiophenes by Paal-Knor synthesis.	
2.2	**Retrosynthetic analysis and applications**	**4L**

2.2.1	Introduction, Different terms used – Disconnection, Synthon, Synthetic equivalence FGI, TM.	
2.2.2	One group disconnection with examples.	
2.2.3	Retrosynthesis and Synthesis of the following Target Molecules- i) Acetophenone ii) t-butyl alcohol iii) Crotonaldehyde iv) Cyclohexene v) Cyclohexene-3-one vi) Benzoin vii) Cyclopentylmethanol viii) Benzyl Benzoate	
2.3	**Structure determination and multistep synthesis**	**4L**
2.3.1	Structure determination through a series of reactions	
2.3.2	Planning multistep synthesis of polysubstituted benzenes	

References:

- Designing Organic Syntheses, Stuart Warren, John Wiley and Sons,Inc.
- Organic Chemistry, 4th Edn, Paula Y. Bruice, WordPress
- Finar, I. L. Organic Chemistry (Volume 1 and 2) Pearson Education

Module 3	Stereochemistry	[12L]

Learning Objectives:

The module is intended to

1. Discuss the elements of symmetry
2. Illustrate conformations and relative stabilities of cyclohexanes
3. Explain the stereochemistry of compounds having axial chirality
4. Discuss the concept of topicity

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Recognise the elements of symmetry in organic compounds.
2. Draw the conformers of cyclohexanes
3. Predict the relative stabilities of different conformers and geometrical isomers of cyclohexanes.
4. Explain the conditions of optical activity in molecules like cumulenes, spirans and biphenyls
5. Relate topicity of ligands and faces.

3.1	Molecular chirality and element of symmetry: Mirror Plane symmetry (inversion centre), rotation-reflection (alternating) axis, Chirality of compounds without stereogenic centre: cumulenes, spirans and biphenyls.	
3.2	Stability of cycloalkanes: Strains in cycloalkanes-angle, eclipsing, transannular (3 to 8 membered). Conformations of cyclohexane, mono- and di- alkyl cyclohexanes and their relative stabilities.	
3.3	Stereoselectivity and Stereospecificity: Idea of enantioselectivity (ee) and diastereoselectivity (de).Topicity-enantiotopic and diastereotopic atoms, groups and faces.	

References:

- Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
- Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
- Robinson, M. J. T., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Core Course- IV

COURSE TITLE: Analytical Chemistry I

COURSE CODE: 23US5CHCC4ANCI [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the importance of statistics and its application in analytical quality systems. 2. Discuss the basics of separation science and classical chromatography 3. Illustrate the applications of different atomic and molecular spectroscopic methods.

Module I	Quality in Analytical Chemistry and Statistical treatment of Data	[12L]

Learning Objectives:

The module is intended to

1. Explain the concept of Quality in Analytical chemistry. Quality systems for chemical analysis.
2. Discuss the basic statistics and use of it for establishing quality in chemical analysis.
3. Describe the use of statistics for data analysis and interpretation of results

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Explain the basic concept Quality, role of quality in chemical analysis. Quality control and quality assurance. Quality management systems like ISO, ICH etc.

2. Use the simple statistical parameters like mean, mode, standard deviation etc. for interpretation of data 3. Apply statistics for rejection of results, concept of errors, types and quantitative measurement of errors.		
1.1	**Introduction to Quality in Analytical Chemistry**	**4L**
1.1.1	Concept of Quality, definition and requirement	
1.1.2	Quality control and quality assurance. Similarities and difference between QC and QA	
1.1.3	Introduction to different quality systems: ISO, ICH guide lines and other quality systems and their use.	
1.2	**Statistical treatment of data**	**8L**
1.2.1	Types of errors, determinate and indeterminate errors, minimization of errors, constant and proportionate errors	
1.2.2	Accuracy and precision, measure of dispersion and central tendency: mean, median, mode, average deviation, relative average deviation, variance, coefficient of variation. (Numerical problems expected)	
1.2.3	Determinate and Indeterminate errors, constant and proportionate errors, distribution of random errors, Histogram, Frequency polygon, Gaussian curve, students t, confidence limits and confidence intervals, criteria for rejection of result 2.5 d rule,4.O d rule, Q-test, F-test, Test of significance method of averages method of least squares. [Numerical problems expected]	

References:

- Fundamentals of Analytical Chemistry by Skoog, Holler etc. IX th edition
- Analytical Chemistry by Gary Christian, sixth edition
- Inorganic Quantitative analysis by Vogel, sixth edition

Module 2	Titrimetric analysis and Introduction to Chromatography	[12L]

Learning Objectives:

This module is intended to

1. Explain two important titrimetric methods viz. Redox titrations and non-aqueous titrations
2. Discuss chromatography as a major separation technique.
3. Describe basic principles, usage and applications of planar chromatographic techniques.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Discuss the basic theory of redox and non-aqueous titrations. Selection of appropriate indicators and applications of both.
2. Define and use of chromatography as a separation technique. Different chromatographic techniques and their classification.
3. Describe basic theory and use of planar chromatographic techniques like Paper chromatography, TLC and HPTLC. Their types and applications.

2.1	Titrimetric analysis	7L
2.1.1	Redox titrations: Introduction and basic principles	
2.1.2	Titration curves for redox titration: Titration of Fe^{+2} v/s Ce^{+4}, Fe^{+2} v/s dichromate ($Cr_2O_7^{2-}$), Fe^{+2} v/s MnO^{-}_4 ions.	

2.1.3	Detection of end point of redox titration using indicators and potentiometrically. Some useful redox indicators.	
2.1.4	Non aqueous titrations: Definition and basic principles. Different types of non-aqueous solvents.	
2.1.5	Requirements for non-aqueous solvents. Properties of non-aqueous solvents. Leveling effect.	
2.1.6	End point detection in non-aqueous titrations. Advantages and limitations of non-aqueous titrations. Applications.	
2.2	**Introduction to chromatography**	**5L**
2.2.1	Introduction to chromatographic techniques, classification of chromatographic techniques.	
2.2.2	Planar Chromatography: Principle, techniques and applications of Paper chromatography Thin layer chromatography and HPTLC	

References:

- Inorganic Quantitative analysis by Vogel, sixth edition
- Quantitative Analysis by Day and Underwood, Prentice hall of India third edition -

Module 3	Optical methods	[12L]

Learning Objectives:

The module is intended to

1. Discuss atomic spectroscopy, different atomic spectroscopic methods like flame photometry and atomic absorption spectroscopy
2. Explain Molecular fluorescence and phosphorescence methods.

3. Describe basic principles, usage and applications of light scattering techniques like Turbidimetry and Nephelometry		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Apply principles of Flame photometry and Atomic spectroscopy for elemental analysis 2. Describe use of Fluorescence and Phosphorescence methods for quantitative analysis 3. Carry out analysis of turbid solutions using Turbidimetry and Nephelometry.		
3.1	**Atomic Spectroscopy**	**6L**
3.1.1	Absorption and emission spectra, energy level diagrams, process involved in atomization.	
3.1.2	Flame photometry, flame atomizer, types of burners, monochromators and detectors	
3.1.3	Atomic absorption spectroscopy; flame and electro thermal atomizer, sources, instrumentation, quantitative applications of atomic absorption and flame photometry, calibration curve method and standard addition method.	
3.2	**Molecular Fluorescence and Phosphorescence Spectroscopy**	**3L**
3.2.1	Basic Theory	
3.2.2	Instrumentation and applications	
3.3	**Turbidimetry and Nephelometry**	**3L**
3.3.1	Scattering of light, effect of concentration, particle size and wavelength on light scattering	
3.3.2	Instrumentation and applications	

Reference

- Instrumental Analysis by Skoog Nieman and Holler, sixth edition, Saunders/Nicole publications
- Fundamentals of Analytical Chemistry by Skoog, Holler etc. ninth edition
- S. M. Khopkar, Basic Concepts of Analytical Chemistry, 3rd ed,New Age International Publishers, 2008
- G.D.Christian, Analytical Chemistry, 6th ed. John Wiley &Sons, Singapore, 2004

T. Y. B. Sc. (CHEMISTRY)

SEMESTER V - Practical Based on CC I and CC IV

COURSE CODE: 23US5CHCCP1 Credit- 02

Learning Objectives:

The practical is intended to

1. Discuss rate constants, effect of temperature on rate constants, energy of activation for the acid catalysed reactions like hydrolysis of methyl acetate
2. Determine of radius of a molecule by viscosity measurements
3. Determine formal redox potential and to determine the amount of metal in the given solution potentiometrically.
4. Determine of acidic and basic dissociation constants of amino acid and to calculate isoelectric point.

Learning Outcomes:

After the successful completion of the practical, the learner will be able to

1. Discuss the effect of temperature on rate constants and determination of energy of activation.
2. Describe the method of determination of radius of a molecule by viscosity measurements.
3. Illustrate experimental determination of standard reduction potential and to determine the amount of metal in the given solution potentiometrically.
4. Explain the concept of isoelectric point, acidic and basic dissociation constants through pH metric determination.

Core Course I	Physical Chemistry III

1. Chemical Kinetics - To determine the energy of activation for the acid catalysed hydrolysis of methyl acetate.

2. Viscosity – To determine the radius of a glycerol molecule by viscosity measurements.
3. Potentiometry – To determine the amount of Fe (II) in the given solution by titration with a standard $K_2Cr_2O_7$ solution and hence to find the formal redox potential of Fe^{3+}/Fe^{2+}
4. pH –Metry –
    a. To determine acidic and basic dissociation constants of amino acid and to calculate isoelectric point
    b. Verification of Henderson's Equation
5. Conductometric Titration – To determine the strength of a given dibasic acid by Conductometric Titration

References:

- Experimental Physical Chemistry, V. D. Athawale, 2007, New Age International Publishers.
- Physical Chemistry Experiments, R. Rajalakshmi, 2020, Notion press Publishers.
- Senior Practical Physical Chemistry, Khosla B. D.; Garg V. C. & Gulati A., R. Chand & Co.: New Delhi (2011).
- · Experiments in Physical Chemistry, Garland C. W. , Nibler J. W. & Shoemaker D. P. , 8th Ed.; McGraw-Hill: New York (2003).
- · Experimental Physical Chemistry, Halpern A. M. & McBane G. C., 3rd Ed., W.H. Freeman & Co.: New York (2003).

Learning Objectives:

The practical is intended to

1. Explain redox titrations for estimation of real samples like Honey
2. Describe the complexo metric titrations and estimations using complexometry.

3. Discuss non-aqueous titrations and Assay of pharmaceutical formulation
4. Describe instrumental methods for analysis of real samples like toothpaste

Learning Outcomes:

After the successful completion of the practical, the learner will be able to

1. Correlate between theoretical principles of different types of titration methods and estimation of commercial samples.
2. Importance of non-aqueous titrations and their relevance for analysis of organic weak acids and bases.

Core Course IV	Analytical Chemistry I

1. Estimation of $K_2S_2O_8$ in the given solution.
2. Determination of glucose in honey by Willstatter's method.
3. To estimate the amount of aluminium in the given solution by back-titration method
4. Determination of percentage assay of Mebendazole drug tablet by non-aqueous titration.
5. Detection of fluoride content in a tooth paste by colorimetry
6. Detection of Vitamin C in a tablet by pH metry.

References:

- Inorganic Quantitative Analysis -By Vogel, Sixth edition

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SEMESTER V - Practical Based on CC II and CC III

COURSE CODE: 23US5CHCCP2 Credit- 02

Learning Objectives:

The practical is intended to

1. Discuss the preparation of inorganic complexes.
2. Impart the analytical chemistry aspects of complexometric titration.
3. Describe the concept of the experiment and the different steps involved in the experiment in the real lab more accurately and precisely.

Learning Outcomes:

After the successful completion of the practical, the learner will be able to

1. Acquire the skills to prepare Mohr's salt, nickel and cobalt amine complexes.
2. Identify the chemicals and apparatus required for the preparation of Mohr's salt, nickel and cobalt amine complexes.
3. Illustrate the basic laboratory technique of titration.
4. Calculate normality gm/L based on titrations.

Core Course II	Inorganic Chemistry III

1. Inorganic Preparation

i. Preparation of Ferric Alum and estimation of Iron by complexometry.

ii. Preparation of Chloropentaaminecobalt (III) chloride and estimation of cobalt by complexometry.

iii. Preparation of tris(ethylene diamine) nickel (II) sulphate and estimation of nickel by complexometry.

2. Titrimetric Analysis

i. To estimate the amount of Calcium present in the whole of the given solution being supplied with ZnS of AR quality and approx. O.25 molar EDTA solution.

ii. Estimation of Nickel complexometrically using mureoxide indicator.

iii. Estimation of Copper complexometrically using Fast sulphone Black F indicator.

References:

- Practical Inorganic Chemistry by S. Gulati, J. L.Sharma and S. Manocha, (2018) CBS Publication LtD.

Learning Objectives:

The practical is intended to

1. Explain separation of a Binary mixture by chemical method.
2. Identify the Separated component
3. Discuss the purification techniques

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Find the chemical type of mixture in the given solid binary mixture.
2. Separate the components using different chemical reagents.
3. Purify the separated organic compound by recrystallisation technique.

Core Course III	Organic Chemistry III

Binary Mixture Separation & identification (Solid + Solid)

References:

- Vogel, A. I. Elementary Practical Organic Chemistry.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Discipline Specific Elective - I

COURSE TITLE: Fundaments of drug chemistry

COURSE CODE: 23US5CHDSIFDC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the various concepts used in drug chemistry, routes of administration and metabolism of drugs. 2. Discuss the various pharmacodynamic agents. 3. Illustrate and classify the various chemotherapeutic agents.

Module 1	Introduction to Drug	[12L]
Learning Objectives: The module is intended to discuss the basic terminologies involved in chemistry of drugs, routes of drug administration and the metabolism of drugs		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Discuss the basic terminologies and concepts involved in drug chemistry, 2. Outline the routes of drugs administration. 3. Explain the drug metabolism steps.		
1.1	General Introduction to Drug	6L
1.1.1	Definition of a drug, Requirements of an ideal drug, Classification of drugs (Based on therapeutic action)	
1.1.2	Nomenclature of drugs: Generic name, Brand name, Systematic name	

1.1.3	Definition of the following medicinal terms: Pharmacon, Pharmacophore, Prodrug, Half Life efficiency, LD50, ED50, Therapeutic Index	
1.1.4	Brief idea of the following terms: Receptors, Drug-receptor interaction, Drug Potency, Bioavailability, Drug toxicity, Drug addiction, Spurious Drugs, Misbranded Drugs, Adulterated Drugs, Pharmacopoeia	
1.2	**Routes of Drug Administration and Dosage Forms**	**3L**
1.2.1	Oral and Parenteral routes with advantages and disadvantages	
1.2.2	Formulations, Different dosage forms (emphasis on sustained release formulations.)	
1.3	**Drug Metabolism** Introduction, Absorption, Distribution, Bio-transformation, Excretion Different types of chemical transformation of drugs with specific examples.	**3L**

References:

- Synthetic Drugs, G.R. Chatwal, Himalaya Publishing House, 2nd Edition
- Synthetic Drugs, M. S. Yadav, Campus Books International, 2nd Edition

Module 2	Pharmacodynamic agents	[12L]

Learning Objectives:

This module is intended to discuss chemistry of pharmacodynamic agents used for various systemic disorders.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Classify the pharmacodynamic agents according to their chemical class 2. Discuss the uses of different pharmacodynamic agents 3. Explain the synthesis of specific pharmacodynamic agents		
	A brief introduction of the following pharmacodynamic agents and the study with respect to their chemical structure, chemical class, therapeutic uses, and side effects	
2.1	**CNS Drugs** Classification based on pharmacological actions Concept of sedation and hypnosis, anaesthesia. Phenobarbitone (Barbiturates), Phenytoin(Hydantoins), Trimethadione (Oxazolidinediones), Piracetam (Pyranones), Midazolam, Alprazolam (Benzodiazepines) Methylphenidate (Piperidines) Chlorpromazine (Phenothiazines) Fluoxetine (Phenyl propyl amines) Synthesis of Trimethadione	2L
2.2	**Analgesics and Antipyretics** Morphine (Phenanthrene alkaloids), Tramadol (Cyclohexanols), Aspirin (Salicylates), Paracetamol (p-Aminophenols), Synthesis of Paracetamol	1L
2.3	**Anti-inflammatory Drugs** Mechanism of inflammation and various inflammatory conditions. Prednisolone, Betamethasone (Steroids), AceclofenacandMefenamic Acid (N-Aryl anthranilic acids). Synthesis of Aceclofenac	2L
2.4	**Antihistaminic Drugs** Mechanism of histamine release & its action Diphenhydramine (ethanolamines), Cetirizine	2L

	(piperazine), Chlorpheniramine maleate (ethyl amines),Omeprazol, Pantoprazole (Benzimidazoles) Synthesis of Cetrizine	
2.5	**Cardiovascular drugs** Classification based on pharmacological action Enalapril (α-amino acids), Isosorbide dinitrate (Nitrates), Atenolol (Aryloxy propanol amines), Nifedipine (Pyridines), Chlorthiazide (Thiazides), Frusemide /Furosemide (Sulfamyl benzoic acid), Spironolactone (Steroidal- 17-δ -lactones).	2L
2.6	**Antidiabetic Agents** General idea and types of diabetes; Insulin therapy Glibenclamide (sulphonylureas), Metformin (Biguanides)	1L
2.7	**Antiparkinsonism Drugs** Idea of Parkinson's disease. Procyclidine hydrochloride (Pyrrolidines), Ethopropazine hydrochloride (Phenothiazines) Levodopa (α-amino acids)	1L
2.8	**Drugs for Respiratory System** General idea of Expectorants; Mucolytes; Bronchodilators Decongestants and Antitussives, Bromhexine (Phenyl methyl amines), Salbutamol, Pseudo- ephedrine (Phenyl ethyl amines) Oxymetazoline (Imidazolines) Codeine Phosphate (Opiates)	1L

References:

- Synthetic Drugs, G.R. Chatwal, Himalaya Publishing House, 2nd Edition

<table>
<tr><td colspan="3">

- Synthetic Drugs, M. S. Yadav, Campus Books International, 2nd Edition

</td></tr>
<tr><th>Module 3</th><th>Chemotherapeutic Agents</th><th>[12L]</th></tr>
<tr><td colspan="3">Learning Objectives:
The module is intended to discuss chemistry of chemotherapeutic agents used for various infectious diseases.</td></tr>
<tr><td colspan="3">Learning Outcome:
After the successful completion of the module, the learner will be able to
1. Classify the chemotherapeutic agents according to their chemical class
2. Describe the different types of diseases caused by specific organisms.
3. Discuss the synthesis of specific chemotherapeutic agents</td></tr>
<tr><td></td><td>Study of the following chemotherapeutic agents with respect to their chemical structure, chemical class, therapeutic uses, and side effects.</td><td></td></tr>
<tr><td>3.1</td><td>Antibiotics
Definition, Amoxicillin; Cloxacillin (β-lactum antibiotics) Cephalexin (Cephalosporins) Doxycycline (Tetracyclines) Gentamycin (Aminoglycosides) Ciprofloxacin (Quinolones) Synthesis of Ciprofloxacin</td><td>2L</td></tr>
<tr><td>3.2</td><td>Antimalarials
Types of malaria: Symptoms; pathological detection during window period (Life cycle of the parasites not o be discussed) Chloroquine (3-Amino quinolines) Paludrine (Biguanides) Pyrimethamine (Diamino pyrimidines) Artemether (Benzodioxepins) Following combination to be discussed (i) Sulfadoxine-Pyrimethamine (ii) Artemether Lumefantrine (no structure) Synthesis of Paludrine.</td><td>2L</td></tr>
</table>

3.3	**Anthelmintics** Drugs effective in the treatment of Nematodes and Cestodes intestations. Diethyl carbamazine (Piperazines) Mebandazole; Albendazole (Benzimidazoles) Niclosamide (Amides) Synthesis of Albendazole	2L
3.4	**Antiamoebic Drugs** Types of Amoebiasis Metronidazole; Diloxamide furoate (Furans) Following combination therapy to be discussed: Ciprofloxacin-Tinidazole Synthesis of Metronidazole	1L
3.5	**Antitubercular and Antileprotic Drugs** Types of Tuberculosis; Symptoms and diagnosis of Tuberculosis. Types of Leprosy. General idea of Antibiotics used in their treatment. PAS (Aminosalicylates) Isoniazid (Hydrazides) Pyrazinamide (Pyrazines) (+) Ethambutol (Aliphatic diamines) Ethionamide (Thioamides) Dapsone (Sulfonamides) Clofazimine (Phenazines) Following combination therapy to be discussed: (i) Rifampin + Ethambutol + Pyrazinamide (ii) Rifampin + Isoniazid + Pyrazinamide (iii) Rifampin + Clofazimine + Ethionamide. Synthesis: (+) Ethambutol.	2L
3.6	**Anti-Neoplastic Drugs** Idea of malignancy; Causes of cancer, brief idea of Immuno Stimulants, Immuno depressants. (1) Lomustine (Nitrosoureas) (2) Fluorouracil (Pyrimidines) (3) Estrogen (Steroidal hormones) (3) Mitomycin C	2L

	(Antibiotics) (5) Vincristine; vinblastine; vindesine (Vinca alkaloids-no structures)	
3.7	**Anti HIV Drugs** Idea of HIV pathogenicity, Symptoms of AIDS, AZT, Lamivudine, Stavudine (Pyrimidines), DDI (Purines)	1L

References:

- Synthetic Drugs, G.R. Chatwal, Himalaya Publishing House, 2nd Edition
- Synthetic Drugs, M. S. Yadav, Campus Books International, 2nd Edition

T. Y. B. Sc. (CHEMISTRY)

SEMESTER V - Practical Based on DSE Courses

COURSE CODE: 23US5CHDSP Credit- 02

Learning Objectives:

The practical is intended to

1. Describe preparation of drugs and Drug intermediates by using organic reactions.
2. Explain the estimation Drugs by titrimetry method.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Acquire the skills to synthesize drugs and drug intermediates
2. Analyse the tincture of Iodine, Ibuprofen using basic laboratory techniques by titrimetry.

Discipline Specific Elective - I	Fundaments of drug chemistry

1. **Preparation**

i. Preparation of p-Nitroacetanilide from Acetanilide

ii. Synthesis of 3, 4-dihydropyrimidin-2(IH)-one from ethyl acetoacetate, benzaldehyde and urea.

iii. Synthesis of 2-phenylIndole from acetophenone and Phenyl hydrazine

2. **Estimation**

i. Estimation of Tincture of Iodine

ii. Estimation of Ibuprofen

3. **Project**- Representation of monogram of any one drug from syllabus by I.P. method

Note: During Practical Examination, only preparation will be evaluated.

References:

- Pharmacology and pharmaceutics Vol.I and II, Satoskar.
- Textbook of organic, medicinal, and pharmaceutical chemistry, Wilson and Gisvold.
- Textbook of medicinal chemistry, William O. Foye and David A. William.
- Medicinal chemistry, G. R. Chatwal

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Discipline Specific Elective - II

COURSE TITLE: Essentials of Radiation Chemistry

(optional for DSE 1: Fundaments of drug chemistry)

COURSE CODE: 23US5CHDS2ERC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the concept of nuclear energy 2. Recognise the applications of radiation chemistry in healthcare. 3. Discuss the radiation hazards and radioactive waste management.

Module 1	Nuclear Energy	[12L]
Learning Objectives: The module is intended to 1. Focus on constructive and peaceful uses of nuclear radiations 2. Make the students aware of energy generation using nuclear energy 3. Explain the nuclear reactions		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Describe the fusion and fission reactions. 2. Classify and name different types of nuclear reactors.		
1.1	Radioactivity, Nuclear radiations and it's importance, Nuclear reactions, Nuclear fission and Nuclear fusion	4L
1.2	Introduction to Nuclear Reactors	2L
1.3	Energy production in nuclear reactor	3L
1.4	Indian Nuclear energy program.	3L

Module 2	Radiation Chemistry	[12L]
Learning Objectives: This module is intended to 1. Make the students aware of applications of radioisotopes. 2. Illustrate the radiation units and radiological protection		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Explain the applications of radioisotopes. 2. Describe the effects of radiations and methods of protection.		
2.1	Applications of radioisotopes in healthcare an effect of radiations	2L
2.2	Diagnostic applications, Radiopharmaceuticals, Therapeutic Applications	3L
2.3	Radiation Units, Measurement of Exposure and dose, Biological effects of Ionizing Radiations	3L
2.4	Radiological protection	2L
2.5	Handling of radioisotopes	2L
Module 3	**Radioactive Waste Management**	**[12L]**
Learning Objectives: The module is intended to 1. Make the students aware of radiation protection. 2. Classify the radioactive waste		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Create awareness about nuclear radiations 2. Know about the types of radioactive waste and the disposal methods.		

3.1	Protection of Human Health, Protection of Environment, Protection of Future Generations	2L
3.2	Classification of radioactive waste, Waste classification by IAEA, Exempt Waste, Short lived Waste, Low level Waste, Intermidiate level waste, High level waste, Waste Categorization in India	2L
3.3	Treatment of radioactive waste Gaseous effluents, Treatment of organic Liquid Effluent, Treatment of Wet Solids, Treatment of solid Wastes	2L
3.4	Radioactive waste disposal	2L
3.5	Disposal of Low and Intermediate Level Waste, Storage of High-Level Waste	2L
3.6	Disposal of High-Level Waste, Treatment of Liquid Waste	2L

T. Y. B. Sc. (CHEMISTRY)

SEMESTER V - Practical Based on DSE Courses

COURSE CODE: 23US5CHDSP **Credit- 02**

Learning Objectives:

The practical is intended to

1. Determine Plateau of GM counter.
2. Determine Dead Time of GM counter
3. Carry out Statistical Analysis of Radioactivity Measurements
4. Determine Range of alpha particles for the given source

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Determine Plateau of GM counter.
2. Determine Dead Time of GM counter
3. Carry out Statistical Analysis of Radioactivity Measurements
4. Find Range of alpha particles for the given source

Discipline Specific Elective - II	Essentials of Radiation Chemistry

1. Determination of Plateau of GM counter
2. Determination of Dead Time of GM counter
3. Statistical Analysis of Radioactivity Measurements
4. Determination of Range of alpha particles for the given source

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Discipline Specific Elective - III

COURSE TITLE: Research methodology in Chemistry

COURSE CODE: 23US5CHDS3RMC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Identify the various types of research and its significance. 2. Explain the basic statistical tools for the treatment of research data. 3. Recognize the importance of safety measures during research

Module 1	Research Methodology: An Introduction	[12L]
Learning Objectives: The module is intended to i. Familiarize students with research terminology ii. Make students aware of the ethical principles of research, ethical challenges and approval processes iii. Introduce quantitative, qualitative and mixed methods approaches to research		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. A student will describe the objective and significance of research. 2. A student will explain Plagiarism and the restrictions in research,		
	Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research	

	Methods versus Methodology, Research and Scientific Method Research Design	
	Importance of Knowing How Research is Done, Research Process, Criteria of Good Research Ethical issues: Plagiarism, Restriction to Plagiarism, concept of patents and trademarks	

References:

- Research Methodology: Methods And Techniques (Multi Colour Edition) by C.R. Kothari and Gaurav Garg, 2nd Edition

Module 2	Data Analysis The Investigative Approach	[12L]

Learning Objectives:

The Module is intended to

1. Discuss the importance and use of statistical treatment of research data.
2. Describe use of various statistical tools for analysis of research data
3. Apply statistical and empirical rules for generating conclusion of research problem.

Learning Outcome:

After the successful completion of the module, the learner will be able to

- Analyse the data using various hypotheses and test.
- Apply statistical methods to draw conclusions of research problems.

	Testing of hypothesis: Basic definition (Null hypothesis, alternate hypothesis, critical region, acceptance region, Probability of type I and Type II errors, Level of significance P value	3
	Type of Test: parametric, non-parametric, comparison between sample mean and population mean, comparison between two sample means, Chi square test	6

	Analysis of variance (ANOVA) for one way, Correlation and regression, Curve fitting, fitting of linear equations	3

References:

- Research Methodology: Methods And Techniques (Multi Colour Edition) by C.R. Kothari and Gaurav Garg, 2nd Edition

Module 3	Chemical Safety and Ethical Handling of Chemicals	[12L]

Learning Objectives:

The module is intended to

1. Discuss the principles of chemical safety
2. Enable students to apply these concepts when working in a laboratory.
3. Encourage the scientific community to keep safety a high priority

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Recognize the source of hazards in the chemical laboratory and industry.
2. Discuss the precautions to minimize/prevent these hazards.
3. Describe the emergency precautions to be taken in case of a laboratory/ industry accident.

	Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation.	
	Material Safety Data Sheet (MSDS), Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage.	

	Safe disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	

References:

- Laboratory Safety for Chemistry Students, Robert H. Hill Jr. David C Finster, Wiley Publications, 1st Edition
- CRC Handbook of Laboratory Safety, A. Keith Furr, CRC Press,5th Edition

T. Y. B. Sc. (CHEMISTRY)

SEMESTER V - Practical Based on DSE Courses

COURSE CODE: 23US5CHDSP **Credit- 02**

Learning Objectives:

The practical is intended to

1. Review research article from different sources
2. Carry out research project
3. write scientific reports
4. Presentation of research outcomes by using powerpoint presentations

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Write scientific reports for their projects.
2. Communicate their project report in power point presentations.
3. Apply research method and perform short term research project

Discipline Specific Elective - III	Research methodology in Chemistry

Reading of the three research articles.

1. Power point presentation based on any Chemistry related research article.
2. Write a T.Y. B.Sc. project report in a scientific method
3. Submit the progress report for the project.
4. Power point presentation of the project finding

References:

- Thesis and assignement writing- J. Anderson, B. H. Dursten and M. Poole, Wiley Eastern 1977.
- A Handbook of methodology of Research- P. Rajammal and P. Devadoss, R. M. M. Vidya Press1976
- The craft of scientific writing-Michael Alley (Springer).
- Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
- Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
- Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
- Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
- Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
- OSU safety manual 1.01.

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Discipline Specific Elective - IV

COURSE TITLE: Environmental Chemistry

(Optional for DSE III: Research methodology in chemistry)

COURSE CODE: 23US5CHDS4ENC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the basic concepts of Environmental Toxicology 2. Recognize the different Sources and control technologies of Air and Water pollution 3. Discuss Soil fertility and methods of Soil analysis.

Module 1	Environmental Toxicology	[12L]
Learning Objectives: The module is intended to explain the types of organic and inorganic toxic substances and their effects on individuals and environment		
Learning Outcome: After the successful completion of the module, the learner will be able to explain the basic concepts of toxicology, different types of toxicants in our daily life and risk analysis.		
1.1	**Introduction too toxic substances and toxicity** Meaning of some important terms used in toxicology, types of toxic substances common environmental toxicants, hazardous waste, Teratogenesis, mutagenesis and carcinogenesis and Neurotoxins.	3L
1.2	**Effects of Metal ion toxicity and Risk analysis**	3L

	Effects of Toxic substances on Individuals: Biochemical effects, Observable physiological effects, Reversible and Irreversible effects, Effect on immune system, Effects after exposure: Acute, subacute and chronic toxic effects Risk analysis: Toxicity tests, Dose response curve, Effective and Lethal dose, NOAEL and LOAEL Mechanism of metal ion toxicity: Possible ways of generation of toxicity due to heavy metal ions, Chemical speciation, Biomethylation	
1.3	**Toxicity of various chemicals** i. Heavy metals-As, Hg (case study of Minamata episode) Pb, Cd ii. Non-metals – SOx, NOx, CO iii. Organic – Benzene, Formaldehyde and acetaldehyde, Phenols, Nitrosamines, Isocyanate and methyl Isocyanate (Case study of Bhopal gas tragedy), organophosphates and carbamates, Dioxins PCB, PAH	6L

References:

- Manahan, Stanley E. 'Fundamentals of Environmental Chemistry ' Boca Raton: CRC Press LLC,2001

Module 2	Environmental Pollution control technologies	[12L]

Learning Objectives:

This module is intended to explain the different types of air and water pollution control technologies

Learning Outcome: After the successful completion of the module, the learner will be able to discuss the different sources of air and water pollution and different chemical technologies for their treatment.		
2.1	**Air Pollution Control Techniques** Contaminants and pathways into atmosphere: Carbon Monoxide; Oxides of nitrogen; Sulphur Dioxide; Volatile Organic Compounds Instrumental techniques to monitor pollution: Carbon Monoxide; Oxides of nitrogen; Sulphur Dioxide; Volatile Organic Compounds;	6L
2.2	**Major Sources of Water Pollution** Possible reasons for groundwater and subsurface water contamination, Major sources: Coal Mine Drains, Pesticides and Fertilizers, Dying and Tanning industries Eutrophication: Sources and effects, Biomagnification	2L
2.3	**Water Pollution Treatment** i. Introduction to Sewage treatment Plant and Effluent treatment Plant ii. Technological Approach: Chemical Degradation of wastes and Chemicals; Coagulation and flocculation; Photocatalytic degradation of pollutants; Supercritical water oxidation Ref: https://nptel.ac.in/courses/104103020/33	5L

References:

- Sonja Krause, Herbert M. Clark, James P. Ferris, Robert L. 'Strong Chemistry of the Environment ', Elsevier Science & Technology Books 2002
- Eugene R. Weiner Applications of Environmental Chemistry 2000 CRC Press, LLC

Module 3	Soil Fertility and soil Analysis	[12L]
Learning Objectives: The module is intended to discuss the Plant nutrients, soil fertility parameters and soil analysis		
Learning Outcome: After the successful completion of the module, the learner will be able to describe the significance of the soil health, plant nutrients and different methods of soil analysis		
3.1	Introduction to soil profile, major soil types in India, classification of soils and their agricultural importance, problem soils, soil composition, soil fertility, Soil health and reasons for deterioration of soil health	4L
3.2	Plant nutrients and their functions-primary, secondary and micro nutrients and their forms in soil, fate of nutrient elements in soil -Crop removal, Erosion, Leaching, Volatilization, De-nitrification and Fixation. Deficiency symptoms of nutrients in plants ,soil fertility rating, Nutrient index, Balanced fertilization	4L
3.3	Soil analysis: Soil sampling techniques, preparation of soil samples, Soil pH, Soil Organic carbon, Soil Organic matter, Soil Organic carbon and climate change, Extraction and analysis of available nutrients(N,P,K) and	4L

	micronutrients by instrumental analysis AAS, ICP-AES etc. Interpretation of soil analysis data-soil Health card scheme of govt of India.	

References:

- By Clair N. Sawyer, Perry L. McCarty, Gene Parkin 'Chemistry for environmental engineering and science' (5th edition) McGraw-Hill Professional

T. Y. B. Sc. (CHEMISTRY)

SEMESTER V - Practical Based on DSE Courses

COURSE CODE: 23US5CHDSP Credit- 02

Learning Objectives:

The practical is intended to develop Skills for analytical techniques of environmental monitoring

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Perform the soil and water analysis
2. Recommend the plants suitable for improvement of air quality Experiments

Discipline Specific Elective - IV	Environmental Chemistry

1. To determine Air Pollution Tolerance Index (APTI) for a given plant species for its use in pollution control as well as pollution indicator
2. Evaluation of low-cost adsorbent from non-toxic agricultural waste and study of adsorption capacity for removal of methylene blue dye from the waste water sample for tertiary treatment processes.
3. Estimation of chloride in water sample by Mohr's method.
4. Estimation of Soil organic carbon, soil pH and Bulk density

5. Estimation of Phosphorous from a soil sample
6. Estimation of potassium from a soil sample

References:

MOOCs -Online Courses

- Ref: https://nptel.ac.in/courses/126105016/36 accessed on 18th May 2019
- Ref: https://nptel.ac.in/syllabus/syllabus_pdf/104103020.pdfaccessed on 18th May 2019
- Ref: https://nptel.ac.in/courses/104103020/33accessed on 18th May 2019

Books

- Manahan, Stanley E. 'Fundamentals of Environmental Chemistry ' Boca Raton: CRC Press LLC,2001
- Sonja Krause, Herbert M. Clark, James P. Ferris, Robert L. 'Strong Chemistry of the Environment ', Elsevier Science & Technology Books 2002
- Eugene R. Weiner Applications of Environmental Chemistry 2000 CRC Press, LLC
- By Clair N. Sawyer, Perry L. McCarty, Gene Parkin 'Chemistry for environmental engineering and science' (5th edition) McGraw-Hill Professional
- Soil testing in India

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Skill Enhancement course - I

COURSE TITLE: Business skills for Chemists

COURSE CODE: 23US5CHSEIBSC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Recognise the economic position, challenges and impact of the chemical industries globally. 2. Discuss the different features of IPR and enforcement process for patent. 3. Illustrate financial aspects of business.

Module 1	Chemistry in Industry and Intellectual property	[12L]

Learning Objectives:

The module is intended to

1. Explain how chemistry impacts our everyday life
2. Discuss the economic position of the chemistry-using industries in India and within the global economy
3. Describe the current and future challenges which face the chemistry-using industries
4. Show where chemistry research is making a difference to solve some of the global challenges which face this industry, contributing to the "green economy"
5. Describe different features of IPR
6. Explain how to get a patent
7. Describe how patent is enforced

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Enlist at least 10 chemistry industry careers
2. Name at least ten chemistry using industries in India and their economic position in global economy
3. Discuss major challenges faced by the chemistry using industries.
4. Demonstrate the use of chemistry in reduced carbon emissions and pollution, enhanced energy and resource efficiency
5. Differentiate between different types of IPRs
6. Demonstrate the patenting procedure with few examples
7. Write some ideas for commercialization of patented technology

1.1	**Chemistry in Industry**	**5 Hrs**
1.1.1	Importance of chemistry in our life, introduction to global chemical economy, Current Challenges faced by the Chemistry Using Industries,	
1.1.2	Drivers for innovation, introduction to the concepts of Green economy and circular economy	
1.2	**Intellectual property**	**5 Hrs**
1.2.1	Intellectual property issues from a business perspective, important features of IPR, Patenting an invention, how to get a patent.	
1.2.2	Patenting abroad, commercializing patented technology, Enforcing patent	

References:

- The online course developed by University of Nottingham http://www.rsc.org/learn-chemistry/resources/business-skills-forchemists/OnlineCourse/

Module 2	Business Basics	[12L]

Learning Objectives:

This module is intended to

1. Analyse the nitty-gritties of some of the chemical industries
2. Explain how a business plan is prepared
3. Generate swot analysis of a business

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Perform detail analysis of challenges basic business, opportunities the at least one of the chemical industries
2. Prepare a business plan for one of the product /services
3. Perform SWOT analysis

2.1	Basic rules of business	
2.2	Components of a business plan- executive summary	
2.3	Background	
2.4	Key personnel	
2.5	Operations	
2.6	Marketing	
2.7	Financial plan	
2.8	Swot analysis	

References:

- Resource developed by University of Warwick and University of York http://www.rsc.org/learn-chemistry/resources/business-skills-and-commercial-awareness-for-chemists/
- Inventing the Future: An Introduction to Patents for Small and Medium-sized Enterprises. WIPO publication No. 917

Module 3	Making money-Introduction to Financial aspects of business	[12L]
Learning Objectives: The module is intended to 1. Illustrate key terms and concepts of finance and cost 2. Differentiate between the different types of cost 3. Categorise different expenses		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Write different examples of cost, price and value of a given product. 2. Derive cost equations for a process and Prepare a profit and loss account 3. Comprehend the balance sheet of a company		
3.1	key terms and concepts of finance, Cost, price and value, rules for debit and credit, classification of expenses-capital expenditure, revenue expenditure, Profit and loss account and balance sheet	
3.2	Costing – different types of costs i.e. Variable cost, fixed cost, semi-variable cost, opportunity cost, marginal cost and preparation of cost sheet	
References: • "Secrets of Intellectual Property: A Guide for Small and Medium-sized Enterprises", ITC/WIPO publication on with questions and answers on intellectual property of relevance to SME exporters.		

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Skill Enhancement course - II

COURSE TITLE: Food Chemistry

(Optional for SEC I: Business Skills for Chemist)

COURSE CODE: 23US5CHSE2FOC [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 4. Explain the types of food and its various macronutrients. 5. Illustrate chemical and instrumental methods for analysis of different food and food products. 6. Demonstrate the food adulterants with suitable examples. 7. Explain basic concepts and tools for food quality control and food laws/regulations

Module 1	Introduction to Food Chemistry	[15L]

Learning Objectives:

The module is intended to

8. Discuss water and water activity with respect to food.
9. Explain nutritional and biological importance of macromolecules (carbohydrates, proteins and lipids) present in the food.
10. Explore basic information with respect to food for - Milk, Honey, Tea and Coffee.
11. Discuss food quality control and food laws.

Learning Outcome:

After the successful completion of the module, the learner will be able to

8. Explain the concepts of nutrition, water and water activity in foods.
9. Describe the role of macromolecules such as carbohydrates, proteins and fats in the food

10. Use classical and instrumental methods for analysis of food products such as honey, milk, tea and coffee.
11. Apply the rules and regulations regarding food products and its productions.

1.1	Food Chemistry, Water and water activity in food.	2L
1.2	Physical, Chemical, Nutritional and biological importance of macromolecules - carbohydrates, lipids and proteins.	5L
1.3	Definition, properties, compositions, types of - Milk, Honey, Tea and Coffee.	6L
1.4	Tools for food Quality Controls, Risk Assessment in food industry – HACCP	2L

References:

- Food Safety and Standards Act, 2006 by Universal Law Publishing
- Food Analysis by Pearson
- Chemical food analysis and a practical analysis; a practical manual; Bruce R. D'Arcy Geoff Hawes, A University of Queensland Publication

Module 2	Food Analysis (Practical/ Project/ Industrial Visit)	[12L]

Learning Objectives:

This module is intended to

4. Perform various analytical methods for estimation of desired constituents of food samples.
5. Compare statistical data for various food samples under the same analytical methods.
6. Design and execute a novel procedure for food sample analysis.

Learning Outcome: After the successful completion of the module, the learner will be able to 4. Explain the concept of analysis to food and food products. 5. Identify different constituents present in the given food sample via known practical procedures. 6. Apply the experimental knowledge to perform or create novel type of qualitative and quantitative analysis for given food and food products		
2.1	Milk sample – Lactose by Cole's Ferricyanide method **and or** Iron by Spectrophotometric method **and or** Calcium by Complexometric method	6L
2.2	Honey sample: Total reducing sugars by Lane-Eynon method (before and after inversion)	6L
2.3	Tea sample – Tannin analysis (Qualitative and Quantitative) OR Coffee sample – Caffeine analysis by Bailey Andrew Method	3L
2.4	Moisture content from a given food sample by lab oven method (min 2 samples).	3L
2.5	Detection of adulterants in different food products (Demonstration) 1. Milk – Starch 2. Paneer – Starch 3. Ghee – Vanaspati/ Margarine/Potato 4. Butter – Vanaspati/Potato 5. Oils – Argemone/Mineral/Caster oil 6. Honey – Sugar solution 7. Ice cream – Metanil yellow/Saccharin/Al foil	3L

	Turmeric powder - Metanil yellow/ Chalk powder	
2.6	Industrial Visit/Project	9L

References:

- A Laboratory Manual of Food Analysis, Shalini Sehgal, I K International Publishing
- Food analysis, 4th edition, S. Suzanne Nielsen; Springer
- https://fssai.gov.in/cms/manuals-of-methods-of-analysis-for-various-food-products.php

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Core Course- I

COURSE TITLE: Physical Chemistry IV

COURSE CODE: 23US6CHCCIPHC4 [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1. Discuss the basic principles of Molecular Spectroscopy. 2. Illustrate the colligative properties of dilute solutions and examine one and two component systems with the help of Phase Rule. 3. Describe the basic concepts of quantum Chemistry and NMR.		
Module I	**Molecular Spectroscopy**	**[12L]**
Learning Objectives: The module is intended to discuss the principles of three key spectroscopic methods- Rotational, Infra-Red and Raman spectroscopies.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Relate dipole moments of molecules with their activity towards different molecular spectroscopic methods. 2. Examine Rotational and Vibrational spectra of diatomic molecules. 3. Determine whether the molecular rotations and vibrations of a molecule are Raman active.		
1.1	Dipole moment: Dipole moment, polarization of a bond, bond moment, dipole moment and molecular structure.	
1.2	Rotational Spectrum: Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia,	

	energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of inter nuclear distance and isotopic shift	
1.3	Vibrational (IR) spectrum: Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum	
1.4	Vibration-Rotation spectrum of diatomic molecules, vibrating rotor, energy levels, selection rule, nature of spectrum, R and P branches, anharmonic oscillator: energy levels, selection rule, fundamental band, overtones. Introduction to infrared spectra of simple molecules like H_2O and CO_2.	
1.5	Raman Spectroscopy: scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum, Stoke's lines, anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion (example of CO_2 molecule).	

References:

- Fundamentals of Molecular Spectroscopy, Colin N Banwell and E. M, McCash, 4th Edition, Tata McGraw-Hill Publishing Company Ltd.
- Molecular Structure and Spectroscopy, G. Aruldhas, Second edition, Eastern Economy Edition.

- Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).

Module 2	Colligative Properties of Dilute Solutions and phase Rule	[12L]

Learning Objectives:

This module is intended to

1. Explain the concepts of colligative properties such as lowering of vapour pressure, elevation of boiling point, depression in freezing point and osmotic pressure.
2. Illustrate the relation between the colligative property and calculations of different parameters.
3. Describe Phase rule and it's applications to one and two component systems.

After the successful completion of the module, the learner will be able to

1. Describe the relation between colligative property and molar mass of the non-volatile solute.
2. Solve numerical problems on determination of molar mass of the non-volatile solutes.
3. Illustrate phase rule for one and two component systems.

2.1	Colligative Properties of Dilute Solutions	7L
2.1.1	Dilute solutions, colligative properties, Raoult's law, relative lowering of vapour pressure.	
2.1.2	Elevation in boiling point of a solution, thermodynamic derivation relating elevation in boiling point of a solution and the molar mass of a non-volatile solute.	

2.1.3	Depression in freezing point of a solution, thermodynamic derivation relating the depression in the freezing point of a solution and the molar mass of a non-volatile solute.	
2.1.4	Osmotic pressure, van't Hoff's equation for osmotic pressure (derivation is expected) and determination of molar mass of the solute. Abnormal molar masses of solutes and van't Hoff factor (calculation of Degree of Association and Degree of Dissociation.)	
2.2	**Phase Rule**	**5L**
2.2.1	Gibb's phase rule and terms involved in the equation	
2.2.2	Application of phase rule to ONE component systems: Water system	
2.2.3	Application of phase rule to TWO component systems, condensed systems, condensed phase rule, eutectic systems (Lead – Silver system), desilverisation of lead.	
2.2.4	Introduction to THREE component systems, triangular plots.	

References:

- Principles of Physical Chemistry, Puri, Sharma, Pathania, 41st Millennium Edition, Vishal Publishers.
- Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).
- The Phase Rule And Its Applications, Alexander Findlay,Longmans, Green, and Co., 1911

Module 3	Quantum Chemistry and Nuclear Magnetic Resonance Spectroscopy	[12L]

Learning Objectives:

The module is intended to

1. Discuss basic concepts of quantum mechanics, operators, eigen function and eigen value.
2. Explain the principles of Nuclear Magnetic Resonance Spectroscopy.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Compare between classical mechanics and quantum mechanics.
2. Explain different operators
3. Examine eigen function and eigen value.
4. Explain the basic principles of NMR spectroscopy
5. Illustrate the principle and working of NMR Spectrometer

3.1	**Quantum Chemistry**	**8L**
3.1.1	Why quantum mechanics? Comparison between classical mechanics and quantum mechanics.	
3.1.2	Progressive and standing waves, boundary conditions, Schrodinger's time independent wave equation, interpretation and properties of wave function.	
3.1.3	Postulates of quantum mechanics, Concept of operators: definition, addition, subtraction, multiplication of operators. Commutative and non-commutative operators, Linear operators, Hamiltonian operator.	
3.1.4	Eigen function and eigen value, eigen value equation	
3.2	**Nuclear Magnetic Resonance Spectroscopy**	**4L**

3.2.1	Nuclear spin, magnetic moment, nuclear 'g' factor, energy levels, Larmor precession. Relaxation processes in NMR (Spin-spin relaxation and spin-lattice relaxation)	
3.2.2	NMR Spectrometer, chemical shift, shielding and de-shielding of protons, low resolution NMR spectrum of methanol and ethanol, fine structure of NMR- nuclear spin-spin interaction with reference to methanol and ethanol.	

References:

- Introductory Quantum Chemistry, A. K. Chandra, 4th Edition, McGraw-Hill India.
- NMR Spectroscopy, Harald Gunther, Third edition, Wiley-VCH Publication.

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Core Course- II

COURSE TITLE: Inorganic Chemistry IV

COURSE CODE: 23US6CHCC2INC4 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Discuss the structure of solids and the concepts of superconductivity. 2. Analyse and understand the electronic spectra of complexes, stability and substitution reactions in octahedral complexes. 3. Discuss the Chemistry of aqueous and non-aqueous solvents.

Module 1	Solid state chemistry	[12L]
Learning Objectives: The module is intended to discuss a very important branch of chemistry which is solid state Chemistry as most of the inorganic compounds are solids under ordinary conditions and greater part of structural inorganic chemistry is concerned with structure of solids.		
Learning Outcome: After the successful completion of the module, the learner will be able to discuss the structure of solids through learning different lattice parameters, closest packing of spheres, atomic packing factor of crystal systems, voids in crystal structure etc.		
1.1	**Structures of Solids**	8L
1.1.1	Importance of Solid State Chemistry	
1.1.2	Crystals: size and shape of crystals, interfacial angles in crystals, Symmetry and elements of symmetry in crystals.	

1.1.3	Classification of solids on the basis of bonding.	
1.1.4	Explanation of terms viz. crystal lattice, lattice points, unit cells, and lattice constants	
1.1.5	Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc, fcc and hcp Lattices (numerical problems expected).	
1.1.6	Tetrahedral and octahedral interstitial voids in ccp lattice, tetrahedral holes, limiting radius ratios for different coordination numbers and their significance, calculation of ionic radii and limiting radius ratio for coordination number 4.	
1.1.7	Structure of sodium chloride, cesium chloride and fluorite. Structure of zinc chloride and failure of radius ratio rule (directional bonding), structure of wurtzite.	
1.2	**Superconductivity**	**4L**
1.2.1	Superconductivity, Meissner effect.	
1.2.2	Different superconducting materials viz., conventional superconductors, organic superconductors, alkali metal fullerides (A_3C_{60}) and high temperature superconductors.	
1.2.3	Applications of superconducting materials.	

References:

- Coordination Chemistry - S.F.A. Kettle - ELBS (2013).
- Solid State Chemistry: An Introduction *By Elaine A. Moore, Lesley E. Smart* (2021)

Module 2	Coordination Chemistry	[12L]

Learning Objectives:

This module is intended to

1. Discuss the electronic spectra of complexes.
2. Illustrate the stability of complexes.
3. Explain the substitution reactions in complexes.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Analyze the electronic spectra of complexes and can recognize various types of electronic transitions, geometry of complexes.
2. Elaborate the complex chemistry of transition metal coordination compounds by studying kinetics, mechanisms of various reactions and stability of complexes

2.1	Electronic Spectra of Complexes	5L
2.1.1	Type of electronic transitions like intra-ligand transitions, charge transfer transitions and intra-metal transitions (d-d or ligand field transitions for transition metals)	
2.1.2	Rule for electronic transitions: Spin and Orbital or Laporte selection rules	
2.1.3	Splitting of Terms in weak crystal field, the Hole formalism	
2.1.4	Orgel Diagrams for D Terms i.e. d^1, d^4 and d^6, d^9 electronic configurations	

2.1.5	Applications of electronic spectra in brief, with special reference to (i) cis-trans isomerism in complexes and (ii) Geometry of complexes	
2.2	**Stability of octahedral complexes**	**3L**
2.2.1	Thermodynamic stability and kinetic stability of complexes with examples	
2.2.2	Stability constants: stepwise and overall constants and their inter relationship	
2.2.3	Factors affecting thermodynamic stability	
2.3	**Substitution reactions in octahedral complexes**	**4L**
2.3.1	Introduction, types of reactions in complexes	
2.3.2	Ligand substitution reactions: basic mechanisms	
2.3.3	Inert and labile complexes and electronic configurations and lability	
2.3.4	Acid hydrolysis, base hydrolysis and anation reactions.	

References:

- Selected Topics in Inorganic Chemistry - W.U. Malik, G.D. Tuli and R.D. Madan - S. Chand Publications (2019).
- Inorganic Chemistry by GARY L. MIESSLER DONALD A. TARR, Third Edition, PPH publication.

Module 3	Solution Chemistry	[12L]

Learning Objectives:

The module is intended to

1. Discuss the study of aqueous chemistry.
2. Explain the concept of Non aqueous solvents.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Discuss various theories of acids and bases, appreciate how these theories provide a common platform to stand.
2. Recognize the behaviour of cations and anions in aqueous solution, changes brought about due to their presence and importance of maintenance of pH in aqueous solution.
3. Illustrate the importance of non-aqueous solvents and study some important and widely used non-aqueous solvents.

3.1	**Concept of acids and Bases**	**4L**
3.1.1	Arrhenius, Bronsted Lowry, Lewis concept of Acids and Bases.	
3.1.2	Solvent System Concept.	
3.1.3	Levelling and differentiating solvents	
3.1.4	Pearson principal and HSBC Concept	
3.1.5	Usanovich Concept	
3.2	**Acid Base Chemistry in Aqueous Medium**	**4L**
3.2.1	Acidity of mono- and polyatomic cations.	
3.2.2	Basicity of mono- and polyatomic anions (Latimer equation and predominance diagrams).	
3.3	**Chemistry of Non-aqueous solvents**	
3.3.1	Classification of solvents and importance of non-aqueous solvents	
3.3.2	Characteristics of study of liquid ammonia, dinitrogentetraoxide and acetic acid as non- aqueous solvents with respect to (i) acid base reactions (ii) redox reactions	

References:

- Concise Inorganic Chemistry - J.D. Lee - III edition - Von Nostrand.
- Chemistry Inorganic - B.R. Puri, L.R. Sharma and K.C. Kallia - Vallabh Publications (2019).

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Core Course- III

COURSE TITLE: Organic Chemistry IV

COURSE CODE: 23US6CHCC3ORC4 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Discuss the chemistry of natural products and biomolecules. 2. Predict the products of reactions using organometallic reagents and catalysts. 3. Elucidate the structure of simple organic compounds using U.V, I.R and NMR spectra.

Module 1	Natural Products and Biomolecules	[12L]

Learning Objectives:

The module is intended to

1. Discuss the rules related to the structure of terpenoids.
2. Explain Hofmann's exhaustive methylation and degradation with respect to terpenoids.
3. Illustrate the structure determination of citral and nicotine.
4. Describe the classification and synthesis of amino acids and proteins

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Classify the terpenoids based on the structure.
2. Predict the products obtained in Hofmann's exhaustive methylation and degradation of alkaloids.
3. Discuss the structure elucidation of citral and nicotine.
4. Classify amino acids and proteins based on structure and constitution.

5. Write the Strecker's synthesis of amino acids and Merrifield solid phase synthesis of peptides.		
1.1	**Natural products**	**6L**
1.1.1	Terpenoids. Introduction, isoprene rule, special isoprene rule, and gem dialkyl rule. Citral: Structure determination of citral, synthesis of citral from methyl heptenone	
1.1.2	Alkaloids: Introduction, Hofmann's exhaustive methylation and degradation Nicotine: Structure determination of nicotine, synthesis of nicotine from nicotinic acid	
1.2	**Chemistry of some Important Biomolecules**	**6L**
1.2.1	α-Amino acids: Structure, configuration, Essential amino acids and their classification, Methods of preparations: Strecker synthesis of amino acids	
1.2.2	Polypeptides and Proteins: Polypeptides: Peptide bond. Nomenclature and representation of polypeptides. Merrifield's solid phase peptide synthesis (example of di- and tri- peptides for nomenclature and synthesis). Proteins: General idea of primary, secondary, tertiary and quaternary structures	

References:

- Organic Chemistry, 4th Edn, Paula Y. Bruice, WordPress
- Natural Products, Volume I and II, O.P. Agarwal, Goyal Publishing House, 38th edition.
- Chemistry of Natural Products, R.S. Thomson, 2nd edition, Springer Publication

- Finar, I. L. Organic Chemistry (Volume 2) Pearson Education

Module 2	Organometallic Chemistry and Reagents and Catalysts	[12L]

Learning Objectives:

This module is intended to

1. Discuss the syntheses of simple organolithium, organomagnesium and organozinc compounds.
2. Illustrate the reactions of organolithium and organozinc compounds.
3. Explain the mechanism of Reformatsky reaction.
4. Explain the application of some catalysts used for hydrogenation and reduction reactions.
5. Describe the various functional group interconversions in organic synthesis involving specific reagents.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Design the synthesis of simple organolithium, organomagnesium and organozinc compounds.
2. Predict the products in reactions of organolithium and organozinc compounds.
3. Write the mechanism of Reformatsky reaction.
4. Identify the catalysts required for hydrogenation and reduction of different compounds.
5. Interconvert the various functional groups in organic synthesis involving specific reagents.

2.1	Organometallic Chemistry	4L
2.1.1	Organolithium Compounds: Preparation using alkyl/aryl halides. Reactions with compounds containing acidic hydrogen, alkyl halides, carbonyl	

	compounds, cyanides and CO_2. Lithium dialkyl cuprates: Preparation and reactions with aliphatic /aromatic/vinylic halides	
2.1.2	Organozinc compounds: Preparation of dialkyl zinc. Reaction with water, acid chlorides and alkyl halides. Reformatsky reaction (with mechanism).	
2.2	**Reagents and Catalysts**	**8L**
2.2.1	Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism).	
2.2.2	Catalysts: Catalysts for hydrogenation: Raney Ni, Pt and PtO_2: C=C, CN, NO_2, aromatic ring; Pd/C: C=C, COCl→ CHO (Rosenmund's); Lindlar catalyst: alkynes; Wilkinson's catalyst for stereo selective reduction of olefins.	
2.2.3	Reagents: (1) $LiAlH_4$ and Red-Al: reduction of CO, COOR, CN, NO_2. (2) $NaBH_4$: reduction of CO (3) SeO_2: hydroxylation of allylic and benzylic positions, oxidation of CH_2, alpha to CO to CO. (5) m-CPBA and R-OOH/H_2O_2 for epoxidation of C=C. (6) NBS: allylic and benzylic bromination of position alpha to CO.	

References:

- Textbook of Organic Chemistry, 2012, by V K Ahluwalia, Rakesh K Parashar, Viva Books Private Limited.
- Organic Chemistry: Second Edition, 2014,Jonathan Clayden, Nick Greeves , Stuart Warren.
- Modern Synthetic Reactions H. O. House, Massachusetts Institute of Technology. W. A. Benjamin, Inc., New York, 1965.

Module 3	Spectroscopy	[12L]

Learning Objectives:

The module is intended to

1. Discuss the basic theory of UV spectroscopy.
2. Explain various functional groups based on IR spectroscopy.
3. Discuss the different terms involved in NMR spectroscopy.
4. Define chemical shift and the factors affecting it.
5. Illustrate structure elucidation of simple organic compounds using individual or combined uses of the UV, IR and NMR spectroscopic techniques.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Identify various functional groups on the basis of the U.V and IR spectra.
2. Predict the electronic environment around different types hydrogen present in the organic compound based on the IH NMR spectrum.
3. Elucidate the structure of simple organic compounds using U.V, IR and IH NMR spectrum in synchronization and vice versa.

3.1	Introduction: Electromagnetic spectrum, units of wavelength and frequency	
3.2	UV- Visible Spectroscopy: Basic theory, solvents, nature of UV-VIS spectrum	
3.3	IR Spectroscopy: Basic theory, nature of IR spectrum, selection rule, fingerprint region.	
3.4	PMR Spectroscopy: Basic theory of NMR, nature of PMR spectrum, chemical shift (ð unit), standard for PMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to C=C, CΞC, C=O and benzene ring). Spin spin	

	coupling and coupling constant. Proton exchange-application of deuterium exchange, Application of PMR in structure determination.	
3.5	Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to UV-VIS, IR, PMR: (1) alkenes (2) alkenes and polyenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) carboxylic acids (9) esters (10) amines (11) amides (broad regions characteristic of different groups are expected).	
3.6	Problems of structure elucidation of simple organic compounds using individual or combined uses of the above spectroscopic technique are expected. (index of hydrogen deficiency should be the first step in solving the problems).	

References:

- P.S. Kalsi, Spectroscopy of Organic compounds, New Age International Ltd., 1995.
- Jagmohan, Organic Spectroscopy- Principles and Applications, 2 nd Edition, Narosa Publication, 2008.
- W. Kemp, Organic Spectroscopy, 3rd Edition, Palgrave, Indian Edition, 2005.
- Williams and Fleming, Spectroscopic methods in Organic Chemistry, 5 th Edition, McGraw Hill, 1995.

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Core Course- IV

COURSE TITLE: Analytical Chemistry II

COURSE CODE: 23US6CHCC4ANC2 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the importance of solvent extraction and other extraction techniques in chemistry. 2. Describe various chromatographic techniques as a major separation tool in Chemistry 3. Illustrate Polarography and related techniques as a analytical method for sample analysis.

Module 1	Solvent extraction and Solid phase extraction	[12L]

Learning Objectives:

The module is intended to

1. Discuss the solvent extraction as a major method of separation in analytical chemistry
2. Describe basic extraction methods using different extraction mechanism and different extraction methodologies
3. Illustrate solid phase extraction as a new versatile method of separation.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Explain the basic concept solvent extraction. Different extraction systems and mechanisms

2. Describe experimental extraction techniques, role of pH and selecting appropriate method for desired separation 3. Apply solvent extraction technique in chemistry 4. Illustrate solid phase extraction as new method of separation.		
1.1	**Solvent Extraction**	**8L**
1.1.1	Partition coefficient and distribution ratio	
1.1.2	Extraction efficiency, separation factor	
1.1.3	Role of complexing agents in solvent extraction, chelation, ion pair formation, solvation	
1.1.4	Types of solvent extraction: batch, continuous. [Numerical problems expected]	
1.2	**Introduction to Solid phase extraction**	**4L**
1.2.1	Limitations of solvent extraction	
1.2.2	Basic Principles, Equipments used	
1.2.3	Applications of Solid phase extraction	

References:

- S. M. Khopkar, Basic Concepts of Analytical Chemistry, 3rd ed,New Age International Publishers, 2008
- R.A.Dey & D.L.Underwood, Quantitative Analysis, 6th ed. Prentice Hall Of India Pvt. Ltd. New Delhi, 1993.

Module 2	Chromatographic methods	[12L]

Learning Objectives:

This module is intended to

1. Explain the basic principles and importance of chromatographic methods
2. Discuss gas Chromatography as a major method of separation in analytical chemistry.

3. Describe the use of High-Performance Liquid Chromatography as an Analysis tool for complex separations and estimations 4. Illustrate ion exchange chromatography as a versatile separation method		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Explain the basic principles of chromatography. Different terms and concepts related to chromatographic separations 2. Describe gas chromatography, its instrumental and operational details and applications. 3. Apply HPLC as versatile method for separations, qualitative and quantitative analysis 4. Discuss ion exchange chromatography and its wide applications in analytical chemistry		
2.1	**Gas chromatography**	**5L**
2.1.1	Gas liquid chromatography, basic principles, retention time, retention volume, resolution, peak width theoretical plates. HETP	
2.1.2	Instrumentation, columns, detectors, applications	
2.2	**High Performance Liquid Chromatography**	**3L**
2.2.1	Instrumentation, types of elution, U.V. and I.R. detector and applications	
2.3	**Ion Exchange Chromatography**	**4L**
2.3.1	Types of ion exchangers	
2.3.2	Mechanism of ion exchange, selectivity coefficients and separation factors, capacity and its determination, factors affecting the separation of ions	
References:		

- D. A. Skoog, D.M.West, F.J.Holler Fundamantals of Analytical Chemistry, 8th ed. Philadelphia, Saunders college Publishing, 1996
- M.Valcarcel, Principles Of Analytical Chemistry, Springer International Edition, Berlin, 2000

Module 3	Electroanalytical methods	[12L]

Learning Objectives:

The module is intended to

1. Describe polarography as a major electro analytical method for analysis.
2. Illustrate qualitative and Quantitative applications of classical polarography
3. Apply the Amperometric titration as a tool for rapid analysis

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Solve Ilkovic equation for quantitative analysis using polarographic method
2. Understand the importance of classical polarography with DME as a potent tool to analyze metal ions using electrolytic cells.
3. Understand the use of rotating platinum electrode and measurement of current from electrolytic cell as means of end point determination in the titration of analyte

3.1	**D.C. Polarography**	9L
3.1.1	Polarizable and nonpolarizable electrodes	
3.1.2	Basic principles, residual current, diffusion current, limiting current, dropping mercury electrode, supporting electrolyte, half wave potential	
3.1.3	Derivation of the polarographic wave equation for a reversible reaction. Ilkovic equation	

3.1.4	Oxygen interference and its removal, maxima and maxima suppressors, polarographic cell	
3.1.5	Qualitative and quantitative analysis, calibration curve and standard addition method, applications. [Numerical problems expected]	
3.2	**Amperometric Titrations**	**3L**
3.2.1	Basic principles, rotating platinum electrode and nature of the titration curves	
3.2.2	Applications, advantages and limitations	

References:

- D. A. Skoog, D.M.West, F.J.Holler, Fundamentals of Analytical Chemistry, 8th ed. Philadelphia, Saunders college Publishing, 1996
- A J Bard, R M Faulkner. Fundamentals of ElectroS. M. Khopkar, Basic Concepts of Analytical Chemistry, 3rd ed,New Age International Publishers, 2008ana, Wiley, 2000
- G.D.Christian, Analytical Chemistry, 6th ed. John Wiley &Sons, Singapore, 2004.
- S. M. Khopkar, Basic Concepts of Analytical Chemistry, 3rd ed,New Age International Publishers, 2008

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI – Practical Based on CC I and CC IV

COURSE CODE: 23US6CHCCP1 Credit- 01

Learning Objectives:

The practical is intended to

1. Discuss the effect of an added electrolyte on the kinetics of the reaction.
2. Describe the partition coefficient method to determine equilibrium constant of a reaction
3. Explain the potentiometric titration method to determine the strength of the given strong acid.
4. Illustrate the conductometric titration method of mixture of acids and salt to determine the percentage composition.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Discuss the effect of addition of electrolyte on the kinetics of the reaction.
2. Practice the partition coefficient method to determine equilibrium constant of a reaction.
3. Demonstrate potentiometric titration method.
4. Illustrate the conductometric titration method.

Core Course I	Physical Chemistry IV

1. Chemical Kinetics – To study the effect of an added electrolyte (KCl) on the kinetics of the reaction between potassium persulphate and potassium iodide.

2. Partition coefficient – To determine the equilibrium constant for the reaction KI + $I_2 \rightarrow KI_3$ by partition coefficient method. (Partition coefficient of I_2 between CCl_4 and water is to be given)
3. Potentiometry –
    a. To determine the strength of the given strong acid (HCl) by potentiometric titration using quinhydrone electrode (Calculation of pH from Ecell and the plot of (i) against V (ii) pH against V graphs are expected).
    b. To determine the solubility and solubility Product of Silver Chloride by using a Concentration cell.
4. Conductometry – To estimate the concentration of sulphuric acid, acetic acid and copper sulphate in the given solution by conductometric titration method.
5. Colourimetry - To determine the amount of Fe(II) present in the given solution by Using Salicylic acid by Colourimetric Titration .

References:

- Experimental Physical Chemistry, V. D. Athawale, 2007, New Age International Publishers.
- Physical Chemistry Experiments, R. Rajalakshmi, 2020, Notion press Publishers.
- Senior Practical Physical Chemistry, Khosla B. D.; Garg V. C. & Gulati A., R. Chand & Co.: New Delhi (2011).
- Experiments in Physical Chemistry, Garland C. W. Nibler J. W. & Shoemaker D. P. , 8th Ed.; McGraw-Hill: New York (2003).
- ·Experimental Physical Chemistry, Halpern A. M. & McBane G. C., 3rd Ed., W.H. Freeman & Co.: New York (2003).

Learning Objectives:

The practical is intended to

1. Explain solvent extraction as a major tool of separation
2. Use ion exchange chromatography for estimation of cations.
3. Describe GC and HPLC for real sample analysis.
4. Use instrumental methods for analysis of real samples like Vinegar

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Use Solvent extraction with different separation mechanisms for separation of desired analyte.
2. Implement use of ion exchange techniques as a separation tool for separation of cations.
3. Use Instrumental methods of analysis for commercial samples like vinegar.
4. Demonstrate use of GC and HPLC as a major separation and estimation techniques in Analytical Chemistry

Core Course IV	Analytical Chemistry II

1. Separation and estimation of Fe(III) and Mg(II) using solvent extraction .
2. Detection of Na^+ ions in a given solution by using cation ion exchanger.
3. Estimation of chloride in the given sample using Mohr's method. (3U)
4. Estimation of acetic acid in vinegar by potentiometry.
5. Water analysis:

   a) Determination of alkalinity of potable water by acid base titration

   b) Estimation of total hardness of water sample by complexometric titrations.
6. Estimation of phenolphthalein in the given sample colorimetrically.
7. Demonstration experiments (3U)

a. To study the separation of alcohols/ esters on gas chromatograph and detection of retention time b. To study the separation of alcohol on HPLC, to calculate HETP from the chromatograph.
References: • Practical HPLC analysis- By Veronica Meyer, Wiley publications • Inorganic quantitative analysis by A I Vogel, sixth edition

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI – Practical Based on CC II and CC III

COURSE CODE: 23US6CHCCP2 Credit- 01

Learning Objectives:

The practical is intended to:

1. Explain the preparation of inorganic complexes.
2. Describe the analytical chemistry aspects of complexometric titration.
3. Discuss the concept of the experiment and the different steps involved in the experiment in the real lab more accurately and precisely.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Prepare Inorganic complexes.
2. Analyze commercial samples using complexometric titration

Core Course II	Inorganic Chemistry IV

1. **Commercial Analysis**

i. Analysis of talcum powder for its magnesium content complexometrically.

ii. Analysis of calcium tablets for its calcium content complexometrically.

iii. Analysis of Boric acid for its percentage purity.

2. **Inorganic Preparations**

i. Nickel Hexaammine and Estimation of Nickel

ii. Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ and estimation of Al.

iii. Bis(acetylacetonato)copper (II) and Estimation of Copper

References:

- PRACTICAL INORGANIC CHEMISTRY LAB MANUAL (2019) by Dr.A.Padmanabha Rao & Dr.M.Akiful Haque.

Learning Objectives:

The practical is intended to

1. Discuss separation of a Binary mixture by Physical method.
2. Purify compounds by distillation method.
3. Prepare different Organic Compounds

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Find the chemical type of mixture in the given Binary mixture.
2. Separate the components using distillation technique
3. Purify the separated organic compound using distillation.

Core Course III	Organic Chemistry IV

1. **Binary Mixture Separation**

Separation of mixture containing (VL + NVL) & (S + VL) components.

2. **Organic Preparations**

i. Aniline/p-toluidine → N-Acetyl derivative
ii. Salicylic acid/nitrobenzene/ Acetanilide → Nitro derivative
iii. β-naphthol → Methyl Ether derivative (Using dimethyl sulphate)
iv. Acetanilide → p-bromoacetanilide derivative
v. Aniline/ p-toluidine → Schiff base with benzaldehyde
vi. Hydroquinone/beta naphthol → Acetyl derivative

Note: During Practical Examination, only preparation will be evaluated.

References:

- Vogel, A. I. Elementary Practical Organic Chemistry, Part I: Small scale Preparations, CBS Publishers and Distributors.

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Discipline Specific Elective - I

COURSE TITLE: Introduction to dyestuff chemistry

COURSE CODE: 23US6CHDS1IDC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the fundamental concepts of dyestuff chemistry. 2. Discuss different colour theories to relate the colour with structure of dyes and recognize the toxic effects of dyes. 3. Describe the dyeing techniques, fibre structure and methodologies involved in the manufacture of dyes.

Module 1	Introduction to Dyestuff	[12L]
Learning Objectives: The module is intended to discuss the basic aspects of dyestuff chemistry		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Describe the important properties of dyes 2. Relate the names of dyes with its properties and application 3. Discuss the procedure for application of dyes to the substrate.		
1.1	**Introduction to Dyestuff Chemistry**	6L
1.1.1	Important landmark in the history of dyes	
1.1.1.1	Natural colouring matter and their limitations: e.g,; Heena, Turmeric, kesar, Chlorolphyll, Indigo, Alizarine from roots of madder plants, Logwood. Tyrian purple.	
1.1.1.2	Synthetic Dyes: Important milestones, i.e. Mauve, Diazotization, aniline Yellow, Congo Red, Synthesis	

	and structure of Indigo, disperse Dye, fluorescent Brighteners, procion reactive Dyes, Remazole Dyes. (Emphasis on Name of the Scientist and dyes and the year of the discovery is required and structure is not expected)	
1.1.2	Definition of dyes, Properties i.e. colour, chromophore and auxochrome, Solubility, Linearity, Coplanarity, fastness properties, substantivity, and Economic viability	
1.1.3	Explanation of nomenclature of commercial dyes with atleast one example. Suffixes-G, O, R, B, 6B, GK, 3GK, 6GK, L, S Explanation: naming of dyes by colour index(two examples)	
1.2	**Classification Based on Application**	**6L**
	Definition, fastness properties & applicability on substrates examples with structures (a) Acid Dyes-Orange II, (b) Basic Dyes-methyl violet, Victoria Blue B (c) Direct cotton Dyes- Benzofast Yellow 5GL (d) Azoic Dyes-Diazo components; Fast yellow G,Fast orange R. Coupling components. Naphtol AS, Naphthol ASG (e) Mordant Dyes-Erichrome Black A, Alizarin. (f) Vat Dyes- Indanthrene brown RRD, Indanthrene Red 5GK. (g) Sulphur Dyes- Sulphur Black T (no structure) (h) Disperse Dyes-Celliton Fast brown 3R, perlon fast blue FFR (i) Reactive Dyes- cibacron Brillant Red B, procion briilant Blue HB.	

References:

- Synthetic Dyes, M. S. Yadav, Campus Books International, 2nd Edition

- Synthetic Dyes, G.R. Chatwal, Himalaya Publishing House
- A Textbook of Synthetic Dyes, O.D Tyagi and M. Yadav, Anmol Publications Pvt Ltd, Ist Edition

Module 2	Properties of dye	[12L]
Learning Objectives: This module is intended to relate the colour property of dye with its structure		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Identify the principles of color theory as it relates to structure, 2. Recognize the use of dyes as optical brighteners and pigments 3. Review the toxic effects caused by dyes and dye intermediates		
2.1	**Colour and chemical constitution of dyes**	**5L**
2.1.1	Absorption of visible light, colour of wavelength absorbed, complementary colour	
2.1.2	Relation between colour and chemical constitution. (i) Witt's Chromophore theory (ii) Armstrong theory (quinonoid theory) and its limitations (iii) Valence Bond theory; Comparative study and relation of colour in the following classes of compounds/dyes: Benzene, Nitrobenzene, Nitroanilines, Nitrophenols, Benzoquinones, Azo, Triphenyl methane, Anthraquinones. (iv) Molecular Orbital Theory.	
2.2	**Optical Brighteners** General idea and important characteristics of optical brighteners, one example each with structure of the following classes: Stilbene, Coumarin, Heterocyclic	**2L**

	vinylene derivatives, Diaryl pyrazolines, Naphthalimide derivatives.	
2.3	**Organic Pigments** General idea, distinguish between dyes and pigments, important characteristics of organic pigments, Toners, Lakes, Classification of organic pigments with suitable examples, i.e. Ionic pigments-Lake of acid and basic dyes. Non-ionic pigments-Azo, Indigoid, Anthraquinone, Quinacridone, Phthalocyanine (Copper phthalocyanine).	2L
2.4	**Ecology and Toxicity of Dyes** With reference to the textile dyes, food colours, cosmetic dyes, benzidine, phenylene diamines.	3L

References:

- Synthetic Dyes, M. S. Yadav, Campus Books International, 2nd Edition
- Synthetic Dyes, G.R. Chatwal, Himalaya Publishing House
- A Textbook of Synthetic Dyes, O.D Tyagi and M. Yadav, Anmol Publications Pvt Ltd, Ist Edition

Module 3	Syntheses of dyes	[12L]

Learning Objectives:

The module is intended to illustrate the characteristic properties and syntheses of specific non-textile dyes and explain the various dyeing techniques

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Discuss the synthesis of specific dyes and different classes of non textile dyes
2. Justify characteristic properties of dyes according to their application.

3. Identify the various unit processes involved in organic chemistry for the synthesis of dyes having non textile applications		
3.1	**Non-textile Uses of Dyes**	5L
	Structural features of the substrate, fastness and other property requirements and main classes of dyes used to be mentioned as applicable (One example of each Class with structure expected). i. Leather -Bismark Brown ii. Paper- Auramine O iii. Foodstuff - Tartazine iv. Cosmetics-4'-Amino Diphenylamine-4-sulphonic acid v. Medicinal - Crystal Violet vi. Biological Stains - Methylene Blue vii. Indicator & Analytical Reagents- Eriochrome Black T viii. Coloured Smokes & Camouflage colours- Purpurin ix. Laser Dyes –Rhodamine G	
3.2	**Synthesis and Uses of Specific Dyes**	3L
	Brief Idea of Unit Process, Unit Operations and Intermediates. i. Bismark Brown from Benzene via m-phenylene diamine ii. Auramine O from Benzene via Aniline iii. Tartazine from aniline via phenyl hydrazine-4-sulphonic acid iv. Crystal Violet from Aniline.	

	v. Methylene Blue from Aniline and 4-Amino-N,N-Dimethyl aniline vi. Eriochrome Black T from Napthalene.	
3.3	**Types of Fibres and Classes of Dyes Applicable to them** Introduction to the following types of fibres with structures and classes of dyes applicable to it. Cotton, Wool, Silk, Polyester	1L
3.4	**Dyeing Method and Dye Fibre Forces**	3L
3.4.1	(i) Direct dyeing (ii) Vat dyeing (iii) Mordant dyeing (iv) Disperse dyeing	
3.4.2	Forces binding of dyes to the fibres: Ionic forces, Hydrogen bonds, Vander-Wall's forces, Covalent linkages.	

References:

- Synthetic Dyes, M. S. Yadav, Campus Books International, 2nd Edition
- Synthetic Dyes, G.R. Chatwal, Himalaya Publishing House
- A Textbook of Synthetic Dyes, O.D Tyagi and M. Yadav, Anmol Publications Pvt Ltd, Ist Edition

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI - Practical Based on DSE Courses

COURSE CODE: 23US6CHDSP **Credit- 01**

Learning Objectives:

The practical is intended to

1. Discuss the preparation of Dye and Dye intermediates using different organic reactions.

2. Describe quantitative estimation of Dyes by colorimetry and diazotization.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Apply concept of diazotization and coupling reaction to synthesize different azo dyes
2. Estimate the dyes quantitatively using the technique of diazotization and colorimetry.
3. Acquire the skill to dye the cotton fibre using specific dyes.

Discipline Specific Elective - I	Introduction to dyestuff chemistry

1. **Preparation**

i. Preparation of Orange-II from sulphanilic acid and 2-Napthol

ii. Preparation of Para Red from p-nitroaniline and 2-Napthol.

iii. Preparation of m-nitroaniline from m-dinitrobenzene

iv. Preparation of Indigo from o-nitrobenzaldehyde

v. Preparation of Martius Yellow from 1-Napthol

2. **Estimation**

i. Estimation of Primary amino group by diazotisation

ii. Estimation of Methyl Orange/ Eriochrome Black T/Eosin/Congo Red by colorimetry.

3. **Project**

i. Dyeing of fabric (cotton) by Direct Dyeing or by Vat Dyeing

ii. Industrial Visit

Note: During Practical Examination, only preparation will be evaluated

References:

- College Practical Organic Chemistry by V K Ahluwalia, Sunita Dhingra and Adarsh Gulati, Universities Press, Ist Edition
- Comprehensive Practical Organic Chemistry,Preparation and Quantitative Analysis by V.K. Ahluwalia and Renu Aggarwal, Universities Press, Ist Edition

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Discipline Specific Elective - II

COURSE TITLE: Pesticides Chemistry

(Optional for DSE I: Introduction to dyestuff chemistry)

COURSE CODE: 23US6CHDS2PSC [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1. Recognize the importance of pesticide chemicals. 2. Discuss the synthesis and technical manufacture of some fungicides and insecticides 3. Illustrate the synthesis and technical manufacture some of herbicides and fertilisers		
Module 1	**Introduction to pesticides**	**[12L]**
Learning Objectives: The module is intended to explain classification, effects and activity of pesticides		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Classify the pesticides according to their origin and the chemical classes. 2. Illustrate the adverse and beneficial effects of pesticides. 3. Relate activity with the structure		
1.1	General introduction to pesticides (natural and synthetic), different types of pesticides- fungicides, insecticides, herbicides	4L
1.2	Benefits and adverse effects, changing concepts of pesticides, pesticides classified as potential carcinogen by US-EPA	5L

1.3	Structure activity relationship	3L

References:

- R. Cremlyn: Pesticides, John Wiley

Module 2	Fungicides and insecticides	[12L]

Learning Objectives:

This module is intended to explain synthesis and technical manufacture of Fungicides and insecticides

Learning Outcome:

After the successful completion of the module, the learner will be able to describe various aspects of synthesis and technical manufacture of Fungicides and insecticides

2.1	Introduction	
2.2	Properties	
2.3	Applications	
2.4	Formulations of some currently used fungicides and insecticides	

References:

- R. Cremlyn: Pesticides, John Wiley

Module 3	Herbicides and fertilizers	[12L]

Learning Objectives:

The module is intended to discuss synthesis and technical manufacture of Herbicides and fertilizers.

Learning Outcome:

After the successful completion of the module, the learner will be able to explain various aspects of synthesis and technical manufacture of Herbicides and fertilizers.

3.1	Introduction	
3.2	Properties	
3.3	Applications	
3.4	Formulations of some currently used Herbicides and fertilize	

References:

- R. Cremlyn: Pesticides, John Wiley

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI - Practical Based on DSE Courses

COURSE CODE: 23US6CHDSP Credit- 01

Learning Objectives:

The practical is intended to

1. Discuss the preparation of pesticides
2. Illustrate the estimation of pesticides

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Use simple reactions to synthesize simple pesticides
2. Estimate the acidity/ basicity of pesticides quantitatively by titrimetry.

Discipline Specific Elective - II	Pesticides Chemistry

1. Estimation

i. To calculate acidity in given sample of pesticide formulations as per BIS specifications.

ii. To calculate alkalinity in given sample of pesticide formulations as per BIS specifications.

2. **Preparation** i. Preparation of simple organophosphates. ii. Preparation of simple phosphonates. iii. Preparation of simple thiophosphates
References: • R. Cremlyn: Pesticides, John Wiley

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Discipline Specific Elective - III

COURSE TITLE: Polymer

COURSE CODE: 23US6CHDS3PLC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Describe the polymer classification, nomenclature and molecular structure. 2. Recognise the structure, stereochemistry and factors affecting the shape and size of polymers. 3. Discuss the environment impact assessment, circular economy, sustainability tenets and different plastic recycling technologies.

Module 1	Concepts and Methods in Polymer Science	[12L]

Learning Objectives:

After the successful completion of the module, the learner will be able to

1. Discuss today's marketplace of polymers.
2. Illustrate the Polymer nomenclature and classification.
3. Describe the polymer molecular structure and polymerizabilty of monomers.

Learning Outcome:

After learning this module, the student will be able to

1. Relate the history of polymers and its market value.
2. Classify and name different polymers based on different factors such as sources, thermal properties
3. Explain polymer molecular structure

1.1	Development of polymer science as a discipline. Why polymers? Today's market place of polymers. History of polymers. Fundamental terms.	
1.2	Macromolecular hypothesis. Polymer nomenclature and classification based on factors - sources, thermal properties, chain type, polymerization processes, applications, Copolymers, Blend IPN Dendrite, Ladder polymers.	
1.3	Molecular structure and polymerizabilty of monomers. Monomer raw materials. Polymer molecular weight. Number-Average and weight-average molecular weight. Molecular weight distribution Polydispersity index.	

References:

- P. Bahadur and N. V. Sastry, Principles of Polymer Science, second edition, Narosa Publishing House, 2005.
- Joel R. Fried, Polymer Science and Technology, Prentice-Hall of India Pvt. Ltd., 2000.

Module 2	Polymer Structure and Properties	[12L]

Learning Objectives:

This module is intended to

1. Describe the structure and factors affecting the shape and size of polymers.
2. Explain the stereochemistry of polymers.
3. Discuss physical and chemical methods for the determination of microstructures

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Compare primary, secondary, tertiary and quaternary structures of polymers.
2. Explain configurations and conformations of polymers.
3. Discuss different methods to find out the microstructures of polymers.
4. Recognise the design tailored functional polymers for specific applications.

2.1	Structural studies of polymers. Factors influencing the shape and size. Primary, secondary, tertiary and the quaternary structures.	
2.2	Stereochemistry of polymers. Molecular interactions. Configurations and strength conformations. Stereochemistry of repeating units. Chiral centres. Tacticity. Repeat unit isomerism. Optical, geometric and substitutional isomerism	
2.3	Physical and chemical methods for the determination of microstructures. Polymer crystals Structure-Property-Performance relations. Cross-linking. Structure-property relations in cross linked functional copolymers. Design of tailored functional polymers for specific applications.	

References:

- V. R. Gowarikar, H. V. Viswanathan and J. Sreedhar, Polymer Science,New Age International Pvt. Ltd., New Delhi, 1990.
- F. W. Billmeyer Jr., Text Book of Polymer Science, 3rd edition, John Wiley and Sons, 1984.

Module 3	Polymer-Plastic Industry and Sustainability	[12L]

Learning Objectives:

The module is intended to

1. Explain the environmental impact assessment.
2. Describe the concept of circular economy, Life Cycle Analysis and sustainability tenets.
3. Recognise different recycling technologies.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Explain the environmental impact assessment.
2. Use circular economy, Life Cycle Analysis and sustainability tenets.
3. Examine different methods of recycling technologies

3.1	Marketplace of polymers and plastics; Environmental Impact Assessment; Ecological footprint.	
3.2	Concept of circular economy; sustainability tenets; Life Cycle Analysis Methodology.	
3.3	Recycling Technologies: Feed preparation, recycling and application. Additives, processing aids and compatibilizers. Waste segregation technology for industrial plastics. Circular economy of plastics recycling. Enhancing properties of recycled plastics. Polymeric green materials. Self-destructing plastics and sustainable polymers.	

References:

- The Principles of Sustainability, Simon Dresner, Second Edition, earthscan from Routledge.
- Sustainability Principles and Practice, Margaret Robertson,Second Edition, 2017, earthscan from Routledge
- Life Cycle Analysis of Plastic in Packaging, A.K. Ghosh, 2005, Thomson Press (India) Ltd
- Plastic for Environment and Sustainable Development, Ministry of Chemicals and Fertilizers, Govt. of India, 2003, ICPE,Thomson Press (India) Ltd

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI - Practical Based on DSE Courses

COURSE CODE: 23US6CHDSP **Credit- 01**

Learning Objectives:

The practical is intended to

1. Discuss viscosity measurements for the molecular weight determination of polymers.
2. Describe experiments to identify different types of polymers.
3. Illustrate experiments to determine saponification value o, iodine value and acid number of resins.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Relate concentration and coefficient of viscosity and how to determine molecular weight from viscosity measurements.

2. Discuss different types of polymers and their identification methods.
3. Determine saponification value and its determination for polymers.
4. Find iodine value and its determination for resins
5. Determine acid number and its determination for resins.

Discipline Specific Elective - III	Polymer

1. Determination of molecular weight of PVA by viscosity measurement.
2. Identification of polymers
3. Determination of saponification value of Polyester
4. Determination Acid number of resin

References:

- Experiments In Polymer Science, Hundiwale D. G., Athawale V.D., Kapadi U.R. and Gite V.V., 2009, New Age International Publishers.

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Discipline Specific Elective – IV

COURSE TITLE: Industrial Chemistry

(Optional for DSE III: Polymers)

COURSE CODE: 23US6CHDS4INC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the physico-chemical principles and manufacturing processes of ammonia, sulphuric acid and nitric acid. 2. Discuss classification and characteristics of fuel 3. Illustrate the manufacturing and fermentation processes in the sugar industry

Module 1	Manufacture of Ammonia, Sulphuric acid & Nitric Acid	[12L]
Learning Objectives: The module is intended to discuss Physico-Chemical principles involved in manufacture of ammonia; sulphuric acid & nitric acid make aware of today's market place of polymers		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Describe the process involved in Haber & Bosch process for the manufacture of ammonia, contact process for sulphuric acid & Ostwald's process for nitric acid. 2. Discuss applications of ammonia, sulphuric acid and nitric acid.		
3.1	Physico-Chemical principles involved in manufacture of ammonia, sulphuric acid & nitric acid.	3L

3.2	Manufacture of ammonia by modified Haber & Bosch process with flow-sheet. Uses of ammonia	3L
3.3	Manufacture of sulphuric acid by contact process with flow sheet. Uses of Sulphuric acid	3L
3.4	Manufacture of nitric acid by Ostwald's process with flow sheet. Uses of nitric acid	3L
Module 2	**Fuels**	**[12L]**

Learning Objectives:

This module is intended to

1. Make the students familiar with fuels.
2. Discuss the importance of depletion in the abundance of natural resources of this country for the benefit of the society

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Classify fuels in to different types.
2. Discuss the different physical and chemical properties of fuels

2.1	Introduction, definition, classification of fuels, criterion of selection of fuel	2L
2.2	calorific value, determination of calorific value by Bomb calorimeter and problems based on it. Other properties of fuel – ignition temperature, flash point, fire point, coke number, viscosity.	4L
2.3	Solid fuels – coal, destructive distillation of coal, chemicals from coal. By products of coal, coking of coal, distillation of coal tar, uses of tar products. Liquid	4L

	fuels – distillation of crude oil, petrol gasoline and diesel oil. Gaseous fuels – Biogas or gobar gas, LPG.	
2.4	Fuel cells – methanol fuel cell, hydrogen fuel cell.	2L
Module 3	**Sugar and Fermentation**	**[12L]**
Learning Objectives: The module is intended to 1. Make the students familiar with organic industries like sugar. 2. Explain the importance of sugar industry and fermentation process		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Explain the manufacturing process involved in sugar industry. 2. Discuss the utilization of byproducts of sugar industry. 3. Describe the fermentation process and operations.		
3.1	**Sugar** Importance of Sugar industry, Manufacture of raw sugar from sugar cane with flow sheet, extraction of juice, compound imbibition process, concentration by multiple compound imbibition process, concentration of multiple evaporators, crystallisation (single vacuum pan) Refining of raw sugar in brief, utilisation of byproducts of sugar industry. Estimation of sugar by Brix hydrometer & refractomer	6L

3.2	**Fermentation** Definition, conditions favourable for fermentation, fementation operation, requirements for fermentation processes. Manufacture of alcohol from molasses, coffey still, proof spirit, rectified spirit, absolute alcohol. Other useful fermentation products with respect to medium organism etc., Acetic acid, vinegar, citric acid etc.	6L

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI - Practical Based on DSE Courses

COURSE CODE: 23US6CHDSP **Credit- 01**

Learning Objectives:

The practical is intended to

1. Analyze different commercial samples
2. Discuss the working of chemical industry

Learning Outcome:

After learning this practical, the student will be able to

1. Measure Moisture content for the fuel.
2. Determine strength of given commercial sample of acid.
3. Determine glucose content in the given sample

Discipline Specific Elective - IV	Industrial Chemistry

1. To determine the moisture content in the given sample of fuel.
2. To determine strength of given commercial sample of acid.
3. To determine glucose content in the given sample by Folin-Wu method.
4. Visit to industry

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Skill Enhancement course - I

COURSE TITLE: Chemistry of Cosmetics

COURSE CODE: 23US6CHSE1COC [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the role of cosmetics for protecting our skin and hair . 2. Prepare formulation of different cosmetic products. 3. Demonstrate the various chemical and instrumental methods for cosmetic analysis. 4. Recognize Career Opportunities in Cosmeticology.

Module 1	Introduction to Cosmetics	[15L]
Learning Objectives: This module is intended to 1. Discuss the role of cosmetics in maintaining healthy hair and skin. 2. Explain preparation of formulations 3. Explore Career Opportunities in Cosmeticology.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Describe the concepts of hair, skin and its role in cosmetics. 2. Illustrate the preparation of formulations of various cosmetics. 3. Use classical and instrumental methods for analysis of cosmetics.		
1.1	The skin and skin products – Introduction, different parts of skins, nutrition and hormonal influences, impact of cosmetics on skin.	6L

	Skin products – Skin cream, face powder, Manicure products, Sanitizers, Antiperspirants & Deodorants, Sunscreen.	
1.2	The hair and hair products - Introduction, different parts of hair, nutrition and hormonal influences, impact of cosmetics. Hair products – Hair oil and hair tonics, Shampoo, Hair colorants, Hair setting lotions/Sprays, Hair Straighteners.	6L
1.3	Cosmetic Rules & Regulations, Manufacturing and Career Opportunities in cosmetics.	3L

References:

- Harry's Cosmeticology 7th edition
- https://ncert.nic.in/vocational/pdf/kvbk101.pdf
- Cosmetic Chemistry: An Instant Approach by Ayaz Mahmood Dar
- Cosmetics: science and technology, Volume 1 edited by M. S. Balsam, Edward Sagarin

Module 2	Cosmetic Analysis (Practical/Project/Industrial Visit)	[30L]

Learning Objectives:

This module is intended to

1. Perform various analytical methods for estimation of desired constituents of cosmetics samples.
2. Design and execute a novel procedure for cosmetic analysis.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Identify different constituents present in the given cosmetic via known practical procedures.

2. Apply the experimental knowledge to perform or create novel types of qualitative and quantitative analysis for given cosmetic and cosmetic products.		
2.1	Formulation (any two) – Hand sanitizers, Skin cream, Shampoo, Hair tonics, Nail polish	12L
2.2	Analysis (any two) – Hair Oil (Acid/Iodine value, Sap value), Skin cream for their Zn content, Lipstick (for heavy metal – Lead), Shampoo (for CMC)	12L
2.3	Industrial Visit/Project	6L

References:

- Handbook on Cosmetics (Processes, Formulae with Testing Methods) by S.K. Singh
- Analysis of Cosmetic Products edited by Amparo Salvador, Alberto Chisvert
- Handbook of Cosmetic Science and Technology edited by André O. Barel, Marc Paye, Howard I. Maibach

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Skill Enhancement course - II

COURSE TITLE: Dairy Chemistry

(Optional for SEC II: Chemistry of Cosmetics)

COURSE CODE: 23US6CHSE2DAC [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 8. Explain the basic constituents of Milk and Milk products 9. Describe the instrumental techniques for milk analysis 10. Inculcate the knowledge regarding quality management & quality assurance related to dairy products

Module 1	Chemistry of functional Dairy ingredients and Nutraceuticals	[12L]

Learning Objectives:

The module is intended to

12. Disucss the chemistry of major and minor milk constituents.
13. Explain the chemistry of milk and its products, composition, role of each component and their interactions

Learning Outcome:

After the successful completion of the module, the learner will be able to

12. Distinguish the major and minor milk constituents
13. Describe the biological significance of micronutrients present in dairy products
14. Demonstrate the estimation of lactose, calcium and magnesium in the diary products

1.	Milk – Composition, factor influencing the composition and physico Chemical properties, Milk lipids, Proteins, carbohydrates: classes, physico-chemical and properties and biological significance, Minerals, Vitamins and Enzymes in Milk	4 L
2	Dairy nutraceuticals: Bio-functional milk proteins and their therapeutic potential, Technological and nutritional aspects of milk lipids, Mineral and vitamins fortification in milk and milk products, health promoting aspects of milk oligosaccharides, Artificial sweeteners Thermal stability of Milk, Freezing Point depression of Milk, Chemistry involved in high pressure processing of milk	4 L
3	Estimation of lactose in milk by volumetric and colorimetric methods & Estimation of calcium and magnesium in milk by EDTA method	4L

References:

- Dairy Science: Petersen (W.E.) Publisher – Lippincott & Company
- Outlines of Dairy Technology – Sukumar (De) – Oxford University press
- The technology of milk Processing – Ananthakrishnan, C.P., Khan, A.Q. and Padmanabhan, P.N. – Shri Lakshmi Publications.
- Handbook on Analysis of Milk Chemical & Microbiological Analysis of Liquid Milk, Dr. M.K. Srivastava

Module 2	Chemical Quality Assurance in Dairy Industry	[12L]

Learning Objectives:

This module is intended to

7. Inculcate the knowledge regarding recent trends in quality management and quality assurance.

8. Discuss the statutory regulations.		
Learning Outcome: After the successful completion of the module, the learner will be able to 7. Illustrate the food safety act and regulations. 8. Apply the experimental techniques to evaluate Specific gravity, fat, SNF, TS, Acidity, pH, etc. 9. Demonstrate safety and Quality assurance strategies in diary chemistry 10. Design packaging material for milk and milk related products		
1	Definition of Milk and Milk Products under the PFA Rules, 1955/Food Safety Act 2006 and Classes of Milk. Sensory analysis of Milk, Determination of Specific gravity, fat, SNF, TS, Acidity & pH in milk and their significance and interpretation, Determination and significance of MBR Test, SPC (Statistical Process Control), Phosphatase activity in milk.	3 L
2	Food safety and Quality assurance strategies - Implementation of HACCP/ISO and certification, BIS, PFA standards, Legal / Statutory standards of milk and milk products, Bacteriological standards for milk and milk products	2 L
3.	Maximum Permissible limits of Aflatoxin, Pesticides, Antibiotic residues and Heavy metals in Milk and Milk Products	1 L
4	Packaging of Market Milk and Milk products and advancements in Liquid Milk and Milk Products Packaging, Storage of Milk and Milk Products and Labelling of Milk and Milk Products	3 L
5	Qualitative colour tests to distinguish between azo dyes and natural dyes in butter & Detection of common adulterants in milk and foreign fat/oil in ghee	3 L

References:

- Indian Dairy Products – Rangappa (K.S.) & Acharya (KT) – Asia Publishing House.
- Dairy Processing and Quality Assurance, Wiley Blackwell
- The technology of milk Processing – Ananthakrishnan, C.P., Khan, A.Q. and Padmanabhan, P.N. – Shri Lakshmi Publications.
- The Chemistry of Dairy Products - A Chemical Analysis of Milk, Cream and Butter (English, Paperback, Various)

Module 3	Latest developments and applications of HPLC	[12L]

Learning Objectives:

The module is intended to

4. Impart the knowledge regarding importance of quality of milk.
5. Discuss the principle and technical aspects of quality control for various dairy equipment.
6. Describe the various test procedures related to maintenance of quality of milk.

Learning Outcome:

After the successful completion of the module, the learner will be able to

4. Apply the skills to develop a new method for qualitative or quantitative analysis
5. Perform complex separation and determination of real samples.
6. Develop advanced analytical skills to make optimum use of latest technologies in the field of dairy chemistry.

1	Electrophoresis: principle and types, isoelectric focusing. Separation of bio-molecules using membranes; ultracentrifugation.	**2 L**
2	Immunobased analytical techniques such as ELISA & Lateral flow assay	2 L
3	Column Chromatography, TLC, GLC, HPLC, gel-permeation, ion-exchange, affinity chromatography	2 L
4	Spectrophotometry: UV, visible, IR and flame photometry; Potentiometry: principle, various electrodes; buffers.	3 L
5	Determination of sodium and potassium by flame photometry & Demonstration of Beer's law using standard protein	3 L

References:

- Dairy Science: Petersen (W.E.) Publisher – Lippincott & Company
- Dairy India 2007, Sixth edition
- Economics of Milk Production – Bharati Pratima Acharya Publishers
- Instrumentation in Analysis of Food & Dairy Products, M. K. Srivastava

7.4 T. Y. B.Sc. Syllabus [3 Units] with effect from the Academic year 2023–2024

Syllabus - T. Y. B.Sc. Chemistry [3 Units]

Course No.	Course Title	Course code	Credits	Hour	Periods (50 min)	Module	Lectures per module (50 minutes)	Examination		
								Internal Marks	External Marks	Total Marks
SEMESTER V										
Core courses THEORY										
I	Physical-Analytical Chemistry I	23US5BCHCCIPACI	2	30	36	3	12	40	60	100
II	Inorganic-Organic Chemistry I	23US5BCHCC2IOCI	2	30	36	3	12	40	60	100
Core courses PRACTICAL										
CCP	Based on CCI and CC II	23US5BCHCCP	2	4	48			40	60	100
Skill Enhancement Courses										
I/II	Business skills for chemist OR Food Chemistry	23US5CHSEIBSC Or 23US5CHSE2FOC	2					40	60	100
SEMESTER VI										
Core courses THEORY										

I	Physical-Analytical Chemistry II	23US6BCHCCIPAC2	2	30	36	3	12	40	60	100
II	Inorganic-Organic Chemistry II	23US6BCHCC2IOC2	2	30	36	3	12	40	60	100
Core courses PRACTICAL										
CC P	Based on CCI and CC II	23US6BCHCCP	1	4	48			20	30	50
Skill Enhancement Courses										
I/II	Chemistry of Cosmetics OR Dairy chemistry	23US6CHSEICOC or 23US6CHSE2DAC	2					40	60	100

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Core Course- I

COURSE TITLE: Physical-Analytical Chemistry I

COURSE CODE: 23US5BCHCC1PAC1 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Recognize the different types of electrochemical cells and their applications. 2. Understand the importance of statistics and its application in chemical analysis 3. Learn the basics of separation science and classical chromatography

Module 1	Electrochemical Cells and Their Applications	[12L]

Learning Objectives:

The module is intended to

1. Discuss different types of Electrochemical Concentration cells
2. Illustrate the applications of EMF Measurements
3. Describe the concepts of Decomposition potential and Over voltage

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Differentiate between Chemical and concentration cells
2. Classify different types of Concentration cells.
3. Describe the Applications of EMF Measurements.
4. Recognize the concepts of Decomposition potential and Over voltage

1.1	Lewis concept of activity and activity coefficient, ionic strength of a solution, Debye- Huckel limiting law (derivation not expected)	
1.2	Classification of cells: Comparison between chemical and concentration cell 1) Concentration cells with and without transference (derivation of expression for concentration cell EMF are expected), 2) Chemical cells without transference. Origin of liquid-liquid junction potential and its elimination using a salt bridge.	
1.3	Faradaic and Non-Faradaic processes. Batteries and Superconductors	
1.4	Polarization, concentration polarization and its elimination, Decomposition potential, experimental determination of decomposition potential, factors affecting decomposition potential (nature of electrolyte, nature of electrodes and temperature), overvoltage, experimental determination of overvoltage, Tafel's theory and Tafel's equation for hydrogen overvoltage, simultaneous deposition of metal. Corrosion and its prevention	

References:

- Electrochemical Methods: Fundamentals and Applications, Allen J. Bard and Larry R. Faulkner, 2006, wiley Student Edition.
- An Introduction to Electrochemistry, Samuel Glasstone, 10th edition, An East-West Edition

Module 2	Quality in Analytical Chemistry and Statistical treatment of Data	[12L]

Learning Objectives:

This module is intended to

1. Explain the concept of Quality in Analytical chemistry. Quality systems for chemical analysis.
2. Discuss the basic statistics and use of it for establishing quality in chemical analysis.
3. Use statistics for data analysis and interpretation of results

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Explain the basic concept Quality, role of quality in chemical analysis. Quality control and quality assurance. Quality management systems like ISO, ICH etc.
2. Use the simple statistical parameters like mean, mode, standard deviation etc. for interpretation of data.
3. Implement statistics for rejection of results, concept of errors, types and quantitative measurement of errors.

2.1	**Introduction to Quality in Analytical Chemistry**	**4L**
2.1.1	Concept of Quality, definition and requirement	
2.1.2	Quality control and quality assurance. Similarities and difference between QC and QA	
2.1.3	Introduction to different quality systems: ISO, ICH guide lines and other quality systems and their use.	
2.2	**Statistical treatment of data**	**8L**

2.2.1	Types of errors, determinate and indeterminate errors, minimization of errors, constant and proportionate errors	
2.2.2	Accuracy and precision, measure of dispersion and central tendency: mean, median, mode, average deviation, relative average deviation, variance, coefficient of variation. (Numerical problems expected)	
2.2.3	Determinate and Indeterminate errors, constant and proportionate errors, distribution of random errors, Histogram, Frequency polygon, Gaussian curve, students t, confidence limits and confidence intervals, criteria for rejection of result 2.5 d rule,4.O d rule, Q-test, F-test, Test of significance method of averages method of least squares. [Numerical problems expected]	

References:

- Fundamentals of Analytical Chemistry by Skoog, Holler etc. IX th edition
- Analytical Chemistry by Gary Christian, sixth edition
- Inorganic Quantitative analysis by Vogel, sixth edition

Module 3	Titrimetric analysis and Introduction to Chromatography	[12L]

Learning Objectives:

The module is intended to

1. Explain two important titrimetric methods viz. Redox titrations and non-aqueous titrations

2. Discuss chromatography as a major separation technique. 3. Describe basic principles, usage and applications of planar chromatographic techniques.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Discuss the basic theory of redox and non-aqueous titrations. Selection of appropriate indicators and applications of both. 2. Define and use of chromatography as a separation technique. Different chromatographic techniques and their classification. 3. Describe basic theory and use of planar chromatographic techniques like Paper chromatography, TLC and HPTLC. Their types and applications.		
3.1	**Titrimetric analysis**	**7L**
3.1.1	Redox titrations: Introduction and basic principles	
3.1.2	Titration curves for redox titration: Titration of Fe^{+2} v/s Ce^{+4}, Fe^{+2} v/s dichromate ($Cr_2O_7^{2-}$), Fe^{+2} v/s MnO^-_4 ions.	
3.1.3	Detection of end point of redox titration using indicators and potentiometrically. Some useful redox indicators.	
3.1.4	Non aqueous titrations: Definition and basic principles. Different types of non-aqueous solvents.	
3.1.5	Requirements for non-aqueous solvents. Properties of non-aqueous solvents. Leveling effect.	
3.1.6	End point detection in non-aqueous titrations. Advantages and limitations of non-aqueous titrations. Applications.	
3.2	**Introduction to chromatography**	**5L**
3.2.1	Introduction to chromatographic techniques, classification of chromatographic techniques.	

3.2.2	Planar Chromatography: Principle, techniques and applications of Paper chromatography Thin layer chromatography and HPTLC	

References:

- Inorganic Quantitative analysis by Vogel, sixth edition
- Quantitative Analysis by Day and Underwood, Prentice hall of India third edition.

T.Y. B. Sc. (CHEMISTRY) SEMESTER V

Core Course- II

COURSE TITLE: Inorganic-Organic Chemistry I

COURSE CODE: 23US5BCHCC2IOC1 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the reaction mechanism of carbonyl compounds and assign the IUPAC nomenclature to bicyclic, biphenyl, cumulene and heterocyclic compounds. 2. Descibe the concept of molecular symmetry and chemical bonding. 3. Recognize the modern theories of bonding in coordination compound

Module 1	Mechanism of Organic Reactions and IUPAC	[12L]

Learning Objectives:

The module is intended to

1. Discuss mechanism of reactions of carbonyl compounds and some rearrangements.
2. Assign IUPAC nomenclature to bicyclic, biphenyl, cumulene and heterocyclic compounds.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Predict and account for the most commonly encountered reaction mechanisms in of carbonyl compounds.
2. Name the bicyclic compounds, biphenyls, cummulenes upto 3 double bonds, heterocyclic compounds containing a maximum of two hetero atom among N, O, S.

3.1	**Mechanism of Organic Reactions**	**9L**
3.1.1	Thermodynamic and Kinetic control of organic reactions: Concept with mechanisms of the following reactions: addition of HX to butadiene; sulfonation of naphthalene. Nucleophilicity / electrophilicity Vs Basicity / acidity.	
3.1.2	Mechanism of reactions of carbonyl compounds with nucleophiles.	
3.1.2.1	Reaction of aldehydes and ketones with primary and secondary amines	
3.1.2.2	Acyl nucleophilic substitution (tetrahedral mechanism): Acid catalysed esterification of carboxylic acids and base promoted hydrolysis of esters.	
3.1.3	Mechanism of rearrangements with examples and stereochemistry wherever applicable.	
3.1.3.1	Migration to electron deficient carbon: Pinacol, Benzilic acid.	
3.1.3.2	Migration to electron deficient nitrogen: Beckmann, Hofmann.	
3.2	**IUPAC** IUPAC systematic and accepted trivial nomenclature of the following classes of compounds, including substituted ones (up to 2 substituents/functional groups):	**3L**
3.2.1	Bicyclic compounds- spiro, fused, and bridged (upto 11carbon atoms)-saturated and unsaturated compound.	
3.2.2	Biphenyls.	

3.2.3	Cummulenes upto 3 double bonds, Monocyclic (5 and 6 membered) aromatic and nonaromatic heterocyclic compounds containing a maximum of two hetero atom among N, O, S.	

References:

- Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
- Carey, F. A. & Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
- Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.
- Nomenclature of organic compounds, S C Pal, Alpha science, 2nd edition,
- Organic Nomenclature, James G Traynham, 6th Edition.

Module 2	Molecular Symmetry and Chemical bonding	[12L]

Learning Objectives:

The module is intended to

1. Discuss different symmetry elements, symmetry operations, concept of point group in molecule.
2. Explain molecular orbital theory in simple polyatomic molecules.
3. Describe band theory of metallic bonding.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Describe the basic concept of symmetry like symmetry elements, symmetry operations and point group.

2. Illustrate molecular orbital approach for bonding in simple polyatomic molecules and draw MOT diagrams for these molecules.

3. Use molecular orbital approach / band theory to explain bonding in metals and properties of conductors, insulators and semiconductors.

2.1	**Molecular Symmetry**	**6L**
2.1.1	Introduction and Importance.	
2.1.2	Symmetry elements and Symmetry operations	
2.1.3	Concept of a Point Group with illustrations using the following point groups: (i) C∞v (HCl), (ii) D∞h (H_2), (iii) C_2v (H_2O), (iv) C_3v (NH_3), (v) C_2h (trans-dichloroethylene), (vi) D_3h (BCl_3)	
2.2	**Molecular Orbital Theory for polyatomic species**	**3L**
2.2.1	Simple triatomic species H_3^+ and H_3 (correlation between bond angle and molecular orbitals)	
2.2.2	Other molecules (considering only σ bonding): (i) BeH_2 (ii) H_2O (with reference to Walsh diagram)	
2.3	**Metallic Bond**	**3L**
2.3.1	Band theory	
2.3.2	Explanation of electric properties of conductors, insulators and semiconductors (n- and p- types) on the basis of Band theory.	

References:

- Chemical Applications of Group Theory by F A Cotton, 3rd Edition
- Chemistry Inorganic - B.R. Puri, L.R. Sharma and K.C. Kallia - Vallabh Publications (2003).

Module 3	Bonding in Coordination Compounds	[12L]

Learning Objectives:

This module is intended to

1. Discuss two theories of bonding in coordination compounds – Crystal field theory and molecular orbital theory.
2. Describe concept of electronic states, term symbols, micro states.

Learning Outcome:

After the successful completion of the module, the learner will be able to

4. Describe the nature of bond between metal and ligand.
5. Discuss thermodynamic, kinetic, spectral and stereo chemical properties of coordination compounds.
1. Interpretate different electronic states, term symbols and micro states for d^1, d^4, d^6, d^9 electronic configurations.

3.1	Crystal Field Theory (CFT) of co-ordination complexes	6L
3.1.1	Basic tenets of Crystal Field Theory (CFT) and effect of Crystal Field on central metal valence orbitals	
3.1.2	Splitting of d orbitals in octahedral, tetrahedral and square planar complexes; Jahn Teller Effect	
3.1.3	Crystal field splitting energy (10Dq/Δo) for octahedral complexes and factors affecting the magnitude of Δo	
3.1.4	Crystal field stabilization energy (CFSE), calculation of CFSE for octahedral and tetrahedral complexes with d^1 to d^{10} metal ion configurations, high spin and low spin complexes.	
3.1.5	Effect of Crystal field splitting on (i) Ionic radius (ii) Lattice energy	

3.1.6	Experimental evidence for co-valence in co-ordination compounds: (i)ESR spectrum of [IrCl6] -2 (ii)Nephelauxetic effect.	
3.1.7	Merits and Demerits of CFT	
3.2	**Molecular Orbital Theory (MOT) of co –ordination complexes**	**3L**
3.2.1	Application to octahedral complexes in case of (i)$[Ti(H_2O)_6]^{+3}$ (ii) Fluoro complexes of Fe(II) and Fe(III) (iii) Cyano complexes of Fe(II) and Fe(III) (iv) Fluoro and amino complexes of Co(III)	
3.2.2	Effect of π- bonding on ligand field splitting parameter in MLπ and LMπ interactions	
3.3	**Electronic states and Terms for Polyelectronic Atoms**	**3L**
3.3.1	Introduction, electronic configuration and electronic states, Term symbols, coupling of spin momenta (MS), orbital momenta (ML) and spin orbit coupling or Russell -Saunders coupling.	
3.3.2	Determination of Terms for p2 electronic configuration (as in a carbon atom).	
3.3.3	Terms and micro-stats for transition metal atoms/ions.	

References:

- Inorganic Chemistry - J.E. Huheey, Harper and Collins - NY IV edition (12011).
- Chemistry Inorganic - B.R. Puri, L.R. Sharma and K.C. Kallia - Vallabh Publications (2016).

T. Y. B. Sc. (CHEMISTRY)

SEMESTER V – Practical Based on CCI

COURSE CODE: 23US5BCHCCP Credit- 01

Learning Objectives:

The practical is intended to

1. Discuss rate constants, effect of temperature on rate constants, energy of activation for the acid catalysed reactions like hydrolysis of methyl acetate
2. Determine acidic and basic dissociation constants of amino acid and to calculate isoelectric point.
3. Explain colorimetric determination of fluoride content in toothpaste.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Explain the effect of temperature on rate constants and determination of energy of activation.
2. Discuss the concept of isoelectric point, acidic and basic dissociation constants through pH-metric determination.
3. Evaluate colorimetric determination of fluoride content.

Core Course I	Physical-Analytical Chemistry I

1. **Chemical Kinetics (Non-Instrumental)**

To determine the energy of activation for the acid catalysed hydrolysis of methyl acetate.

2. **pH –Metry**

To determine acidic and basic dissociation constants of amino acid and to calculate isoelectric point.

3. **Colorimetry**

Detection of fluoride content in a tooth paste **4. Non-Instrumental** Estimation of $K_2S_2O_8$ in the given solution.
References: • Experimental Physical Chemistry, V. D. Athawale, 2007, New Age International Publishers. • Physical Chemistry Experiments, R. Rajalakshmi, 2020, Notion press Publishers. • Vogel's Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.B. Barnes, M. Thomas, B. Sivsankar, 2009, Pearson Publication.

T. Y. B. Sc. (CHEMISTRY)

SEMESTER V - Practical Based on CC II

COURSE CODE: 23US5BCHCCP **Credit- 01**

Learning Objectives: The practical is intended to 1. Separate binary mixture of compounds by physical separation 2. Prepare of inorganic complexes. 3. Discuss the analytical chemistry aspects of complexometric titration. 4. Describe the concept of the experiment and the different steps involved in the experiment in the real lab more accurately and precisely.
Learning Outcome: After the successful completion of the practical, the learner will be able to 1. Separate mixtures containing various organic compounds based on their physical properties.

2. Acquire the skills to prepare nickel and cobalt amine complexes.
3. Demonstrate the basic laboratory technique of titration.

Core Course II	Inorganic-Organic Chemistry I

1. **Separation of binary mixture of compounds by chemical separation**
2. **Inorganic Preparation**

i. Preparation of Chloropentaaminecobalt (III) chloride and estimation of cobalt by complexometry.

ii. Preparation of tris(ethylene diamine) nickel (II)sulphate and estimation of nickel by complexometry

3. **Titrimetric Analysis**

i. Estimation of Nickel complexometrically using mureoxideindicator.

ii. Estimation of Copper complexometrically using Fast sulphone Black Findicator.

References:

- Vogel, A. I. Elementary Practical Organic Chemistry.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Core Course- I

COURSE TITLE: Physical-Analytical Chemistry II

COURSE CODE: 23US6BCHCCIPAC2 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Discuss the basic principles of Molecular Spectroscopy. 2. Illustrate the colligative properties of dilute solutions and examine one and two component systems with the help of Phase Rule. 3. Explain importance of solvent extraction and other extraction techniques in chemistry. 4. Describe chromatography as a major separation tool in Chemistry.

Module 1	Molecular Spectroscopy	[12L]
Learning Objectives: The module is intended to discuss the principles of three key spectroscopic methods- Rotational, Infra-Red and Raman spectroscopies		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Relate dipole moments of molecules with their activity towards different molecular spectroscopic methods. 2. Examine Rotational and Vibrational spectra of diatomic molecules. 3. Determine whether the molecular rotations and vibrations of a molecule are Raman active.		
1.1	Dipole moment: Dipole moment, polarization of a bond, bond moment, dipole moment and molecular structure.	

1.2	Rotational Spectrum: Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia, energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of internuclear distance and isotopic shift	
1.3	Vibrational (IR) spectrum: Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum	
1.4	Vibration-Rotation spectrum of diatomic molecules, vibrating rotor, energy levels, selection rule, nature of spectrum, R and P branches, anharmonic oscillator: energy levels, selection rule, fundamental band, overtones. Introduction to infrared spectra of simple molecules like H_2O and CO_2.	
1.5	Raman Spectroscopy: scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum, Stoke's lines, anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion (example of CO_2 molecule).	

References:

- Fundamentals of Molecular Spectroscopy, Colin N Banwell and E. M, McCash, 4th Edition, Tata McGraw-Hill Publishing Company Ltd.

- Molecular Structure and Spectroscopy, G. Aruldhas, Second edition, Eastern Economy Edition.

Module 2	Colligative Properties of Dilute Solutions and phase Rule	[12L]

Learning Objectives:

This module is intended to

1. Explain the concepts of colligative properties lowering of vapour pressure, elevation of boiling point, depression in freezing point and osmotic pressure.
2. Illustrate the relation between the colligative property and calculations of different parameters
3. Describe Phase rule and it's applications to one and two component systems.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Describe the relation between colligative property and molar mass of the non-volatile solute.
2. Solve numerical problems on determination of molar mass of the non-volatile solutes.
3. Apply phase rule to understand behaviour of one and two component systems.

2.1	Colligative Properties of Dilute Solutions	7L
2.1.1	Dilute solutions, colligative properties, Raoult's law, relative lowering of vapour pressure.	

2.1.2	Elevation in boiling point of a solution, thermodynamic derivation relating elevation in boiling point of a solution and the molar mass of a non-volatile solute.	
2.1.3	Depression in freezing point of a solution, thermodynamic derivation relating the depression in the freezing point of a solution and the molar mass of a non-volatile solute.	
2.1.4	Osmotic pressure, van't Hoff's equation for osmotic pressure (derivation is expected) and determination of molar mass of the solute. Abnormal molar masses of solutes and van't Hoff factor (calculation of Degree of Association and Degree of Dissociation.)	
2.2	**Phase Rule**	**5L**
2.2.1	Gibb's phase rule and terms involved in the equation	
2.2.2	Application of phase rule to ONE component systems: Water system	
2.2.3	Application of phase rule to TWO component systems, condensed systems, condensed phase rule, eutectic systems (Lead – Silver system), desilverisation of lead.	
2.2.4	Introduction to THREE component systems, triangular plots.	

References:

- Principles of Physical Chemistry, Puri, Sharma, Pathania, 41st Millennium Edition, Vishal Publishers.
- Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).

- The Phase Rule And Its Applications, Alexander Findlay,Longmans, Green, and Co., 1911

Module 3	Solvent extraction and Solid phase extraction	[12L]

Learning Objectives:

The module is intended to

1. Discuss the solvent extraction as a major method of separation in analytical chemistry
2. Describe basic extraction methods using different extraction mechanism and different extraction methodologies
3. Illustrate solid phase extraction as a new versatile method of separation.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Explain the basic concept solvent extraction. Different extraction systems and mechanisms
2. Describe experimental extraction techniques, role of pH and selecting appropriate method for desired separation
3. Apply solvent extraction technique in chemistry
4. Illustrate solid phase extraction as new method of separation.

3.1	**Solvent Extraction**	**8L**
3.1.1	Partition coefficient and distribution ratio	
3.1.2	Extraction efficiency, separation factor	
3.1.3	Role of complexing agents in solvent extraction, chelation, ion pair formation, solvation	
3.1.4	Types of solvent extraction: batch, continuous. [Numerical problems expected]	
3.2	**Introduction to Solid phase extraction**	**4L**

3.2.1	Limitations of solvent extraction	
3.2.2	Basic Principles, Equipments used	
3.2.3	Applications of Solid phase extraction	

References:

- S. M. Khopkar, Basic Concepts of Analytical Chemistry, 3rd ed,New Age International Publishers, 2008
- R.A.Dey & D.L.Underwood, Quantitative Analysis, 6th ed. Prentice Hall Of India Pvt. Ltd. New Delhi, 1993.
- G.D.Christian, Analytical Chemistry, 6th ed. John Wiley &Sons, Singapore, 2004.

T.Y. B. Sc. (CHEMISTRY) SEMESTER VI

Core Course- II

COURSE TITLE: Inorganic-Organic Chemistry II

COURSE CODE: 23US6BCHCC2IOC2 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Design the synthesis of simple organolithium, organo magnesium and organo zinc compounds and predict their reactivity. 2. Elucidate the structure of simple organic compounds using U.V, I.R and NMR spectra. 3. Explain the electronic spectra of complexes, stability and substitution reactions in complexes.

Module 1	Organometallic Chemistry and Reagents and Catalysts	[12L]
Learning Objectives: This module is intended to discuss chemistry of organometallic compounds and various reagents along with their uses in organic synthesis		
Learning Outcome: After the successful completion of the module, the learner will be able to: 1. Design the synthesis of simple organolithium, organo magnesium and organo zinc compounds and predict their reactivity. 2. Predict the use of some catalysts and reagent in carrying out various functional group interconversions used in organic synthesis. 3. Predict the reagent for carrying various functional group interconversion useful in synthesis of a particular molecule.		
1.1	Organometallic Chemistry	4L

1.1.1	Organolithium Compounds: Preparation using alkyl/aryl halides. Reactions with compounds containing acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO_2. Lithium dialkylcuprates: Preparation and reactions with aliphatic /aromatic/vinylic halides	
1.1.2	Organozinc compounds: Preparation of dialkyl zinc. Reaction with water, acid chlorides and alkyl halides. Reformatsky reaction (with mechanism).	
1.2	**Reagents and Catalysts**	**8L**
1.2.1	Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism).	
1.2.2	Catalysts: Catalysts for hydrogenation: Raney Ni, Pt and PtO_2: C=C, CN, NO_2, aromatic ring; Pd/C: C=C, COCl→ CHO (Rosenmund's); Lindlar catalyst: alkynes; Wilkinson's catalyst for stereo selective reduction of olefins.	
1.2.3	Reagents: (1) $LiAlH_4$ and Red-Al: reduction of CO, COOR, CN, NO_2. (2) $NaBH_4$: reduction of CO (3) SeO_2: hydroxylation of allylic and benzylic positions, oxidation of CH_2, alpha to CO to CO. (5) m-CPBA and R-OOH/H_2O_2 for epoxidation of C=C. (6) NBS: allylic and benzylic bromination of position alpha to CO.	

References:

- Textbook of Organic Chemistry, 2012, by V K Ahluwalia, Rakesh K Parashar, Viva Books Private Limited.
- Organic Chemistry: Second Edition, 2014,Jonathan Clayden, Nick Greeves , Stuart Warren.

- Modern Synthetic Reactions H. O. House, Massachusetts Institute of Technology. W. A. Benjamin, Inc., New York, 1965.

Module 2	Spectroscopy	[12L]

Learning Objectives:

This module is intended to elucidate the structure of simple organic compounds using U.V, I.R and NMR spectra.

Learning Outcome:

After the successful completion of the module, the learner will be able to:

1. Identify various functional groups on the basis of the U.V and IR spectra.
2. Predict the electronic environment around different types hydrogen present in the organic compound based on the IH NMR spectrum.
3. Predict the structure of simple organic compounds using U.V, IR and IH NMR spectrum in synchronization and vice versa.

2.1	Introduction: Electromagnetic spectrum, units of wavelength and frequency	
2.2	UV- Visible Spectroscopy: Basic theory, solvents, nature of UV-VIS spectrum	
2.3	IR Spectroscopy: Basic theory, nature of IR spectrum, selection rule, fingerprint region.	
2.4	PMR Spectroscopy: Basic theory of NMR, nature of PMR spectrum, chemical shift (ò unit), standard for PMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to C=C, CΞC, C=O and benzene ring). Spin spin coupling and coupling constant. Proton exchange-application of deuterium exchange, Application of PMR in structure determination.	

2.5	Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to UV-VIS, IR, PMR: (1) alkenes (2) alkenes and polyenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) carboxylic acids (9) esters (10) amines (11) amides (broad regions characteristic of different groups are expected).	
2.6	Problems of structure elucidation of simple organic compounds using individual or combined uses of the above spectroscopic technique are expected. (index of hydrogen deficiency should be the first step in solving the problems).	

References:

- P.S. Kalsi, Spectroscopy of Organic compounds, New Age International Ltd., 1995.
- Jagmohan, Organic Spectroscopy- Principles and Applications, 2 nd Edition, Narosa Publication, 2008.
- W. Kemp, Organic Spectroscopy, 3rd Edition, Palgrave, Indian Edition, 2005.
- Williams and Fleming, Spectroscopic methods in Organic Chemistry, 5 th Edition, McGraw Hill, 1995.

Module 3	Coordination Chemistry	[12L]

Learning Objectives:

The module is intended to

4. Discuss the study of electronic spectra of complexes.

5. Illustrate the stability of complexes 6. Explain the substitution reactions in complexes.		
Learning Outcome: After the successful completion of the module, the learner will be able to: 1. Explain the electronic spectra of complexes and to recognize various types of electronic transitions, geometry of complexes. 2. Illustrate the complex chemistry of transition metal coordination compounds by studying kinetics, mechanisms of various reactions and stability of complexes		
3.1	**Electronic Spectra of Complexes**	**5L**
3.1.1	Type of electronic transitions like intra-ligand transitions, charge transfer transitions and intra-metal transitions (d-d or ligand field transitions for transition metals)	
3.1.2	Rule for electronic transitions: Spin and Orbital or Laporte selection rules	
3.1.3	Splitting of Terms in weak crystal field, the Hole formalism	
3.1.4	Orgel Diagrams for D Terms i.e. d^1, d^4 and d^6, d^9 electronic configurations	
3.1.5	Applications of electronic spectra in brief, with special reference to (i) cis-trans isomerism in complexes and (ii) Geometry of complexes	
3.2	**Stability of octahedral complexes**	**3L**
3.2.1	Thermodynamic stability and kinetic stability of complexes with examples	
3.2.2	Stability constants: stepwise and overall constants and their inter relationship	

3.2.3	Factors affecting thermodynamic stability	
3.3	**Substitution reactions in octahedral complexes**	**4L**
3.3.1	Introduction, types of reactions in complexes	
3.3.2	Ligand substitution reactions: basic mechanisms	
3.3.3	Inert and labile complexes and electronic configurations and lability	
3.3.4	Acid hydrolysis, base hydrolysis and anation reactions.	

References:

- Selected Topics in Inorganic Chemistry - W.U. Malik, G.D. Tuli and R.D. Madan - S. Chand Publications (2019).
- Inorganic Chemistry by GARY L. MIESSLER DONALD A. TARR, Third Edition, PPH publication.

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI - Practical Based on CCI

COURSE CODE: 23US6BCHCCP Credit- 01

Learning Objectives:

The practical is intended to

1. Discuss partition coefficient method to determine equilibrium constant of a reaction.
2. Illustrate conductometric titration method of mixture of acids and salt to determine the percentage composition.
3. Describe GC and HPLC for real sample analysis.
4. Use instrumental methods for analysis of real samples like Vinegar.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Determine equilibrium constant of a reaction by partition coefficient method.
2. Illustrate conductometric titration method.
3. Demonstrate use of GC and HPLC as a major separation and estimation techniques in Analytical Chemistry
4. Use Instrumental methods of analysis for commercial samples like vinegar.

Core Course I	Physical-Analytical Chemistry II

1. Partition coefficient – To determine the equilibrium constant for the reaction $KI + I_2 = KI_3$ by partition coefficient method.
2. Conductometry – To estimate the concentration of sulphuric acid, acetic acid and copper sulphate in the given solution by conductometric titration method.

3. Potentiometry - Estimation of acetic acid.
4. Determination of hardness of water
    a. Determination of alkalinity of potable water by acid base titration
    b. Estimation of total hardness of water sample by complexometric titrations.

References:

- Experimental Physical Chemistry, V. D. Athawale, 2007, New Age International Publishers.
- Physical Chemistry Experiments, R. Rajalakshmi, 2020, Notion press Publishers.
- Vogel's Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.B. Barnes, M. Thomas, B. Sivsankar, 2009, Pearson Publication.

T. Y. B. Sc. (CHEMISTRY)

SEMESTER VI - Practical Based on CC II

COURSE CODE: 23US6BCHCCP **Credit- 01**

Learning Objectives:

The practical is intended to

1. Separate binary mixture of compounds by physical separation
2. Prepare of inorganic complexes.
3. Discuss the analytical chemistry aspects of complexometric titration.
4. Describe the concept of the experiment and the different steps involved in the experiment in the real lab more accurately and precisely.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Use the technique of separation of mixtures containing various organic compounds based on their physical properties.
2. Acquire the skills to prepare Inorganic complexes

Core Course II	Organic-Inorganic Chemistry II

1. **Binary Mixture Separation & Identification**

(Volatile liquid + Nonvolatile liquid) (Solid + Volatile liquid)

2. **Commercial Analysis**

i. Analysis of calcium tablets for its calcium contentcomplexometrically.

ii. Analysis of Boric acid for its percentagepurity.

3. **Inorganic Preparations**

i. 8-hydoxyquinolinato magnesium(II).

ii. Bis-(acetylacetanato) copper(II).

References:

- 1. Vogel, A. I. Elementary Practical Organic Chemistry.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).