

CURRICULUM & SYLLABUS



Bachelor of Science (Hons.) Chemistry

or

Bachelor of Science (Hons.) Chemistry with Research/

Academic Projects

(A 4 Year Undergraduate Degree Program)

Under UGC Framework - 2022 based on NEP – 2020

(w.e.f. Academic Year 2025-26)

DEPARTMENT OF CHEMISTRY

FACULTY OF SCIENCE AND HUMANITIES

SRM UNIVERSITY DELHI-NCR, SONEPAT

Plot No.39, Rajiv Gandhi Education City

Sonepat Haryana-131029

Vision

The Department of Chemistry is committed to providing intellectual, innovative, and motivational surroundings to students and faculty members. The department is focused on contributing academic, scientific, research, and experimental knowledge through excellence and producing scientists, researchers, and bureaucrats. The department wants to strive and achieve the reputation of seeking the attention of the government of India and the use of others to be invited to provide services on subjects involving chemistry and allied areas.

Mission

- To improve the problem-solving capability of students through continuous learning to produce quality Chemists, Scientists, Academic intellectuals etc. in the field of Science and Technology.
- To bridge the gap between industry and academia by imparting technical/experimental knowledge along with its application in the practical world.
- To encourage innovation through multidisciplinary research and development activities.
- To inculcate human values and ethics into students to serve the society and nation with utmost devotion.
- To develop the overall personality of students along with the learning process simultaneously.

SCIENCE GRADUATE EMPLOYABILITY ATTRIBUTES

- Sound Knowledge and Understanding of the Domain Area
- Analytical and Critical Thinking and Problem-Solving Skills
- Scientific Temperament Towards Research and Innovation for the Betterment of Society
- Efficient Communication and Presentation Skills
- Dependability, Reliability, Responsibility, and Independent Leadership Abilities

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

- To impart knowledge and understanding of the concepts of Organic Chemistry, Inorganic Chemistry, Physical Chemistry and related allied subjects.
- To equip students to handle apparatus and basic instrumentation used in chemistry laboratory to synthesize, isolate, and characterize molecules and materials.
- To interpret, analyze, and connect the multiple concepts of various topics through numerical, assignment, quiz, and experiment or project.
- To organize seminars, workshops, and group discussions on related topics and societal problems.
- To develop and enhance the writing, reviewing, and presentation skills of students.
- To develop the commitment to foster sustainable future through research and development.

PROGRAM LEARNING OUTCOMES (PLOs)

The students would be able to have:

- Knowledge and understanding of the fundamental concepts of Physical Chemistry, Organic Chemistry, Inorganic Chemistry, and allied subjects, along with their applications in research and industry.
- Better learning through a theoretical and evidence-based approach to explaining the chemical synthesis, analysis, and characterization of materials.
- Ability to demonstrate the basic principles of equipment and instruments.
- Ability to work both independently and in groups on complex problems to apply scientific knowledge to develop entrepreneurial abilities.
- Capacity to identify the research problem(s), plan, design, execute, and present the results and findings in a scientific manner.

MAPPING OF PROGRAM EDUCATIONAL OBJECTIVES AND PROGRAM LEARNING OUTCOMES

Programme Educational Objectives (PEO's)	Program Learning Outcomes (PLO's)				
	PLO1	PLO2	PLO3	PLO4	PLO5
PEO1					
PEO2					
PEO3					
PEO4					
PEO5					

PROGRAM CREDIT STRUCTURE

Semester	Broad Category of Courses								Total Credits	Remarks
	Major	Minor	Multidisciplinary	AEC	SEC	VAC	RP/Dissertation	Live Projects/Vocational Courses/Summer Internship		
I	8	4	3	2	2	2	*		21	Certificate: 46 Credits
II	8	4	3	2	2	2	*	4	25	
III	12	4	3	2	2	*	*		23	Diploma: 95 Credits
IV	12	4	*	2	2	2	*	4	26	
V	16	8	*	*	2	*	*		26	Degree : 145 Credits
VI	16	4	*	*	*	*	*	4	24	
VII	12	6*	*	*	*	*	6		18	Honours / Honours with Research: 181 Credits
VIII	12	6*	*	*	*	*	6		18	
3 Years	72	28	9	8	10	6	0	12	145	
%	49.66	19.31	6.21	5.52	6.90	4.14	0.00	8.28	100.00	
4 Years	96	28	9	8	10	6	12	12	181	
%	53.04	15.47	4.97	4.42	5.52	3.31	6.63	6.63	100.00	
<p>*Students pursuing Honours will do 3 courses for 12 Credit in lieu of a Research Project/Dissertation. (2 Courses of 8 Credit in 7th Sem and 1 Course of 4 Credit in 8th Sem)</p> <p>**Students pursuing Honours with Research would complete 12 Credits of Research/Dissertation (2 Credit RM & 4 Credit Minor Project in 7th Sem and 6 Credit Major Project in 8th Sem)</p>										

First Year First Semester								
S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS101	Inorganic Chemistry-I (Atomic Structure and Chemical Bonding)	4	0	0	4	Major Course	
2	25CYBS102	Physical Chemistry-I (Gaseous State and Kinetics)	4	0	0	4	Major Course	
3	25CYBS151	Practical Inorganic Chemistry-I	0	0	4	2	Major Course Lab	
4	25CYBS152	Practical Physical Chemistry-I	0	0	4	2	Major Course Lab	
5		MDC#	3	0	0	3	Multidisciplinary Course	
6		Functional English-I	2	0	0	2	Ability Enhancement Course	
7		Effective Communication Skills	0	0	2	1	Skill Enhancement Course (Soft)	
8		Digital Literacy & IT Skills	0	0	2	1	Skill Enhancement Course (Tech)	
9		Indian Constitution & Polity	2	0	0	2	Value Added Course	
TOTAL						21		
# Multidisciplinary Course List is attached separately, and a course shall be offered only when there is sufficient number of students opt for it								

First Year Second Semester								
S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS201	Organic Chemistry-I (Basic Concepts in Organic Chemistry)	4	0	0	4	Major Course	
2	25CYBS202	Physical Chemistry-II (Solid & Liquid State and Equilibria)	4	0	0	4	Major Course	
3	25CYBS251	Practical Organic Chemistry-I	0	0	4	2	Major Course Lab	
4	25CYBS252	Practical Physical Chemistry-II	0	0	4	2	Major Course Lab	
5		MDC#	3	0	0	3	Multidisciplinary Course	
6		Functional English-II	2	0	0	2	Ability Enhancement Course	
7		Advanced Excel Skills	0	0	2	1	Skill Enhancement Course (Soft)	
8		Teamwork & Interpersonal Skills	0	0	2	1	Skill Enhancement Course (Tech)	
9		Environment Protection & Sustainable Development	3	0	0	2	Value Added Course	
10	25CYBS271	Live Projects/Vocational Courses/Summer Internship				4	Live Projects/Vocational Courses/Summer Internship	
TOTAL						25		
# Multidisciplinary Course List is attached separately, and a course shall be offered only when there is sufficient number of students opt for it								
* Students would do Live Project/Vocational Course/Summer Internship of 4 Credits during Summer term of 6 to 8 weeks								
On Exit, students shall be awarded UG Certificate (in Chemistry) on securing the requisite 46 Credits on completion of II-Semester.								

Second Year Third Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS301	Inorganic Chemistry-II (Chemistry of s and p-block Elements)	4	0	0	4	Major Course	
2	25CYBS302	Organic Chemistry-II (Haloalkanes, Haloarenes and Oxygen Containing Functional Groups)	4	0	0	4	Major Course	
3	25CYBS351	Practical Inorganic Chemistry-II	0	0	4	2	Major Course	
4	25CYBS352	Practical Organic Chemistry-II	0	0	4	2	Major Course	
5	25CYBS303	Introduction of Nanochemistry and its applications	2	0	2	4	Minor Stream Course	
6		MDC-3	3	0	0	3	Multidisciplinary Course	
7		Hindi/French-I/German-I	2	0	0	2	Ability Enhancement Course	Either Sem Course
8		Presentation Skills	0	0	2	1	Skill Enhancement Course (Soft)	
9		Statistical Analysis with SPSS	0	0	2	1	Skill Enhancement Course (Tech)	
TOTAL						23		
# Multidisciplinary Course List is attached separately, and a course shall be offered only when there is sufficient number of students opt for it								

Second Year Fourth Semester								
S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS401	Inorganic Chemistry-III (d & f block elements and Coordination Chemistry)	4	0	0	4	Major Course	
2	25CYBS402	Physical Chemistry-III (Phase Transition and Chemical Thermodynamics)	4	0	0	4	Major Course	
3	25CYBS451	Practical Inorganic Chemistry-III	0	0	4	2	Major Course	
4	25CYBS452	Practical Physical Chemistry-III	0	0	4	2	Major Course	
5	25CYBS403	Analytical Methods in Chemistry	4	0	0	4	Minor Stream Course	
6		Professional Skills	0	0	2	1	Skill Enhancement Course (Soft)	
7		R Language Programming	0	0	2	1	Skill Enhancement Course (Tech)	
8		Sports, Yoga & Fitness				2	Value Added Courses	
9	23UAEC301/401	Hindi/French-II/German-II	2	0	0	2	Ability Enhancement Course	Either Sem Course
10	25CYBS471	Live Projects/Vocational Courses/Summer Internship				4	Live Projects/Vocational Courses/Summer Internship	
TOTAL						26		
* Students would do Live Project/Vocational Course/Summer Internship of 4 Credits during Summer term of 6 to 8 weeks								
On Exit, students shall be awarded UG Diploma (in Chemistry) on securing the requisite 95 Credits on completion of IV-Semester.								

Third Year Fifth Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS501	Organic Chemistry-III (Heterocyclic Chemistry, Nitrogen Containing Functional Groups and Polynuclear Hydrocarbons)	4	0	0	4	Major Course	
2	25CYBS502	Physical Chemistry-IV (Electrochemistry, Surface Chemistry & Photochemistry)	4	0	0	4	Major Course	
3	25CYBS503	Inorganic Chemistry-IV (Organometallics and Bioinorganic Chemistry)	4	0	0	4	Major Course	
4	25CYBS551	Practical Organic Chemistry-III	0	0	4	2	Major Course	
5	25CYBS552	Practical Physical Chemistry-IV	0	0	4	2	Major Course	
6	25CYBS504	Medicinal Chemistry	2	0	2	4	Minor Stream Course	
7	25CYBS505	Biomolecules of Life	4	0	0	4	Minor Stream Course	
8		Aptitude & Reasoning	0	0	2	1	Skill Enhancement Course (Soft)	
9		Programming with MATLAB	0	0	2	1	Skill Enhancement Course (Tech)	
TOTAL						26		

Third Year Sixth Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS601	Organic Chemistry-IV (Spectroscopy and its applications)	4	0	0	4	Major Course	
2	25CYBS602	Physical Chemistry-V (Molecular Spectroscopy)	4	0	0	4	Major Course	
3	25CYBS603	Principle of Quantum Chemistry	4	0	0	4	Major Course	
4	25CYBS651	Practical Organic Chemistry-IV	0	0	4	2	Major Course	
5	25CYBS652	Practical Physical Chemistry-V	0	0	4	2	Major Course	
6	25CYBS604	Computers for Chemist	2	0	2	4	Minor Stream Course	
8	25CYBS571	Live Projects/Vocational Courses/Summer Internship				4	Live Projects/Vocational Courses/Summer Internship	
TOTAL						24		

*** Students would do Summer Internship of 4 Credits during Summer term of 6 to 8 weeks**

On Exit, students shall be awarded UG Degree (in Chemistry) on securing the requisite 145 Credits on completion of VI-Semester.

Fourth Year Seventh Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS701	Reagents and Chemical Processes	3	0	1	4	Major Course	
2	25CYBS702	Polymer and Colloidal Chemistry	3	0	1	4	Major Course	
3	25CYBS703	Green Chemistry	4	0	0	4	Major Course	
4	25CYBS704	Energy & Environment*	2	0	0	2	Minor Course*	Students pursuing Honours
5	25CYBS705	Research Methodology#	2	0	0	2		Students pursuing PR
6	25CYBS706	Research Project	3	1	0	4	Research Project/Dissertation #	
TOTAL						18		
<p>* Students pursuing Honours will do 1 Course of 2 Credits in lieu of Research Project in 7th Semester & 4 Credit Dissertation # Students pursuing Honours with Research will do 6 Credits RP/Dissertation (2 Credit RM & 4 Credit Research Project)</p>								

Fourth Year Eighth Semester								
S. No.	Course Code	Course Title	L	T	P	Credits	Course Category	Remarks
1	25CYBS801	Novel Inorganic Solids	3	0	1	4	Major Course	
2	25CYBS802	Metals in Medicine	2	0	2	4	Major Course	
3	25CYBS803	Inorganic Materials and its Industrial Importance	3	0	1	4	Major Course	
4	25CYBS804	Pharmaceutical Chemistry	4	0	0	4	Minor Course*	Students pursuing Honours
5	25CYBS805	Artificial Intelligence & Machine Learning in Chemistry	1	0	1	2	Minor Course*	Students pursuing Honours
6	25CYBS871	Research Project				6	Research Project/Dissertation	Students pursuing RP
TOTAL						18		
<p>* Students pursuing Honours will do 2 Courses of 6 Credits in 8th Semester # Students pursuing Honours with Research would complete 6 Credits of Research/Dissertation in the 8th Semester</p>								

On Exit, students shall be awarded Bachelor Degree (in Chemistry) (Honours with Research) or (Honours) after securing the requisite 181 Credits on completion of VIII-Semester.

Inorganic Chemistry-I (Atomic Structure & Chemical Bonding)	
Course Code: 25CYBS101	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To impart the students' knowledge about atomic structure, wave functions & all the related theories.
- To develop student's understanding about periodic table and some properties of the periodic table.
- To illustrate the various chemical bonds present in molecules.
- To make students acquainted with the various concepts of chemical bonds and their properties.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Solve the conceptual questions about all the models of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbital,
- Explain periodicity in atomic radii, ionic radii, ionization energy and electron affinity of elements.
- Replicate the plausible structures and geometries of molecules using VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Describe the importance and applications of chemical bonding and their effect on physical & chemical properties.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

15Hrs

Atomic Structure: Recapitulation of Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Schrödinger's wave equation, significance of ψ and ψ^2 . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shape of s, p, d and f orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau principle, applications and its limitations.

Unit-II

14Hrs

Periodicity of Elements: Brief discussion of the following properties of the s & p-block elements: Effective nuclear charge, shielding or screening effect, Slater's rule, variation of effective nuclear charge in periodic table. Atomic and ionic radii. Ionization enthalpy; successive ionization enthalpies

and factors affecting ionization enthalpy and trends in groups and periods. Electron gain enthalpy and trends in groups and periods. Electronegativity, Pauling's/Allred Rochow's scale, Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

Unit-III

16Hrs

Chemical Bonding: *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii equation for lattice energy. Madelung constant, Born-Haber cycle and its application, solvation energy.

Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of homo and hetero diatomic molecules N_2 , O_2 , C_2 , B_2 , F_2 , CO , NO , and their ions. Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pair and bond pairs of electrons: H_2O , NH_3 , PCl_3 , PCl_5 , SF_6 , ClF_3 , I^- , BrF^+ , PCl^- , ICl^- , ICl^+ and SO^{2-} .

Unit-IV

15Hrs

Multiple bonding: δ and π bond approach and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajans' rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Metallic Bond: Qualitative idea of valence bond and band theories of solid. Semiconductors and insulators, defects in solids.

Non-covalent Forces: Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of non-covalent forces on physical properties.

TEXT BOOKS

1. Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd Edition, 1994, Wiley.
2. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, 3rd Edition 1994, John Wiley & Sons.
3. Ajai Kumar, *Basic Inorganic Chemistry*, 2018, Aaryush Education.

FURTHER SUGGESTED READINGS

1. Lee, J.D. *Concise Inorganic Chemistry*, 5th Edition. 2008, Wiley India Pvt. Limited
2. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, 2019, Pearson Education India.

PHYSICAL CHEMISTRY-I (Gaseous State and Kinetics)	
Course Code: 25CYBS102	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To understand states of gases, behavior of real gases and ideal gases.
- To describe the behavior of real gases.
- To illustrate the theory of reaction rates.
- To explain the mechanism of enzyme catalysis and its effect on the reaction.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Derive mathematical expressions for different properties of gas and understand their physical significance.
- Demonstrate the behavior of real gases.
- Determine the rate law and rate of reaction.
- Explain the mechanism of enzyme catalysis.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

18Hrs

Gaseous state: Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, and its calculation; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities, liquefaction of gases.

Unit-II

12Hrs

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor Z , and its variation with pressure and temperature for different gases. Causes of deviation from ideal behavior. Van der Waals equation of state, its derivation and application in explaining real gas behavior, calculation of Boyle's temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit-III**15Hrs**

Chemical kinetics: Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to n^{th} order reactions with same reactants & different reactants, experimental methods of the determination of rate laws, half-life, kinetics of complex reactions (only introductory and steady state approximation with examples), Temperature dependence of reaction rates; Arrhenius equation; activation energy

Unit-IV**15Hrs**

Collision theory of reaction rates, Lindemann mechanism (unimolecular), qualitative treatment of the theory of absolute rates.

Catalysis: Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

TEXT BOOKS

1. Kapoor, K.L. (Vol. 1 to 5) Physical Chemistry, 2004, Macmillan Publishers India.
2. Barrow, G.M. Physical Chemistry 6th ed., Tata McGraw Hill 1988.
3. Puri, B. R.; Sharma, L.R.; Pathania, M. S., Principle of Physical Chemistry, Vishal Publishing Co.

FURTHER SUGGESTED READINGS

1. Atkins, P.; Paula, J.P. Physical Chemistry, 11th Edition 2017, Oxford University, New York.
2. Castellan, G. W. Physical Chemistry 4th Ed. 2004, Narosa Publications.

PRACTICAL INORGANIC CHEMISTRY-I	
Course Code: 25CYBS151	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To be familiar with the calibration and use of apparatus, preparation of standard solutions.
- To illustrate the volumetric titrations.
- To understand the concept of redox titrimetry.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Illustrate the calibration, use of laboratory apparatus & preparation of standard solutions of different concentrations.
- Explain concept of basicity & acidity on the basis of volumetric analysis.
- Demonstrate external & internal indicators in redox titrimetry.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum of 7 experiments)

Volumetric Analysis I

- To perform calibration of apparatus such as burette, pipette and thermometer.
- To prepare solutions of titrants of different Molarity/Normality.
- To perform standardization of solutions.
- To determine the concentration of given sodium carbonate solution using standardized HCl.
- To find out the amount of carbonate and hydroxide present together in a mixture.

Redox Titrations

- To estimate Fe(II) and oxalic acid using standardized KMnO_4 solution.
- To estimate Fe(II) using $\text{K}_2\text{Cr}_2\text{O}_7$ as internal indicator. (diphenylamine, *N*-phenyl anthranilic acid)
- To estimate Fe(II) using $\text{K}_2\text{Cr}_2\text{O}_7$ as external indicator.

Number and nature of experiments can vary as per the available facilities.

REFERENCE BOOKS

- G H Jeffery, J Bassett, J Mendham, R C Denney, Vogel A Textbook of Quantitative Inorganic Analysis 4th Edition, 1978, The School of Chemistry,

Thames Polytechnic, London

2. Ahluwalia, V. K.; Dhingra, S.; Dhingra, S. College Practical Chemistry, 2005, Universities Press
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, 2018, R. Chand & Co. New Delhi.
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. 1990, McGraw-Hill: New York.
5. Yadav J. B. Advanced Practical Physical Chemistry, 30th Edition, Goel Publications, Meerut, 2003.

PHYSICAL CHEMISTRY PRACTICAL-I	
Course Code: 25CYBS152	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To study the kinetics of the reactions by different methods of measurement.
- To explain the first order kinetics through model reactions.
- To have an understanding of monitoring a reaction rate on real time basis.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the reaction kinetics by different methods.
- Apply the concepts of chemical kinetics for studying the kinetics of various reactions.
- Set up model kinetic reaction and monitor them.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum of 6 experiments)

Chemical Kinetics:

1. To study the kinetics of Iodide-persulphate reaction using (i) Initial rate method (ii) Integrated rate method
2. To study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.
3. To study the kinetics of acid hydrolysis of methyl acetate with sulphuric acid.
4. To compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate.
5. To determine the temperature coefficient of acid hydrolysis of methyl acetate with hydrochloric acid.
6. To study the kinetics of saponification of ethyl acetate.
7. To study the kinetics of iodination of propanone in acidic medium.
8. To study the kinetics of hydrolysis of starch by salivary amylase.
9. To study the effect of pH on the kinetics of hydrolysis of starch by salivary amylase.

Number and nature of experiments can vary as per the available facilities

REFERENCE BOOKS

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, 2018, R. Chand & Co. New Delhi.
2. Ahluwalia, V. K.; Dhingra, S.; Dhingra, S. *College Practical Chemistry*, 2005, Universities Press.
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. 1990, McGraw-Hill: New York.
4. Yadav J. B. *Advanced Practical Physical Chemistry* 30th Edition, Goel Publications,

Semester II

ORGANIC CHEMISTRY-I (Basic Concepts in Organic Chemistry)	
Course Code: 25CYBS201	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To discuss the basics of organic chemistry and different types of organic reactions.
- To illustrate the conformation of alkane and cycloalkane and stereochemistry, geometries and absolute and relative configuration of chiral compounds.
- To develop students' understanding about the general methods for the synthesis of alkanes, alkenes, alkynes and their properties and chemical reactions.
- To understand the chromatographic techniques for separating organic compounds.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP).

After completion of course, students would be able to:

- Apply the fundamental concepts of different nature and behavior of organic compounds.
- Elucidate the conformational, configurational and geometrical isomerism of organic molecules.
- Identify the various organic reaction mechanisms with examples
- Separate different organic compounds using chromatographic techniques.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit I

15 Hrs

Recapitulation of basics of Organic Chemistry: Electronic effects: inductive, electromeric, resonance and mesomeric effects, hyperconjugation, dipole moment; hydrogen bonding. Homolytic and heterolytic fission with suitable examples. electrophiles and nucleophiles; types, shape and relative stability of carbocations, carbanions, free radicals, carbenes, nitrenes and benzyne.

Introduction to types of organic reactions: addition, elimination and substitution reactions. **Aromaticity:** Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples.

Unit II

15

Hrs

Conformational Analysis of Alkanes and Cycloalkanes: Conformational analysis of alkanes: Relative stability and Energy diagrams ethane & n-butane, Baeyer's strain theory: Chair, Boat and Twist boat forms of cyclohexane with energy diagrams; Relative stability of mono & di substituted cycloalkanes.

Stereochemistry: Optical Isomerism: Optical activity, specific rotation, chirality/symmetry, enantiomers, molecules with two or more chiral-centers, distereoisomers, meso structures, racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations. Fischer, Newman and Sawhorse projection, wedge formulae and their inter- conversions. Geometrical isomerism: cis-trans, syn-anti and E/Z notations with C.I.P. rules.

Unit III**18 Hrs**

Chemistry of Aliphatic Hydrocarbons: (A) Carbon-Carbon sigma bonds: General methods of preparation, physical and chemical properties of alkanes: Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Mechanism of halogenation, relative reactivity and selectivity. (B) Carbon-Carbon pi bonds: General methods of preparation, physical and chemical properties of alkenes and alkynes, Mechanism of E₁, E₂, E_{1cb} reactions. Saytzeff and Hofmann eliminations. Electrophilic additions; their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and; allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. (C) Reactions of alkynes: Acidity, electrophilic & nucleophilic additions. Hydration to form carbonyl compounds, alkylation of terminal alkynes.

Unit IV**12 Hrs**

Aromatic hydrocarbons: General methods of preparation, physical and chemical properties of benzene; Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

TEXT BOOKS

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 7th Edition, 2010, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), 6th Edition, 2010, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), 5th Edition 2002, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, 12th Edition, 2016, John Wiley & Sons.
5. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, 2012, S. Chand.
6. Mehta, B.; Mehta, M. Organic Chemistry 2nd Edition, 2015, Kindle Edition.
7. Yadav, L. D. S., Singh, J. Advanced Organic Chemistry, 15th Edition, 2017, Pragati Edition.

FURTHER SUGGESTED READINGS

1. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, 6th Edition, 1985, Orient Longman, New Delhi.
2. Eliel, E.L. Stereochemistry of Carbon Compounds, 3rd Edition, 1994. Tata McGraw Hill education.
3. Clayden J, Greeves N, Warren S, Organic Chemistry, 2nd Edition, 2012, Oxford University Press, New York.
4. McMurry, J.E. Fundamentals of Organic Chemistry. 7th Edition, 2012, Cengage Learning India Edition.

PHYSICAL CHEMISTRY-II (Liquid & Solid State and Equilibria)	
Course Code: 25CYBS202	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To discuss the properties of liquid and solid states of matter.
- To develop students' understanding about the X-Ray crystallography.
- To highlight chemical equilibria in liquids and ideal gases.
- To understand the concept of ionic equilibrium of various electrolytes.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the chemistry of Micelles and cleansing agents.
- Explain the crystal structure and calculate related properties of cubic systems.
- Demonstrate the effects of parameters like pressure, temperature and catalyst on chemical reactions.
- Replicate the preparation of buffer solutions to store enzymes or to carry out biological reactions.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

12Hrs

Liquid state: Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, Clausius-Clapeyron equation, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Micelle's formation, critical micelle concentration (CMC) and explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Unit-II

15Hrs

Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.

Unit-III

15Hrs

Systems of Variable Composition: Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in n_2

thermodynamic functions in mixing of ideal gases.

Chemical Equilibrium: Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration (Le Chatelier Principle). Free energy of mixing and spontaneity, equilibrium between ideal gases and pure condensed phase.

Unit-IV

18Hrs

Ionic equilibria: Strong, moderate and weak electrolytes; true and potential electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts—applications of solubility product principle. Qualitative treatment of acid-base titration curves. Theory of acid–base indicators; selection of indicators and their limitations.

TEXT BOOKS

1. Kapoor, K.L. (Vol. 1 to 5) *Physical Chemistry*, 2004, Macmillan Publishers India.
2. Atkins, P.; Paula, J.P. *Physical Chemistry*, 11th Edition 2017, Oxford University, New York
3. Puri, B. R.; Sharma, L.R.; Pathania, M. S. *Principles of Physical Chemistry*. 47th 2020, Vishal PublishingCo.
4. Gurtu, J. N.; Gurtu, A. *Advanced Physical Chemistry*, 2019, Pragati Prakashan.
5. R.P. Rastogi and R.R. Mishra

FURTHER SUGGESTED READINGS

1. Barrow, G.M. *Physical Chemistry* 6th ed., 1988 Tata McGraw Hill.
2. Engel, T. & Reid, P. *Physical Chemistry* 3rd Edition, 2012, Prentice-Hall.
3. McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* 2004, Viva Books Pvt. Ltd.: New Delhi.

ORGANIC CHEMISTRY PRACTICAL-I	
Course Code: 25CYBS251	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To understand the purification process of organic compounds by crystallization method.
- To determine the boiling and melting point of organic compounds.
- To develop students' understanding about the basic concept of chromatography for the separations of organic compounds
- To illustrate the detection of extra elements of the given sample.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Determine boiling and melting point of organic compounds.
- Analyze the effect of impurity in organic compounds and their purification by crystallization method.
- Apply the concepts of separation techniques such as chromatography to separate mixtures.
- Elucidate detecting various extra elements present in an organic compound.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum of 10 experiments)

- A) 1.** Calibration of the thermometer
- 2.** Purification of organic compounds by crystallization using the following solvents:
- a. Water
 - b. Alcohol
 - c. Alcohol-Water
- B) 3.** Determination of the melting points of unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
- 4.** Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
- 5.** Determination of boiling point of liquid compounds (boiling point lower than and more than 100 °C by distillation and capillary method).
- C) 6.** Chromatography
- a. Separation of a mixture of two amino acids by radial paper chromatography.
 - b. Separation of a mixture of two sugars by ascending paper chromatography.

- c. Separation of a mixture of *o*- and *p*-nitrophenol or *o*- and *p*-aminophenol by thin layer chromatography (TLC).
7. Detection of extra elements.

Number and nature of experiments can vary as per the available facilities.

REFERENCE BOOKS

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, 5th Edition, 2007, Pearson Education, London.
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, 5th Edition, 1989, Prentice-Hall.
3. Ahluwalia, V. K.; Dhingra, S.; Dhingra, S. College Practical Chemistry, 2005, Universities Press.
4. F.G. & Saunders, B.C. *Practical Organic Chemistry*, 4th Edition, 2009, Pearson Education India
5. Pandey, O.P.; Bajpai, D. N.; Giri, S. *Practical Chemistry*, 2016, S. Chand Limited.
6. Vishnoi & Vishnoi

PHYSICAL CHEMISTRY PRACTICAL-II	
Course Code: 25CYBS252	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To illustrate the determination of surface tension by different methods.
- To demonstrate the viscosity measurement by Ostwald method.
- To describe the powder diffraction pattern of crystals.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the concept of surface tension and its measurement by different methods.
- Determine the coefficient of viscosity at different concentrations.
- Identify the types of crystal structures.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum of 6 experiments)

1. Surface tension measurement using stalagmometer.

- To determine the surface tension by drop number method.
- To determine the surface tension by drop weight method.
- To study the variation of surface tension with different concentration of detergent
- To determine the CMC of surfactant and effect of salt on CMC.

2. Viscosity measurement using Ostwald's viscometer.

- To determine the co-efficient of viscosity of an unknown aqueous solution.
- To study the variation of co-efficient of viscosity with different concentration of Poly Vinyl Alcohol (PVA) and its molar mass determination.
- To study the variation of viscosity with different concentration of sugar solutions.

3. Solid State:

To interpret a given powder diffraction pattern of a cubic crystalline system.

4. Conductance

To study precipitation reaction of AgNO_3 and KCl using the conductometry.

Number and nature of experiments can vary as per the available facilities

REFERENCE BOOKS

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, 2018, R. Chand & Co. NewDelhi.
- Ahluwalia, V. K.; Dhingra, S.; Dhingra, S. *College Practical Chemistry*, 2005, Universities Press.
- Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry*, 2001 New Age International: New Delhi.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, 2018, R. Chand & Co. NewDelhi.

5. Ahluwalia, V. K.; Dhingra, S.; Dhingra, S. College Practical Chemistry, 2005, Universities Press.
6. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, 2001 New Age International: New Delhi.

Semester-III

INORGANIC CHEMISTRY II (Chemistry of s & p block elements)	
Course Code: 25CYBS301	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To explain the principles of metallurgy & various processes of metal extraction from their ores.
- To illustrate the properties of s-block elements and to study the properties of some of their compounds.
- To make student comprehend the properties of p-block elements and the properties of some of their compounds.
- To describe students the methods for the preparation, structure and properties of some inorganic compounds.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the fundamental principles of metallurgy and the importance of recovery of byproducts during extraction.
- Illustrate the periodicity in atomic and ionic radii, electronegativity, ionization energy, electron affinity of elements of the s-block elements.
- Explain the periodicity in atomic and ionic radii, electronegativity, ionization energy, electron affinity of elements of the p-block elements.
- Demonstrate the preparation, structure and properties of some inorganic compounds.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

UNIT I

10Hrs

General Principles of Metallurgy: Metallurgy & process of metal extraction from their ores. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy process for silver and gold. Methods of purification of metals: Electrolytic process, van Arkel-de Boer process, Mond's process & Zone refining.

UNIT II

20Hrs

Chemistry of s-Block Elements: i) General characteristics: melting point, flame color, reducing nature, diagonal relationships and anomalous behavior of first member of each group. (ii) Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. (iii) Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates. (iv) Complex formation tendency

of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. (v) Solutions of alkali metals in liquid ammonia and their properties.

UNIT III

15Hrs

Chemistry of p-Block Elements (group 13,14,15): Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Allotropy of C, P; inert pair effect, diagonal relationship between B and Si and anomalous behavior of first member of each group. Structure, bonding and properties of:

- Hydrides of Group 13 (only diborane), Group 14, Group 15
- Oxides, Halides & Oxoacids of phosphorus,
- Halides of silicon
- Preparation, properties, structure and uses of Borazine, silicates, silicones, phosphonitrilic halides $\{(\text{PNCl}_2)_n\}$, where $n = 3$ and 4

UNIT IV

15Hrs

Chemistry of p-Block Elements (group 16 & 17): Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Allotropy of S; inert pair effect.

Structure, bonding and properties of:

- Hydrides of Group 16 and Group 17.
- Oxides of sulfur and chlorine
- Oxoacids of chlorine; peroxyacids of sulphur.
- Preparation, properties, structure and uses of the Interhalogen and pseudohalogen compounds

REFERENCE BOOKS

1. F. A. Cotton, & G. Wilkinson, Basic Inorganic Chemistry, 6TH edition, 2007, Wiley.
2. D. F. Shriver, & P.W. Atkins, Inorganic Chemistry, 7th edition, 2018, Oxford University Press.
3. J. D. Lee, Concise Inorganic Chemistry, 2008, 5th edition, 2008, Oxford University Press.
4. Ajai Kumar, Basic Inorganic Chemistry, 1st edition, 2018, Aaryush. Education.

FURTHER SUGGESTED READINGS

1. G. Wulfsberg, Inorganic Chemistry, 1st edition, 2002, Viva Books Pvt. Ltd.
2. G. E. Rodgers, Inorganic & Solid State Chemistry, 1st edition, 2008, Cengage Learning India Ltd.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4th edition, 2006, Pearson Education India.

ORGANIC CHEMISTRY II (Haloalkanes, Haloarenes and Oxygen Containing Functional Groups)	
Course Code: 25CYBS302	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To discuss the reaction mechanism of organic halides and effect of various parameters on the rate of reaction.
- To illustrate the chemistry of oxygen containing molecules like alcohols, phenols, ethers and epoxides.
- To highlight the chemistry of carbonyl compounds and carbonyl compounds based various name reactions.
- To make students familiar with the chemical reactions of carboxylic acids and its derivatives such as ester, amide, acyl chloride, anhydride etc.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the preparation, properties and reactions of haloalkanes, haloarenes.
- Explain the chemical reactions of alcohols, phenols, ethers and epoxides. Will be able to carry out the functional group transformations.
- Correlate the concept of chemistry of carbonyl compounds and their application in organic transformations.
- Illustrate various reactions of carboxylic acids and its derivatives.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

UNIT-I

15Hrs

Haloalkanes & haloarenes: Haloalkanes: Methods of preparation and properties, nucleophilic substitution reactions – S_N1 , S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; Elimination reactions of alkyl halides, nucleophilic substitution vs elimination.

Haloarenes: Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; S_NAr , Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

UNIT-II

14Hrs

Alcohols, Phenols, Ethers and Epoxides: Alcohols: preparation, properties and relative reactivity of 1° , 2° , 3° alcohols, Lucas test and Victor Mayer test to distinguish between 1° , 2° , 3° alcohols, Bouvaelt-Blanc reduction; Oxidation of diols by periodic acid and lead tetra-acetate, Pinacol-Pinacolone rearrangement; semi-pinacol rearrangement

Phenols: Preparation and properties; Acidity and factors effecting, Ring substitution reactions, Reimer-Tiemann and Kolbe's-Schmidt Reactions, Fries and Claisen rearrangements with mechanism, dienone-

phenol rearrangement.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, unsymmetrical epoxide ring opening in presence of base and acid, ammonia derivatives and LiAlH_4 .

UNIT-III

16Hrs

Carbonyl Compounds: Structure, reactivity, preparation and properties; nucleophilic additions, nucleophilic addition-elimination reactions and mechanism of ammonia derivatives, mechanisms of Aldol condensation, Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro, Wittig reactions, Beckmann, Benzil-Benzilic acid rearrangements, Haloform reaction, Baeyer Villiger oxidation, α - substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH_4 , NaBH_4 , MPV, PDC).

Addition reactions of α , β -unsaturated carbonyl compounds: Michael addition, Robinson annulation, Grignard reagent, Gilman reagent

Unit-IV

15 Hrs

Carboxylic Acids and their derivatives: General methods of preparation, physical properties and chemical reactions of monocarboxylic acids, effect of substituents on acidic strength. Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids.

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group. Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann, Reformatsky reactions, Curtius rearrangement.

TEXT BOOKS

1. Graham Solomon, T.W. Craig, B. Fryhle, & S. A. Snyder, Organic Chemistry, 12th edition, 2016, JohnWiley & Sons.
2. J. E. McMurry, Fundamentals of Organic Chemistry, 7th edition, 2013, Cengage Learning India.
 - a. Bahl & B. S. Bahl, Advanced Organic Chemistry, S. Chand.
 - b. Mehta, M. Mehta, Organic Chemistry, 2nd Edition, 2015, Kindle Edition.
3. L. D. S. Yadav, J. Advanced Organic Chemistry, 16th edition, 2017, Pragati Prakashan.
4. I. L. Finar, Organic Chemistry, Volume 1, 5th edition, 2002, Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
5. I. L. Finar, Organic Chemistry, Stereochemistry and the Chemistry of Natural Products), Volume 2, 5th Edition 2002, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 7th Edition, 2010, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

FURTHER SUGGESTED READINGS

1. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Edition, 2012, Oxford University Press, New York.
2. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Edition, 1985, Orient Longman, New Delhi.

Introduction to Nanochemistry & Applications	
Course Code: 25CYBS303	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 2 0 2	Course Type: Core Course (Minor)

COURSE OBJECTIVES

- To illustrate the concept of size dependent properties of nano-materials/particles.
- To impart the knowledge about the syntheses of nanomaterials.
- To be familiar with the basic principles of techniques for characterization of nanomaterials.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the size dependent properties of nano-materials/particles.
- Demonstrate different methods for synthesis of nanomaterials.
- Illustrate basic principles of techniques used for characterization of nanomaterials.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

COURSE CONTENTS

Unit-I

12Hrs

Introduction and Properties of Nanomaterials

Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles. Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties

Unit-II

8Hrs

Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

Unit-III

10Hrs

Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique; TEM, SEM, XRD, DLS, Optical Characterization.

Practical:

Credits: 01

30 Hrs

(Laboratory periods: 30)**(At least four practical to be done)**

1. Synthesis of silver nanoparticles by chemical methods/ green approach and characterization using UV-visible spectrophotometer.
2. Synthesis of metal sulphide and selenide nanoparticles (MnS, CdS, CdSe, ZnS & CuS) and characterization using UV-visible spectrophotometer.
3. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.
4. To study the λ^{\max} of different concentration of metal nanoparticles.

TEXT BOOKS

1. C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, 2005, Willey-VCH Verlag, Germany.
2. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, 3rd Edition, Springer.
3. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, 2004, ImperialCollege Press, London.
4. R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, 2005, John Wiley & Sons, England.

FURTHER SUGGESTED READINGS

1. Charles P. Poole and Frank J Owens, Introduction to nano technology, 2003, Wiley Interscience.
2. Pradeep, T., A text of book of nanoscience and nanotechnology, 2012, Tata McGraw Hill Education Pvt.Ltd., New Delhi.
3. Orbaek, W.; McHale, M.M.; Barron, A. R.; Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory, J. Chem. Educ. 2015, 92, 339–344.

INORGANIC CHEMISTRY PRACTICAL-II	
Course Code: 25CYBS351	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To discuss the redox titration by using iodine.
- To highlight the concept of complexometric titration & calculate the hardness of water sample.
- To make students familiar with the synthesis of various inorganic compounds.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Apply the concept of redox titration by using iodine.
- Perform the complexometric titration.
- Demonstrate the preparations of different inorganic compounds.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 6 of experiments)

Volumetric Analysis II

- Estimation of Cu(II) using sodium thiosulphate solution (Iodometrically).
- Estimation of $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodometrically).
- Estimation of antimony in tartar-emetec iodimetrically.
- Estimation of hardness of given water sample.
- Estimation of Ni^{2+} ion in a given sample complexometrically.

Inorganic preparations

- Cuprous chloride, Cu_2Cl_2
- Aluminium potassium sulphate $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ (Potash alum)
- Chrome alum.

REFERENCE BOOKS

- B. D. Khosla, V.C. Garg & A. Gulati, Senior Practical Physical Chemistry, 18th edition, 2018, R. Chand & Co., New Delhi.
- V. K. Ahluwalia, A. Gulati, S. Dhingra, College Practical Chemistry, 2005, Universities Press.
- O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, 2016, S. Chand Limited.

FURTHER SUGGESTED READINGS

- G. Svehla, Vogel's Qualitative Inorganic Analysis, 7TH Edition, 2012, Pearson Education.
- G H Jeffery, J Bassett, J Mendham, R C Denney, Vogel A Textbook of Quantitative Inorganic Analysis 4th Edition, 1978, The School of Chemistry, Thames Polytechnic, London

ORGANIC CHEMISTRY PRACTICAL-II	
Course Code: 25CYBS352	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To discuss the qualitative analysis of unknown organic compound.
- To highlight the synthesis of organic compounds by conventional method as well by greener approach.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Perform qualitative analysis of unknown organic compounds.
- Prepare different organic compounds by conventional method as well as green approach.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)	
	CLO 1	CLO 2
CO 1		
CO 2		

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 7 of experiments)

1. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols, carbonyl compounds and esters).
2. Organic preparations:
 - i. Benzoylation, bromination & nitration of organic compounds.
 - a. Using conventional method.
 - b. Using green approach
 - ii. Acylation of organic compounds.
 - iii. Iodoform reaction.
 - iv. Semicarbazone synthesis.

REFERENCE BOOKS

1. F.G. Mann and B.C. Saunders, Practical Organic Chemistry, 4th revised edition, 1960, Orient-Longman.
2. G H Jeffery, J Bassett, J Mendham, R C Denney, Vogel A Textbook of Quantitative Inorganic Analysis 4th Edition, 1978, The School of Chemistry, Thames Polytechnic, London
3. V.K. Ahluwalia, S. Dhingra, College Practical Chemistry, 2005, Universities Press.
4. A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hannaford, & P. W. G. Smith, Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
5. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, 2016, S. Chand Limited.

Semester-IV

Inorganic Chemistry-III (Chemistry of d & f Block Elements and Coordination Chemistry)	
Course Code: 25CYBS401	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To discuss the various theories & chemistry of coordination compounds.
- To illustrate the chemistry of transition metal elements & their important compounds.
- To explain the inorganic reaction mechanism and various factors, which can influence the rate of reaction in, square planar complexes.
- To describe the chemistry of lanthanides and actinides.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the basic concept of coordination compounds.
- Explain the properties of transition elements.
- Demonstrate the reaction mechanism of coordination compounds.
- Analyze the various properties of lanthanides and actinides.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

20Hrs

Coordination Chemistry: Werner's theory, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds & its types. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, Labile and inert complexes. Valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding.

Crystal field theory, measurement of $10 Dq$ (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of $10 Dq$ (Δ_o , Δ_t). Octahedral vs. tetrahedral coordination, Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and elementary idea of MO Theory.

Unit-II

15Hrs

Transition Elements: General group trends to electronic configuration, color, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states. Difference between the first, second and third transition series. Chemistry of potassium dichromate, potassium permanganate, potassium ferrocyanide, potassium ferricyanide.

Unit-III

15Hrs

Inorganic Reaction Mechanism: Introduction to Inorganic reaction mechanisms (octahedral – elementary idea). Substitution reactions in square planar complexes, Trans-effect, theories of trans-effect.

Non-aqueous solvent: Acid-base concept, HSAB principle and applications, relative strength of acids

and bases, effect of solvent, levelling effect, effect of polarity and dielectric constant, effect of substituents.

Unit-IV

10Hrs

Lanthanides and Actinides: Electronic configuration, oxidation states, color, spectral, magnetic properties & their important compounds, lanthanide contraction, separation of lanthanides (ion-exchange method only).

TEXT BOOKS

1. G.L. Miessler & Donald A. Tarr, Inorganic Chemistry, 5th edition, 2014, Pearson Publication.
2. J.D. Lee, A New Concise Inorganic Chemistry, 5th edition, 2008, Oxford University Press.
3. Ajai Kumar, Basic Inorganic 2018, Aaryush. Education.
4. Ajai Kumar, Coordination Chemistry, Aaryush. Education.

FURTHER SUGGESTED READINGS

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, & O.K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4th edition, Pearson Education India.
2. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 1984, Pergamon Press.

PHYSICAL CHEMISTRY-III (Phase Transition and Chemical Thermodynamics)	
Course Code: 25CYBS402	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To discuss the terms of the phase equilibria and draw the phase diagram of different component system.
- To illustrate the change in the colligative properties of the system.
- To highlight the various laws of thermodynamics.
- To understand the reversible and irreversible processes based on the different free energy functions and concept of entropy.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Identify the state of various component system using phase diagrams.
- Illustrate the effect of solute on the physical properties of solution.
- Implement the laws of thermodynamics to explain the behavior of a system.
- Demonstrate the second and third law of thermodynamics and related applications.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

15Hrs

Phase Equilibria: Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for non-reactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapor and solid-vapor equilibria, phase diagram for one component systems (H_2O and S), with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, Pb-Ag system.

Three component systems: triangular plots, water-chloroform-acetic acid system.

Unit-II

15Hrs

Binary solutions: Gibbs-Duhem-Margules equation, its derivation, azeotropes, lever rule, partial miscibility of liquids, CST, LCST, UCST, miscible pairs, steam distillation, Nernst distribution law: its derivation and applications.

Solutions and Colligative Properties: Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties (i) relative lowering of vapour pressure, (ii) elevation in boiling point, (iii) Depression in freezing point, (iv) osmotic pressure. van't Hoff factor, Applications in calculating molar masses of normal dissociated and associated solutes in solution.

Unit-III

15Hrs

Recapitulation of Chemical Thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems.

First law: Concept of heat Q , work W , internal energy U , and statement of first law; enthalpy H , relation between heat capacities, calculations of Q , W , ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Thermochemistry: Heats of reactions: standard states; enthalpy of formation and enthalpy of combustion and its applications; effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Unit-IV

15Hrs

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics. Calculation of entropy change for reversible and irreversible processes. Free energy Functions: Gibbs and Helmholtz energy; variation of S , G , A with T , V , P ; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. Introduction to Clausius-Clapeyron Equation.

REFERENCE BOOKS

1. K. L. Kapoor, Physical Chemistry, Vol. 1, Macmillan.
2. Peter Atkins, Julio de Paula and James Keeler, Physical Chemistry, 11th edition, 2011, Oxford University Press.
3. S. S. Zumdhal, Chemistry concepts and applications, 1st edition, 2011, Cengage, India.
4. R.P. Rastogi, R.R. Mishra, An Introduction Chemical Thermodynamics, 6th Ed., Vikas Publishing House.

FURTHER SUGGESTED READINGS

1. G. M. Barrow, Physical Chemistry, 4th edition, 2007, Tata McGraw Hill.
2. G.W. Castellan, Physical Chemistry, 4th edition, 2004, Addison-Wesley Publishing Company.
3. D. W. Ball, Physical Chemistry, 2nd edition, 2015, Cengage India.
4. R. G. Mortimer, Physical Chemistry, 3rd edition, 2009, Elsevier: NOIDA, UP.
5. I. M. Levine, Quantum Chemistry, 7th edition, 2013, Pearson Education India.
6. C. R. Metz, Physical Chemistry, 2nd edition, 2009, Tata McGraw-Hill.

ANALYTICAL METHODS IN CHEMISTRY	
Course Code: 25CYBS403	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Minor)

COURSE OBJECTIVES:

- To understand the fundamentals of analytical chemistry, analytical tools, statistical methods applied to analytical chemistry.
- To explain the principles of XRD & electron microscopy and their applications.
- To apply the basic principles of spectroscopic, thermal, electrochemical techniques
- To implement the basics and advanced separation technique.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP).

After completion of course, students would be able to:

- Perform experiment with accuracy and precision and develop methods of analysis for different samples independently.
- Elucidate the basic principle and working of instrument like Flame Photometer, XRD & electron microscopy.
- Demonstrate separation of analytes by chromatography and test contaminated watersamples.
- Determine the applications of separation techniques.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

UNIT-I

15Hrs

Qualitative and quantitative aspects of analysis: Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F , Q and t test, rejection of data, and confidence intervals.

UNIT-II

17Hrs

Electron Microscopy: Introduction to Electron microscopy (SEM, TEM, EDX)–Working principle and electron matter interaction

X-ray diffraction: Generation and characteristics of X-Ray, Lattice planes and Bragg's law, Theory and applications of diffraction.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner design).

UNIT-III

13Hrs

Thermal methods of analysis: Theory of thermogravimetry (TG), basic principle of

instrumentation of TGA, DSC & DTA. Methods for quantitative estimation of Ca and Mg from their mixture.

UNIT-IV

15Hrs

Separation techniques: Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

TEXT BOOKS

1. Arthur Vogel, A Text book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman.
2. Hobart H. Willard et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA.
3. Gary D Christian, Analytical Chemistry, 6th Ed. John Wiley & Sons, New York.
4. Daniel C Harris, Exploring Chemical Analysis, Ed. New York, W.H. Freeman.
5. D. A., Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.

FURTHER SUGGESTED READINGS

1. O. Mikes, and R.A. Chalmers, Ed. Laboratory Hand Book of Chromatographic and Allied Methods, Elles, Horwood Ltd. London.
2. R.V. A., Dilts, Analytical Chemistry – Methods of separation Van Nostrand

INORGANIC CHEMISTRY PRACTICAL- III	
Course Code: 25CYBS451	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To discuss the gravimetric analysis of different transition metals.
- To discuss the preparation of various coordination complexes.
- To impart the knowledge of transition metal complexes spectrophotometrically.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Determine the Execute gravimetric analysis of different transition metals.
- Demonstrate how to prepare coordination compounds.
- Explain the properties of transition metal complexes experimentally.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 7 of experiments)

1. Gravimetric Analysis:

- Estimation of nickel (II) using Dimethylglyoxime (DMG).
- Estimation of copper as CuSCN
- Estimation of iron as Fe₂O₃ by precipitating iron as Fe(OH)₃.
- Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)₃ (aluminiumoxinate).

2. Inorganic Preparations:

- Tetraamminecopper (II) sulphate, [Cu(NH₃)₄]SO₄.H₂O
- Acetylacetonate complexes of Cu²⁺/Fe³⁺
- Tetraamminecarbonatocobalt (III) nitrate

3. Potassium tri(oxalato)ferrate(III)

4. Properties of Complexes

- Measurement of 10 Dq by spectrophotometric method
- Synthesis & Verification of spectrochemical series: ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetonate, DMG, glycine) by substitution method.

REFERENCE BOOKS

1. J. Mendham, R.C. Denney, J. D. Barnes, M. J. K Thomas., Vogel's Textbook of

- Quantitative Chemical Analysis, 6th edition, 2009, Pearson's Education Ltd.
2. V. K. Ahluwalia, S. Dhingra, College Practical Chemistry, Universities Press.
 3. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, 2016, S. Chand Limited.

FURTHER SUGGESTED READINGS

1. A. I. Vogel, A. R. Tatchell, B.S. Furnis, A. J. Hannaford, & P.W.G. Smith, Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, 2016, S. Chand Limited.

PHYSICAL CHEMISTRY PRACTICAL-III	
Course Code: 25CYBS452	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To discuss the determination of critical solution temperature and composition.
- To impart the knowledge of the equilibrium of reactions by distribution method.
- To conduct the pH metric titration.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Determine the critical solution temperature and composition.
- Estimate the equilibrium of reactions by distribution method.
- Demonstrate the pH metric titration of different acids and bases.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)	
	CLO 1	CLO 2
CO 1		
CO 2		

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 7 of experiments)

1. Phase Equilibria

- To determine the critical solution temperature (CST) and composition at CST of the phenol-water system.
- To study the effect of impurities of sodium chloride and succinic acid on the CST of phenol-water system.
- Phase equilibria: To construct the phase diagram using cooling curves or ignition tube method: a. simple eutectic system.
- To study the distribution of acetic/benzoic acid between water and chloroform or cyclohexane.
- To study the equilibrium of at least one of the following reactions by the distribution method:
 - $I_2(aq) + I^-(aq) \rightarrow I_3^-(aq)$
 - $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n^{2+}$

2. Thermochemistry:

- To Determine the heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulfuric acid or enthalpy of neutralization).
- To Determine the enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

3. pH metric titration:

- To study the effect of addition of HCl/NaOH on pH to the solutions of acetic acid, sodium acetate and their mixtures.
- To perform pH metric titration of (i) strong acid with strong base, (ii) weak acid with strong base.

Number and nature of experiments can vary as per the available facilities

REFERENCE BOOKS

1. B. D. Khosla; V. C. Garg & A. Gulati, Senior Practical Physical Chemistry, 18th edition, 2018, R. Chand &Co., New Delhi.
2. V. K. Ahluwalia, S. Dhingra, College Practical Chemistry, 2005, Universities Press.
3. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, 2016, S. Chand Limited.

FURTHER SUGGESTED READINGS

1. Khosla; V. C. Garg & A. Gulati, Senior Practical Physical Chemistry, 18th edition, 2018, R. Chand &Co., New Delhi.
2. V. K. Ahluwalia, S. Dhingra, College Practical Chemistry, 2005, Universities Press.
3. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, 2016, S. Chand Limited.

Semester-V

ORGANIC CHEMISTRY-III (Heterocyclic Chemistry, Nitrogen Containing Functional Groups and Polynuclear Hydrocarbons)	
Course Code: 25CYBS501	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To discuss the preparation and properties of nitrogen containing molecules.
- To illustrate the polynuclear hydrocarbons, their structure elucidation and preparation with properties.
- To explain the five and six-membered heterocyclic molecules, their methods of preparation and properties.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the preparation and properties of nitrogen containing molecules.
- Explain the polynuclear hydrocarbons, their structure elucidation and preparation with properties.
- Demonstrate the various types of five and six-membered heterocyclic molecules, their methods of preparation and properties such as aromaticity, basicity, etc.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

COURSE CONTENTS

Unit-I

15Hrs

Nitrogen Containing Functional Groups

Amines: Preparation: Gabriel phthalimide synthesis, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction. Properties: effect of substituent and solvent on basicity distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid, carbylamine reaction.

Preparation and properties of nitro compounds, nitrite and nitriles

Preparation and reactions of aniline, nitrobenzene. Diazonium salts: preparation and their synthetic applications.

Unit- II

10Hrs

Polynuclear Hydrocarbons: Aromaticity of polynuclear hydrocarbons, comparison of aromaticity of naphthalene, anthracene, and phenanthrene relative to benzene, structure elucidation of naphthalene; Preparation and reactions of naphthalene, phenanthrene and anthracene.

Unit-III

20Hrs

Heterocyclic Compounds I: Classification and nomenclature, Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene.

Unit-IV

15Hrs

Heterocyclic Compounds II: Synthesis, reactions and mechanism of substitution reactions of: Pyridine (Hantzsch synthesis), Piperidine, Quinoline and isoquinoline, (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction), Indole.

REFERENCE BOOKS

1. R. T. Morrison, & R. N. Boyd, Organic Chemistry, 7th edition, 2010, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. L. Finar, Organic Chemistry, Volume 1, 2002, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. L. Finar, Organic Chemistry, Stereochemistry and the Chemistry of Natural Products, Volume 2, 2002, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. P. S. Kalsi, Textbook of Organic Chemistry, 1st Ed., New Age International (P) Ltd. Pub.

FURTHER SUGGESTED READINGS

1. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, 12th Edition, 2016, John Wiley & Sons.
2. Clayden J, Greeves N, Warren S, Organic Chemistry, 2nd Edition, 2012, Oxford University Press, New York.
3. R. M. Acheson, An Introduction to the Chemistry of Heterocyclic compounds, 1976, John Wiley & Sons Ltd.

Inorganic Chemistry-IV (Organometallics & Bioinorganic Chemistry)	
Course Code: 25CYBS502	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To understand the structure, properties, preparation & bonding in organometallic compounds.
- To illustrate the formation of important complexes, their properties and bonding.
- To describe the concept of catalysis by organometallic compounds.
- To impart the knowledge about the concept of various categories of metal ions in biological systems.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the structure, properties, preparation & bonding in organometallic compounds.
- Identify important structural features of important complexes and explain the concept of multicentre bonding in these compounds.
- Demonstrate the mechanism of Wilkinson's catalyst, Zeigler- Natta catalyst and synthetic gasoline manufacture by Fischer-Tropsch process.
- Explain the importance of various categories of metal ions in biological systems.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

15Hrs

Organometallic Compounds: Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.

Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π -acceptor behavior of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Stability of 3d/4d/5d metal carbonyl complexes.

Unit-II

15Hrs

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkylaluminium (dimer), concept of multicentre bonding in these compounds.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Unit-III

15Hrs

Catalysis by Organometallic Compounds: Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Polymerisation of ethene using Ziegler-Natta catalyst
3. Hydroformylation
4. Wacker Process

Unit-IV

15Hrs

Bioinorganic Chemistry: Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Na/K-pump, carbonic anhydrase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems; Elementary idea about storage and transfer of iron (Haemoglobin, Myoglobin).

TEXT BOOKS

1. Huheey, J. E.; Keiter, E.; Keiter, R. Inorganic Chemistry: Principles of Structure and Reactivity, 2006, Pearson Publication.
2. Kumar, A.; Organometallic & Bioinorganic Chemistry, 2021, Aaryush education.
3. Lee, J. D. A New Concise Inorganic Chemistry, 2008, Oxford University Press.
4. Cotton, F. A., Wilkinson, G. Basic Inorganic Chemistry, 3rd Edition, 1994, John Wiley & Sons.

FURTHER SUGGESTED READINGS

1. Miessler, G. L.; Tarr, D. A. Inorganic Chemistry, 5th Edition, 2014, Pearson Publication.
2. Ivano Bertini & Harry B. Gray, Biological Inorganic Chemistry: Structure and Reactivity, 2006, University Science Books.

PHYSICAL CHEMISTRY IV (Electrochemistry, Surface Chemistry & Photochemistry)	
Course Code: 25CYBS503	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To discuss the principles of conductance and electrolysis.
- To understand the concept and formulations of the electrochemical cells.
- To describe the theories of surface chemistry.
- To explain the laws of photochemistry.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Demonstrate the conductance behavior of different electrolytes in solution.
- Compare the reduction potential and cell potential of ionic solutions.
- Describe the theories of photochemistry.
- Elucidate the absorption of light and subsequent photochemical reactions

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

20Hrs

Conductance: Quantitative aspects of Faraday's laws of electrolysis, Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Introduction to Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Applications of conductance measurement:

- (i) degree of dissociation of weak electrolytes (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts and (iv) conductometric titrations

Unit-II

15Hrs

Electrochemical Cells: Rules of oxidation/reduction of ions based on half-cell potentials. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application

to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction (ii) equilibrium constants and (iii) pH values using hydrogen, quinone-hydroquinone, glass and gold electrodes. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Unit-III

10Hrs

Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms (Langmuir and Freundlich), adsorption kinetics, nature of adsorbed state. Qualitative discussion of BET, Introduction to application of BET theory.

Unit-IV

15Hrs

Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitized reactions, quenching. Role of photochemical reactions in biochemical processes, photo stationary states, chemiluminescence.

TEXT BOOKS

1. Peter Atkins, Julio de Paula and James Keeler, Physical Chemistry, 11th edition, 2011, Oxford University Press.
2. G. W. Castellan, Physical Chemistry, 4th Ed., Narosa Publication House.
3. R. G. Mortimer, Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP.
4. G. M. Barrow, Physical Chemistry, 4th edition, 2007, Tata McGraw Hill.

FURTHER SUGGESTED READINGS

1. T. Engel, & P. Reid, Physical Chemistry, 3rd Ed., Prentice-Hall.
2. D. W. Rogers, Concise Physical Chemistry, 1st edition, 2011, Wiley.
3. Bockris & Reddy, Modern Electrochemistry: Ionics, Volume 1, 2001, Springer.
4. Bockris & Reddy, Modern Electrochemistry: Fundamentals of Electrochemistry, Volume 2A, 2001, Springer.

Medicinal Chemistry	
Course Code: 25CYBS504	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Minor)

COURSE OBJECTIVES

- To understand about biophysical properties of medicine/drugs.
- To make students familiar with structure, mode of action of therapeutic agents.
- To explain the basic concept of inflammation, steroids, vitamins, enzymes, contraceptive agents.
- To highlight the concept of drug design, SAR, QSAR.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe basics of medicinal chemistry, biophysical properties
- Analyze the biological activity, mode of action of therapeutic agents
- Illustrate drug metabolism, biophysical and chemical properties of enzymes, hormones, vitamins
- Explain the concept of rational drug design, SAR & QSAR

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

20Hrs

Bio-physicochemical properties Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as K_i , K_d , LD_{50} , EC_{50} , IC_{50} , CC_{50} , ADMET properties

Structural properties Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along with bond length, bond angle and dihedral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples, Stereoselective receptors or enzymes such as muscarinic receptor, Stereochemically pure drug and racemates, Examples such as catechol amines, etc.

Unit-II

15Hrs

Drug target understanding Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples. Medicinal Chemistry of Therapeutic Agent Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents.

Unit-III

15Hrs

Introduction to Steroids, hormones and their receptors, Prostaglandins (COX-1 & 2 inhibitors), and Enzyme. Biophysico-chemical properties, chemical contraceptive agents, pharmaceutically important enzyme products: Pancreatin, Trypsin, Insulin.

Unit-IV

10Hrs

Concept of rational drug design Structure activity relationship, Drug-receptor understanding, Molecular modelling, Structure based drug design. QSAR.

REFERENCE BOOKS

1. John Block, John Beale, Charles Owens., Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical, 11th Edition, 2004, Lippincott Williams and Wilkins.
2. David A. Williams, Thomas L. Lemke, William O. Foye: Foye's Principles of Medicinal Chemistry, 2008, Kluwer publication.
3. Joseph Price Remington, Alfonso R. Gennaro: Remington-The Science and Practice of Pharmacy Vol 1, Ed. 19, 1995, MACK Publishing.
4. Abraham D. J., Lewis F. L., Burger A., Burgers Medicinal Chemistry and Drug Discovery, vol.5, 6th Edition., 2003, Hoboken N. J. Wiley.

FURTHER SUGGESTED READINGS

1. Silverman R. B., The Organic Chemistry of Drug Design and Drug Action, 2nd Edition, 2012, Academic Press.
2. Hansch C. and Leo, Exploring QSAR: Fundamental and applications in Chemistry and Biology, 1995, American Chemical Society.
3. Patrick, G. Medicinal Chemistry, 2000, Oxford University Press.

Biomolecules of Life	
Course Code: 25CYBS505	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Minor)

COURSE OBJECTIVES

- To impart the knowledge of structures, functions of carbohydrates.
- To describe about proteins, enzymes, mechanism of their action.
- To highlight the chemistry of oils, fats and their biological importance.
- To impart the knowledge about nucleic acid components, structures and about central dogma of life.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain how structure of carbohydrates determines their reactivity and biological functions.
- Illustrate the concepts of enzyme, proteins and their acting mechanism along with their biological importance.
- Demonstrate the lipid metabolic pathways, their inter-relationship and biological implications.
- Interpret the concept of genetic code, central dogma of life process.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

18Hrs

Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Occurrence, classification and their biological importance. Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation; Introduction to disaccharides and polysaccharides.

Unit-II

18Hrs

Proteins: Classification, biological importance; Primary, secondary and tertiary structures of proteins: α helix and β -pleated sheets, Denaturation of proteins.

Enzymes: Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, coenzymes and cofactors, Enzyme inhibitors.

Unit-III**12Hrs**

Lipids: Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Unit-IV**12Hrs**

Structure of DNA/RNA: Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides (DNA and RNA). Introduction to Gene therapy.

TEXT BOOKS

1. Berg, J. M., Tymoczko, J. L. and Stryer, L., Biochemistry, 6th Edition, 2006, W.H. Freeman and Co.
2. Nelson, D. L., Cox, M. M. and Lehninger, A. L., Principles of Biochemistry, 4th Edition, 2009, W.H. Freeman and Co.
3. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V.W., Harper's Illustrated Biochemistry. XXVIII Edition, 2009, Lange medical Books/ McGraw-Hill.

ORGANIC CHEMISTRY PRACTICAL- III	
Course Code: 25CYBS551	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO)

- To discuss the qualitative analysis of unknown organic compounds containing simple functional groups.
- To impart the practical experience about organic preparation and selective reduction.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Perform qualitative analysis of unknown organic compounds containing simple functional groups.
- Employ the practical experience about organic preparation and selective reduction.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)	
	CLO 1	CLO 2
CO 1		
CO 2		

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 5 of experiments)

1. Qualitative analysis of unknown organic compounds containing simple functional groups (nitro, amine, amide and carbonyl groups).
2. Organic preparations:
 - i. Nitration of nitrobenzene
 - ii. Selective reduction of m-dinitrobenzene to m-nitroaniline.
 - iii. Hydrolysis of amides and esters.
 - iv. Aldol condensation using either conventional or green method.
 - v. Preparation of Aspirin from salicylic acid.

Number and nature of experiments can vary as per the availability of chemicals

REFERENCE BOOKS

1. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 4th revised edition, 1960, Pearson Education.
2. B. S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, Practical Organic Chemistry, 5th Ed., Pearson.
3. V. K. Ahluwalia, R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, 2000 Universities Press.
4. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry: Qualitative Analysis, 2004, Universities Press.

PHYSICAL CHEMISTRY PRACTICAL-IV	
Course Code: 25CYBS552	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course

COURSE OBJECTIVES (CO)

- To understand the basics of electrochemical instruments.
- To impart the knowledge about the working principle of pH meter and potentiometer by different combination of acid, base and buffer solutions.
- To discuss the verification of the Freundlich and Langmuir isotherms

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Determine the cell constant and conductivity by conduct meter.
- Describe the concept of buffer solution and working principle of pHmeter, potentiometer and its applications.
- Describe the adsorption properties of some acids.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 8 of experiments)

1. Conductometry:

I. To determine of cell constant

II. To determine the conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid.

III. Conductometric titrations:

(i) To determine the strength of unknown strong acid conductometrically using strong base.

(ii) To determine the strength of unknown weak acid conductometrically using strong base.

(iii) To determine the strength of unknown mixture of strong acid and weak acid conductometrically using strong base.

(iv) To determine the strength of unknown strong acid conductometrically using weak base.

2. Potentiometry:

(i) To determine the strength of unknown strong acid potentiometrically using strong base.

(ii) To determine the strength of unknown weak acid potentiometrically using strong base.

(iii) To determine the strength of unknown dibasic acid potentiometrically using strong base.

3. Adsorption

To verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Number and nature of experiments can vary as per the available facilities

FURTHER SUGGESTED READINGS

1. B. D. Khosla, V. C. Garg, & A. Gulati, Senior Practical Physical Chemistry, 18th edition, 2018, R.Chand & Co.: New Delhi.
2. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, 2016, S. Chand Limited.
3. V. K. Ahluwalia, S. Dhingra, *College Practical Chemistry*, 2005, Universities Press.

Semester-VI

Organic Chemistry-IV (Spectroscopy and its Applications)	
Course Code: 25CYBS601	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES:

- To discuss the knowledge of basic principle of Spectroscopy, electromagnetic radiation, electronic transition and its applications.
- To illustrate the identification of different functional group of various classes of compounds.
- To make students familiar with basic principles of NMR and its applications.
- To impart the knowledge of mass Spectroscopy and how to determine the mass of compounds.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course students will be able to

- Describe the basic principle of spectroscopy, electromagnetic radiation, electronic transition and its applications.
- Identify the different functional group of various classes of compounds.
- Explain the basic principles of NMR and its applications for the characterization of compounds.
- Demonstrate the Mass Spectroscopy and determination of the mass of compounds.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

12Hrs

UV Spectroscopy: Basic Principles of UV Spectroscopy, electromagnetic radiation, electronic transitions, λ_{\max} & ϵ_{\max} , chromophore, auxochrome, bathochromic and hypochromic shifts applications of Woodward-Fisher rule in interpretation of organic compounds and in calculating λ_{\max} of conjugated dienes and α,β -unsaturated compounds.

Unit-II

13Hrs

IR Spectroscopy: Basic principles of IR Spectroscopy, identification of functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on $>C=O$ stretching absorptions).

Unit-III

20Hrs

NMR Spectroscopy: Basic principles of ^1H NMR and ^{13}C NMR, Chemical Shifts, Splitting of signals, Spin coupling and Nuclear overhauser effect in interpretation of NMR spectra, isotopic exchange. Problem based on structure elucidation.

Unit-IV

15Hrs

Mass Spectrometry: Basic principles Mass Spectrometry, basic of fragmentation rule in characterization of organic compounds. McLafferty rule, ortho effect, nitrogen rule. Combined Problems on structure elucidation of organic compounds based on spectral data.

REFERENCE BOOKS

1. R. M. Silverstein, G. C. Bassler & T.C. Morrill., 2014, Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
2. D. L. Pavia, Introduction to Spectroscopy, 2015, Cengage Learning India Private Limited.
3. K. E. M. P. William, Organic Spectroscopy, 2019, Macmillan.

FURTHER SUGGESTED READINGS

1. J. R. Dyer, Applications of absorption spectroscopy of organic compounds, 2012, Prentice Hall India.
2. L. D. S. Yadav, Organic Spectroscopy, 2004, Springer.

PHYSICAL CHEMISTRY-V (Molecular Spectroscopy)	
Course Code: 25CYBS602	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES:

- To impart the knowledge about the interaction of electromagnetic radiation with molecules and spectra of molecules.
- To describe the concept of various vibrational spectroscopy their principles, selection rules and spectra.
- To be familiar with the concept, applications and limitation of Raman Spectroscopy and various types of electronic spectroscopy and its applications.
- To understand the concept & applications of NMR, ESR for the characterization of molecules.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the concepts behind molecular and rotational spectroscopy.
- Explain the concepts of vibrational spectroscopy in explaining the properties of molecules.
- Illustrate Raman spectroscopy and electronic spectra.
- Interpret the NMR and ESR spectra for the characterization of molecules/radicals.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

14 Hrs

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

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

Unit-II

15Hrs

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

Vibration-rotation Spectroscopy: diatomic vibrating rotator, P, Q, R branches. molecules, modes of vibration, concept of group frequencies.

Unit-III**16Hrs**

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

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

Unit-IV**15Hrs**

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales (δ and τ), relaxation; transverse and longitudinal; spin-spin coupling and high-resolution spectra.

Electron Spin Resonance (ESR) spectroscopy: Principle, hyperfine structure, ESR of simple radicals.

REFERENCE BOOKS

1. C. N. Banwell, and E. M. McCash, Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi.
2. A. K. Chandra, and A. K. Introductory Quantum Chemistry Tata McGraw-Hill.
3. R. Kakkar, Atomic & Molecular Spectroscopy, Cambridge University Press.
4. J. Michael Hollas, Modern Spectroscopy, 4th Edition, John Wiley & Sons Ltd.

FURTHER SUGGESTED READINGS

1. R. S. Drago, Physical Methods for Chemists, 2nd Edition, Surfside Scientific Publishers.
2. J.E. House, Fundamental of Quantum Chemistry 2nd Ed. Elsevier: USA.
3. J.P. Lowe, Peterson, K. Quantum Chemistry, Academic Press.

Principles of Quantum Chemistry	
Course Code: 25CYBS603	Continuous Evaluation: 60 Marks
Credits: 4	End Semester Examination: 40 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES:

- To understand the postulates of quantum chemistry
- To apply the concept of quantum chemistry in simple chemical systems
- To be familiar with the qualitative treatment of hydrogen atom and hydrogen-like ions
- To explain the LCAO-MO treatment of homo-nuclear and heteronuclear diatomic molecules.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the postulates of quantum chemistry.
- Formulate and solve Schrodinger wave equation for simple chemical systems.
- Determine the probability distribution, and energy of hydrogen and hydrogen-like atoms.
- Elucidate the LCAO-MO treatment of homo-nuclear and heteronuclear diatomic molecules.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1	√			
CO 2		√		
CO 3			√	
CO 4				√

COURSE CONTENTS

UNIT-I

15Hrs

Quantum Chemistry: Postulates of quantum mechanics, quantum mechanical operators and commutation rules, Hermitian operator, Hamiltonian operator, Schrödinger equation and its application to free particle and particle-in-a-box (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two- and three-dimensional boxes, separation of variables, degeneracy.

UNIT-II

15Hrs

Qualitative treatment of simple harmonic oscillator model & rigid rotator: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation in Cartesian and spherical polar. Separation of variables. Spherical harmonics. Discussion of solution (Qualitative). Applications of Harmonic Oscillator and Rigid Rotator.

UNIT-III

15Hrs

Qualitative treatment of hydrogen atom and hydrogen-like ions: Setting up of Schrödinger equation

in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods.

UNIT-IV

15Hrs

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO- MO treatment of H_2^+ . Bonding and anti-bonding orbitals. Qualitative extension to H_2 . Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Statement of variation theorem & applications to simple systems (particle in a box, harmonic oscillator, hydrogen atom).

TEXT BOOKS

1. Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Pub.
2. Gurtu & Gurtu, Advanced Physical Chemistry, Pragati Edition.
3. P.W. Atkins, Physical Chemistry, Oxford University Press.
4. A.K. Chandra Introductory Quantum Chemistry, Tata McGraw Hill.
5. I.M. Levine, Quantum Chemistry, Prentice Hall.

FURTHER SUGGESTED READINGS

1. M.L. Strause, Quantum Mechanics, Prentice – Hall
2. J. P. Lowe & K. Peterson, Quantum Chemistry, 2005, Academic Press.
3. P.W. Atkins & R.S. Friedman Molecular Quantum Mechanics, 3rd Ed.1997, Oxford University Press.

COMPUTER FOR CHEMISTS	
Course Code: 25CYBS605	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 2 0 2	Course Type: Core Course (Minor)

COURSE OBJECTIVES

- To understand the basic applications of computer in chemistry.
- To make students familiar with programming language in chemistry.
- To explain the use of computer applications in chemistry.
- To execute some computer programming in chemistry.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP).

After completion of course, students would be able to:

- Describe basic applications of computer in chemistry.
- Explain the programming language
- Illustrate the applications of computers in chemistry.
- Execute computer programming in chemistry.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

UNIT I

8 Hrs

Basic Computer system (in brief): Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS, WINDOWS, and Linux); Software languages: Low level and High-Level languages (Machine language, Assembly language; QBASIC, FORTRAN and C++); internet application.

UNIT II

7Hrs

Use of Programming Language for solving problems in Chemistry: Computer Programming Language- QBASIC, (for solving some of the basic and in turn complicated chemistry problems). QB4 version of QBASIC can be used.

Simple programs using above mentioned commands.

UNIT III

10

Hrs

Use of Software Products: Computer Software like Scilab, Excel, etc to solve some of the plotting or calculation problems. Basic idea of Molecular Modelling using software like chemsketc or JDrawetc for geometry optimization and potential energy surface (local and global minima).

Practical

30Hrs

Computer programs using QBASIC based on numerical methods

1. Roots of equations: (e.g. volume of gas using van der Waals equation and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data).
4. Probability distributions (gas kinetic theory) and mean values.
5. Matrix operations.
6. Graphic programs related to Chemistry problems. *e.g.* van der Waals isotherm, Compressibility versus pressure curves, Maxwell distribution curves, concentration-time graph, pH metric titration curve, conductometric titration curves, Lambert Beer's law graph, s, p, d orbital shapes, radial distribution curves, etc.

Use of Software Products

1. Computer Software Scilab for data handling and manipulation.
2. Simple exercises using molecular visualization software like JDraw, geometry optimization and potential energy surface of molecules like carbon dioxide, water, ethane, cyclohexane and benzene (local and global minima)

TEXT BOOKS

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical calculations. 2nd Ed. CRC Press (2007).
5. Computational Chemistry by A. C. Norris, John Wiley

FURTHER SUGGESTED READINGS

1. Numerical Recipes in FORTRAN/C by W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery, Cambridge University Press, 2nd Ed. 1996.
2. Fortran 77 and Numerical Methods by C. Xavier, New Age International, 2002
3. Inside the IBM PC by Peter Norton.

Practical Organic Chemistry-IV	
Course Code: 25CYBS651	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES

- To illustrate how to purify of liquid and solid organic substances/compounds for further characterization.
- To discuss and interpret the recorded spectra by FTIR, NMR & UV-Vis Spectroscopy.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Demonstrate the purification process of liquid and solid organic compounds.
- Analyze different spectra obtained by FTIR, NMR & UV-Vis Spectroscopy for the identification of compounds/substances.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)	
	CLO 1	CLO 2
CO 1		
CO 2		

LIST OF EXPERIMENTS

1. Purification method for liquid & solid organic substance (distillation, recrystallization, chromatography)
2. Analysis of spectra of UV-Vis, FTIR, NMR and Mass of simple organic compounds.
(Students may encourage to synthesize simple organic compounds following given protocol (azo dyes, acetanilide, benzoic acid, etc.) (or may use commercially available organic compounds) and can be trained to identify/analyze important peaks/functionality, determine mass of the molecules (mass-spectra). They can submit a report regarding their analysis to course teacher.

FURTHER SUGGESTED READINGS

1. J. Mendham, R.C. Denney, J. D. Barnes, M. J. K. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, 1999, Pearson's Education Ltd.
2. Aggarwal R. and Ahluwalia V.K., Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, 2001, Universities Press India (Pvt.) Ltd.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, 5th Edition, 1989, Prentice-Hall.

PRACTICAL PHYSICAL CHEMISTRY -V	
Course Code: 25CYBS652	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Practical Examination: 40 Marks
L T P : 0 0 4	Course Type: Core Course (Major)

COURSE OBJECTIVES:

1. To understand the working principle of Colorimetry.
2. To be familiar with the adsorption by Freundlich and Langmuir isotherm.
3. To understand the working principle of UV-Visible spectrum.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Determine the concentration of unknown solution of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$.
2. Calculate λ_{max} values and J values.
3. Find out the dissociation constant of indicators.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 7 of experiments)

1. Colorimetry:

- I. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration
- II. Determine the concentrations of CuSO_4 , KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture.
- III. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- IV. Determine the amount of iron present in a sample using 1, 10-phenanthroline.

2. Determine the dissociation constant of an indicator (phenolphthalein). UV/Visible spectroscopy:

- I. Study the absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1} , kJ mol^{-1} , cm^{-1} , eV).
- II. Study the pH-dependence of the UV-Vis spectrum of $\text{K}_2\text{Cr}_2\text{O}_7$.
- III. Record and analyze UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water.

REFERENCE BOOKS

1. B.D. Khosla, V.C. Garg and A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co.
2. C.W. Garland and J.W. Nibler, Experiments in Physical Chemistry, McGraw-Hill: New York.
3. A. M. Halpern, and G.C. McBane, Experimental Physical Chemistry, W.H. Freeman & Co.: New York.

Semester-VII

Reagents and Chemical Process	
Course Code: 25CYBS701	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 0 1	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO):

- To understand the important organic name reactions and which are crucial for the synthesis of valuable organic compounds.
- To study the role of various reducing reagents in various organic reactions for the synthesis of chemo-, diastereo- and enantio-selective products
- To describe the role of various oxidizing reagents mechanism and their applications in various organic reactions
- To explain the various chemical processes for industrial applications

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Illustrate the reaction mechanism and their practical demonstration of the name and coupling reactions
- Explain the role of the reagents in organic synthesis and apply these reagents for the bulk chemical synthesis
- Describe the application of various reagents for selective synthesis organic products
- Demonstrate the techniques for chemical processes and will enhance skills for human resource development for the chemical industry

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

Unit 1: Named Reactions

16 Hrs

Application, scope and mechanism of following reactions: Prevost Reaction, Chugaev Reaction, Maukaiyama, Aldol Reaction, Mzingo Reaction, Ramberg Backlund Reaction, Shapiro Reaction, Barbier Reaction, Clark- Eschweiler Reaction, Darzen's Reaction, Julia Olifination Reaction, Tiffeneau-Demjanov Reaction, Darkin-West Reaction, Bischler-Napieralaski Reaction, Birch reduction of aromatic compounds, Appel Reaction, Mitsunobu Reaction, Corey Kim Oxidation, Azide-alkyne 1,3-dipolar cycloaddition reaction, Olefin metathesis: Grubbs reaction, Heck Reaction, Suzuki coupling and Wittig reaction.

Unit 2: Reducing Reagents

9 Hrs

Reactions, mechanism and applications of following reducing agents: Sodium borohydride, Lithium

aluminium hydride, NaBH₃CN, DIBALH, lithium-tri-tert-butoxyaluminum hydride, Red-Al Na[AlH₂(OCH₂OCH₂OCH₃)₂], Zinc borohydride, L and K selectrides, LiBHEt₃ and KBHEt₃, Luche Reagent NaBH₄-CeCl₃, K[BH(OAc)₃], bis-Boric Acid (BBA), Catecholborane, DEMS (Diethoxymethylsilane), 3-Mercapto propionic acid, Polymethylhydrosiloxane (PMHS), Schwartz's Reagent (Zirconocene chloride hydride).

Unit 3: Oxidizing Reagents

10 Hrs

Reactions, mechanism and applications of following oxidizing agents: Jones Reagent (CrO₃, H₂SO₄, H₂O), Swern Reagent (DMSO, oxalyl chloride), Dess Martin, TEMPO, TPAP (Tetrapropyl ammonium perruthenate), Fetizon's Reagent, Fenton's Reagent [H₂O₂ + Fe(II) ion], Sodium perborate NaH₂BO₄, Sodium Bismuthate NaBiO₃, ABNO (9-Azabicyclo[3.3.1]nonane *N*-oxyl), DEAP (Diethyl allyl phosphate,), AZADO (2-Azaadamantane *N*-oxyl), Wacker oxidation.

Unit 4: Process Chemistry

10 Hrs

1. Process chemistry a) Introduction, stages of scale up process: Bench, pilot and large-scale process with at least two examples of scale up process of API. b) In-process control and validation of large-scale process.

2. Unit Processes: The following unit processes should be studied with mechanism and one example of each process Nitration: Nitrating agents, process equipment for technical nitration. Halogenation: Types of halogenations, catalytic halogenations. Reduction: Catalytic hydrogenation, hydrogen transfer reactions, metal hydrides. Oxidation: Types of oxidative reactions, and nonmetallic oxidizing agents such as H₂, sodium hypochlorite, oxygen gas, ozonolysis.

Practical:

Credits: 01

(Laboratory periods: 30)

1. Oxidation of alcohols to acid using Jones reagent.
2. Reduction of acetophenone and its derivatives to 1-phenyl ethanol derivatives by NaBH₄.
3. Reduction of 4-tert-butyl-cyclohexanone to cis and trans 4-tert-butyl-cyclohexanol
4. Synthesis of 2,5-dimethyl-2,5-hexanediol from tert-butanol using Fenton's reagents
5. Wittig reaction of benzyltriphenylphosphonium chloride and 4-bromobenzaldehyde using potassium phosphate (tribasic)
6. Substitution (S_N2) reaction of 1-iodobutane and 2-naphthol
7. Aldol condensation reaction: solventless synthesis of chalcones
8. Borohydride reduction of a ketone: hydrobenzoin from benzil
9. Visit to chemical industry of the demonstration of pilot scale

REFERENCE BOOKS

Theory:

1. Clayden, J. Greeves, N., Warren, S. Organic Chemistry, South Asian Edition, Oxford University Press, USA
2. Gadamasetti K., Process Chemistry in the Pharmaceutical Industry: Challenges in an Ever- Changing Climate-An Overview, Vol-2, CRC Press, London.
3. Murphy R.M., Introduction to Chemical Processes: Principles, Analysis, Synthesis, McGraw-Hill Education, New York.
4. Harrington P. J., Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale up, John Wiley and Sons, Inc, New Jersey.

Practical:

1. Mann F.G, Saunders, B.C., Practical Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.
2. Vogel A.I., Elementary Practical Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.

Polymers and Colloidal Chemistry	
Course Code: 25CYBS702	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 0 1	Course Type: Core Course (Major)

COURSE OBJECTIVES (CO):

- The objective of this course is to give students a comprehensive coverage of important physical aspects of polymers chemistry and their synthesis.
- To help the student to know properties and applications of polymers.
- This course aims to give students a comprehensive coverage of important physical aspects of colloidal chemistry and their properties
- To study emulsions, surfaces and interfaces and their applications.
- To study important characterization of colloidal particles.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the types of polymers, kinetics of polymerization and polymer properties.
- Understand and apply the concepts of properties of polymer solutions and their thermodynamics.
- evaluate kinetic chain length of polymers based on their mechanism • differentiate between polymers and copolymers
- Comprehend the basic concepts of surface chemistry specifically in relation to colloids
- Understand and apply the important characterization of colloidal particles

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objective s (COs)	Course Learning Outcomes (CLOs)				
	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CO 1					
CO 2					
CO 3					
CO 4					
CO 5					

Unit 1: Introduction to polymers

12 Hrs

Introduction to basic concepts of polymers. Types of polymerizations and their mechanism and kinetics: Free radical, ionic, step-growth, coordination, copolymerization. Polymerization techniques: Bulk, solution, suspension, and emulsion.

Polymer solution – solubility parameter, properties of dilute solutions and their criteria, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change. Molar Mass of Polymer; No. Avg. and Weight Avg. Molar Mass, Polydispersity Index, Flory Huggins theory.

Unit 2: Introduction to Colloid Chemistry

8 Hrs

Recapitulation of basic concepts of Adsorption, Distinction among true solutions, colloids and suspensions, Components of Colloids, classification of colloids - lyophilic, lyophobic; Preparation methods and properties of lyophobic solutions, Hydrophile-lyophile balance (HLB), multi molecular, macromolecular and associated colloids (micelles formation), preparation and properties of colloids - Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation; Charge on Colloidal particles and Electrical double layer concept, Suspensions and their characteristics, Emulsions and their characteristics.

Unit 3: Surface Chemistry in relation to colloids

10 Hrs

Surface film on liquid surface, surface potential, monomolecular films, Langmuir Blodgett layers. Emulsions, foams and aerosols; electrical aspects of surface chemistry; Surface of solids, solid-liquid interface, stability of dispersions, stabilization of suspensions

Unit 4: Applications of colloidal particles

10 Hrs

Role of colloid chemistry in Nanotechnology (wet colloid chemical approach, “bottom up” fabrication of nanoparticles and nanostructured materials), applications of colloid chemistry in petroleum recovery, coating and painting, food, pharmaceuticals and cosmetic industry, medicinal chemistry (use in drug formulations), Sewage disposal, Purification of water, cleansing action of soap, Formation of Delta, Smoke precipitation, Photography, Artificial rain:

PRACTICALS:

Credits: 01

(Laboratory periods: 10)

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA)/MethylAcrylate (MA).
2. Preparation of nylon 6,6
3. Determination of molecular weight of polyvinyl propylidene in water by viscometry.
4. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.
5. Determination of molecular weight by end group analysis of polymethacrylic acid.
6. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
7. Preparation of Colloidal Sols of following A. Arsenic sulphide, B. Antimony sulphide C. Ferric chloride D. Aluminium hydroxide
8. To find out the precipitation values of arsenious sulphide sol by using monovalent, bivalent and trivalent cations.
9. To determine the nature of charge on particle in given colloidal solution and their electrophoretic velocity and zeta potential.
10. To prepare lyophilic sol of starch.

Suggested Readings:

Theory:

1. Carraher, C. E. Jr. (2013), Seymour's Polymer Chemistry, Marcel Dekker, Inc.
2. Odian, G. (2004), Principles of Polymerization, John Wiley.
3. Billmeyer, F.W. (1984), Text Book of Polymer Science, John Wiley
4. Myers D., Surface, interfaces and colloids Principles and Applications, 2nd Edition, Wiley-VCH
5. V.R. Gowarikar (2010), Polymer Science, New Age International Publishers Ltd.

Practical:

1. Sperling, L.H. (2005), Introduction to Physical Polymer Science, John Wiley & Sons.

GREEN CHEMISTRY

Course Code: 25CYBS703	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Major)

COURSE OBJECTIVES:

- To impart the students' knowledge about the basic concept Green Chemistry
- To describe the importance of Green Chemistry in today's world and its impact on environment.
- To illustrate the role of green solvent for the preparation of different molecules.
- To be familiar with the synthesis of different molecules by efficient method of Green Chemistry approaches.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the twelve principles of green chemistry and will build the basic understanding of toxicity, hazard and risk of chemical substances.
- Perform stoichiometric calculations and relate them to green chemistry metrics. Understand benefits of use of catalyst and bio catalyst, use of renewable feed stock which helps in energy efficiency and protection of the environment, renewable energy sources.
- Design safer chemical, products and processes that are less toxic, than current alternatives.
- Demonstrate that chemistry can be used to solve rather than cause environmental problems.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit-I

16 Hrs

Introduction to Green Chemistry, What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry Principles of Green Chemistry and Designing a Chemical synthesis.

Unit-II

14 Hrs

Twelve principles of Green Chemistry with their explanations and special emphasis on the following with examples:

Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum

incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.

Prevention/ minimization of hazardous/ toxic products reducing toxicity risk = (function) hazard x exposure; waste or pollution prevention hierarchy

Green solvents– super critical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents

Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy

Selection of starting materials; avoidance of unnecessary derivatization-careful use of blocking/protecting groups;

Use of catalytic reagents (wherever possible), stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, bio catalysis, asymmetric catalysis and photo catalysis.

Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD -

What you don't have cannot harm you, greener alternative to Bhopal Gas Tragedy (safer route to carbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Unit- III

15 Hrs

Examples of Green Synthesis/ Reactions and some real-world cases :

1. *Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)*
2. *Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction*
3. *Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)*
4. *Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.*
5. *Designing of Environmentally safe marine antifoulant.*

Unit-IV

15 Hrs

Examples of Green Synthesis/ Reactions and some real-world cases :

6. *Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.*
 7. *An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.*
 8. *Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils*
 9. *Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting*
- Future Trends in Green Chemistry Oxidation reagents and catalysts;*
Biomimetic, multifunctional reagents; combinatorial green chemistry; Proliferation of solventless reactions

REFERENCE BOOS

1. K. Ahluwalia, and M. R. Kidwai, *New Trends in Green Chemistry*, 2005, Anamalaya Publishers.
2. P. T. Anastas and J. K Warner, *Oxford Green Chemistry -Theory and Practical*, 1998 University Press.
3. S. Matlack, *Introduction to Green Chemistry*, 2001, Marcel Dekker
4. M. C. Cann, and M. E. Connely, *Real-World Cases in Green Chemistry*, 2000, American Chemical Society, Washington.

FURTHER SUGGESTED READINGS

1. M. A. Ryan, and M., Tinnes, *Introduction to Green Chemistry*, 2002, American Chemical Washington.
2. P. T. Anastas and J. C. Warner *Green Chemistry: Theory and Practice*, 1988, Oxford University Press.
3. M. Kirchoff and M.A. Ryan, *Greener approaches to undergraduate chemistry experiment*, 2002, American Chemical Society, Washington DC.

Energy & Environment	
Course Code: 25CYBS704	Continuous Evaluation: 40 Marks
Credits: 2	End Semester Practical Examination: 60 Marks
L T P : 2 0 0	Course Type: Core Course (Minor)

COURSE OBJECTIVES:

- To develop basic understanding of energy, issues related to energy, importance of energy in terms of economy, health and the environment.
- To understand different sources of energies, renewable and non-renewable sources of energy.
- To learn the importance of green fuels.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe and Account for basic energy concepts conventional and renewable energy technologies and their application
- Reflect and evaluate the environmental impact of energy production and the relationship between energy production, consumption and climate change
- Analyse energy costs, the consequences of today's energy consumption and use of renewable energy

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

COURSE CONTENTS

UNIT 1

8 Hrs

Introduction, chemistry and energy, conversion of chemical energy to electrical energy, Carbon cycle, Greenhouse gases, Global warming and climate change, Carbon footprint, zero-carbon or low-carbon energy. Electrical energy and steam energy, Energy Alternatives, Hidden Costs of Energy.

UNIT 2

10 Hrs

Production methods for electric power: Non-Renewable (conventional) sources of energy: Fossil fuels: Coal, petroleum and Natural gas. Energy transformation. Renewable energy sources: solar, hydropower, wind, geothermal, wave, ocean thermal, tidal, ocean currents, nuclear energy, biomass.

UNIT 3

12 Hrs

Production methods for electric power: Renewable (green) energy, conversion and storage systems. Nuclear fusion, Hydrogen fuels, photovoltaic solar cells, hydroelectric. Sustainable energy, biomass, Biofuels, production of biofuels, advantages, blending of biofuels with conventional fuels, Carbon

REFERENCE BOOKS

1. "Energy and Civilization: A History" by Vaclav Smil
2. "Sustainable Energy - Without the Hot Air" by David MacKay
3. "Energy, Environment, and Climate" by Richard Wolfson
4. "Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle
5. "Energy and the Environment: Sources, Technologies, and Impacts" by Robert A. Ristinen and Jack J. Kraushaar

FURTHER SUGGESTED READINGS

1. "The Green and Virtual Data Center" by Greg Schulz
2. "Environmental Science: A Global Concern" by William P. Cunningham and Mary Ann Cunningham
3. "Energy, Environment and Development" by Jose Goldemberg
4. "The Future of Energy: An Introduction to Sustainable Energy" by John Evans and Kerry Ressler
5. "Introduction to Renewable Energy" by Vaughn C. Nelson and Kenneth L. Starcher

SEMESTER – VIII

Novel Inorganic Solids	
Course Code: 25CYBS801	Continuous Evaluation: 40 Marks
Credits:4	End Semester Examination: 60 Marks
L T P : 3 0 1	Course Type: Core Course

COURSE OBJECTIVES (CO):

The exposure of this course to the undergraduates with science backgrounds can groom them for future research.

- To understand solid state chemistry and different type of synthetic procedures.
- To discuss the various characterization techniques of inorganic solids
- To describe the various mixed materials and their properties.
- To study nanomaterials, properties and their applications.
- To analyze composites material, properties, and their applications.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Discuss the mechanism of solid-state synthesis.
- Explain about the different characterization techniques and their principles.
- Describe the concept of mixed solid electrolytes and inorganic pigments
- Demonstrate the concept of nanomaterial, their synthesis, properties, and the real-world importance of bioinorganic nanomaterials.
- Explain the importance of composites and their real-life application of solid materials.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CO 1					
CO 2					
CO 3					
CO 4					
CO 5					

COURSE CONTENTS

Unit 1: Synthesis of Inorganic solids

5 Hrs

Conventional heat and beat method, Co-precipitation method, Sol-gel method, Hydrothermal method, Chemical vapor deposition (CVD), Ion-exchange and Intercalation method.

Unit 2: Characterization techniques of inorganic solids

10 Hrs

Powder X-ray Diffraction, UV-visible spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Fourier-Transform Infrared (FTIR) spectroscopy, Brunauer–Emmett–Teller (BET) surface area analyser, Dynamic Light Scattering (DLS)

Unit 3:**10 Hrs**

Cationic, anionic and mixed solid electrolytes and their applications. Inorganic pigments – coloured, white and black pigments. One-dimensional metals, molecular magnets, inorganic liquid crystals.

Unit 4: Nanomaterials**10 Hrs**

Overview of nanostructures and nanomaterials, classification, preparation and optical properties of gold and silver metallic nanoparticles, concept of surface plasmon resonance, carbon nanotubes, inorganic nanowires, Bioinorganic nanomaterials, DNA and its nanomaterials, natural and artificial nanomaterials, self-assembled nanostructures, control of nanoarchitecture, one dimensional control.

Unit 5: Composite Materials**10 Hrs**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, bio-nanocomposites, environmental effects on composites, applications of composites.

Practicals:**Credits: 01****15 Hrs****(Laboratory periods: 30)****(At least four practicals to be done)**

1. Synthesis of silver nanoparticles by chemical methods / green approach and characterization using UV-visible spectrophotometer.
2. Synthesis of metal sulphide nanoparticles (MnS, CdS, ZnS & CuS) and characterization using UV-visible spectrophotometer.
3. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.
4. Synthesis of inorganic pigments (PbCrO₄, ZnCrO₄, Prussian Blue, Malachite).
5. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.
6. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.

FURTHER SUGGESTED READINGS**Theory:**

1. West, A. R. (2014), Solid State Chemistry and Its Application, Wiley. Undergraduate Programme in Chemistry (Hons) Page 67 of 211 University of Delhi
2. Smart, L. E.; Moore, E. A., (2012), Solid State Chemistry: An Introduction CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997), New Direction in Solid State Chemistry, Cambridge University Press.
4. Poole Jr.; Charles P.; Owens, Frank J. (2003), Introduction to Nanotechnology, John Wiley and Sons.

Practicals:

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory, J. Chem. Educ. 2015, 92, 339–344.
2. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981), Hexagonal Tungsten Trioxide and Its Intercalation Chemistry, Solid State Ionics, 5, 1981, 355-358.
3. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; Synthesis of ZnO Nanoparticles by Precipitation Method, Orient J Chem 2015, 31(2).

Metals in Medicines	
Course Code: 25CYBS802	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 2 0 2	Course Type: Core Course

COURSE OBJECTIVES (CO):

- To be familiar about role of metal ions in biological system
- To understand Diagnostic and therapeutic agents
- To discuss the role of metal ions in drug
- To describe the role of metal ions in multivitamins
- To explain different Radiopharmaceuticals and MRI contrast agents

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Illustrate the role of metal ions in various biomolecules and their functions.
- Explain the role of metals in Diagnostic and therapeutic agents
- Designate the role of metals in commercially available medicines and their functions
- Describe the role of metals in multivitamins and their functions
- Elucidate the role of Radiopharmaceuticals and MRI contrast agents and their functions

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CO 1					
CO 2					
CO 3					
CO 4					
CO 5					

COURSE CONTENT

Unit 1:

Bio role of Metals

4 Hrs

Brief introduction of following metals in biological system Fe, Cu, Zn, Mn, Cr(III), V, Mo, W, Co, Ni, Na, K, Mg and Ca Chemical structure, Commercial name, Name of the disease it is made for and its brief mechanism of action shall be taught for all the mentioned metals below.

Unit 2: Diagnostic and Therapeutic Agents

8 Hrs

Diagnostic and therapeutic agents with Pt (Cisplatin) and Ga for cancer, Au (auranofin) for arthritis and V for diabetes.

Unit 3: Metals in Drugs**6 Hrs**

Li_2CO_3 (Camcolit) for manic-depressive illness, NaHCO_3 (Alka-seltzer) for heartburn, $\text{Al}(\text{OH})_3$ (Gaviscon) for heartburn, As (melarsoprol) for sleeping sickness, Bi subsalicylate (pepto-Bismol) for heartburn and diarrhea, Bi subcitrate (De-nol) peptic ulcer, Zinc oxide with Fe_2O_3 (Calamine lotion) as antimicrobial agent.

Unit 4: Metals in Multivitamins**6 Hrs**

Cyanocobalamin (Co), Ferrous fumerate (Fe), Magnesium oxide (Mg), Zinc Sulfate (Zn), Manganese sesulphate (Mn), Copper Sulfate (Cu), Sodium selenite (Se) and Chromium trichloride (Cr).

Unit 5: Radiopharmaceuticals and MRI contrast agents**6 Hrs**

$^{99\text{m}}\text{Tc}$ for heart, brain and bone imaging, ^{123}I radiopharmaceuticals, BaSO_4 for X-ray contrast agent, Gd (III) for MRI contrast agents.

Practical/Hands-on Training: Credits: 02**(Laboratory periods: 30)**

Volumetric titrations:

1. To estimate the acidity of commercially available antacids.
2. To estimate the concentration of Fe in commercially available medicines.
3. To estimate the concentration of Ca in commercially available medicines.
4. To estimate the strength of carbonate in tablets containing Li_2CO_3
5. To estimate the sodium bicarbonate in synthetic/commercially available drug.
6. To estimate the zinc and iron present in Calamine lotion.
7. To estimate the Mg present in multivitamins.

FURTHER SUGGESTED READINGS

1. Metals in Medicine, John Wiley & Sons Ltd, Nov 2009
2. Chapter-9, Metals in Medicine, Stephen J. Lippard
3. Medicinal applications of coordination chemistry, Chris Jones and John Thornback, Cambridge, UK: Royal Society of Chemistry, 2007

Inorganic Materials and its Industrial Importance

Course Code: 25CYBS803	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 0 1	Course Type: Core Course (Minor)

COURSE OBJECTIVES (CO):

- To learn the diverse roles of inorganic materials in the industry.
- To give an insight into how these raw materials are converted into products used in day-to-day life.
- To understand about silicates, fertilizers, for mechanical construction
- To gain knowledge about surface coatings, batteries, engineering materials for mechanical construction.
- To develop the interest of students in the frontier areas of inorganic and material chemistry.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the composition and applications of the different kinds of glass and ceramics.
- Explain the suitability of fertilizers for different kinds of crops and soil.
- Elucidate the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
- Demonstrate the principle, working and applications of different batteries.
- List and explain the properties of engineering materials for mechanical construction used in day-to-day life.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CO 1					
CO 2					
CO 3					
CO 4					
CO 5					

COURSE CONTENTS

Unit 1: Silicate Industries

10 Hrs

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Ceramics: Brief introduction to types of ceramics. glazing of ceramics.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

Unit 2: Fertilizers

7 Hrs

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime, potassium chloride and potassium nitrate.

Unit 3: Surface Coatings

12 Hrs

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC) and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing.

Unit 4: Batteries

8 Hrs

Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Li- ion batteries, Li-polymer batteries, solid state electrolyte batteries, fuel cells, solar cells and polymer cells.

Unit 5: Engineering materials for mechanical construction

8 Hrs

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminium and their alloys like duralumin, brasses and bronzes cutting tool materials, superalloys, thermoplastics, thermosets.

Practicals:

Credits: 01

(Laboratory periods: 30)

At least four experiments to be done

1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.
2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
3. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
4. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).
5. Analysis of (Cu, Ni) in alloy or synthetic samples (Multiple methods involving Complexometry, Gravimetry and Spectrophotometry).
6. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, Complexometry and Potentiometry)

REFERENCE BOOK

1. "Introduction to Materials Chemistry" by Harry R. Allcock, Frederick W. Lampe, and James E. Mark

2. "Inorganic Materials Chemistry" by Mark T. Weller, Tina Overton, Jonathan Rourke, and Fraser Armstrong
3. "Structure and Bonding in Crystalline Materials" by Gregory S. Rohrer
4. "Inorganic Chemistry" by Gary L. Miessler, Paul J. Fischer, and Donald A. Tarr
5. "Solid State Chemistry and its Applications" by Anthony R. West
6. "Inorganic Chemistry: Principles of Structure and Reactivity" by James E. Huheey, Ellen A. Keiter, and Richard L. Keiter

FURTHER SUGGESTED READINGS

1. "Introduction to Solid State Physics" by Charles Kittel
2. "Inorganic Materials: Synthesis and Fabrication" by Ulrich Schubert, Nils Hüsing, Ludwig Bohrer, and Rudolf Meyer
3. "Inorganic Materials Chemistry" by Geoffrey A. Lawrance and Alister G. Maddock

Pharmaceutical Chemistry	
Course Code: 25CYBS804	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	Course Type: Core Course (Minor)

COURSE OBJECTIVES (CO):

- To understand students, the principles of drug action & synthesis of drugs.
- To develop various classes of antibiotics & their mode of action
- To understand the basic knowledge of Prostaglandins, Antipyretic & analgesics
- To understand the mode of action of antihypertensive & Contraceptive agents.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Illustrate retro-synthesis approach in relation to drug design and drug discovery.
- Describe about various classes of antibiotics & their mode of action.
- Explain the functioning of Prostaglandins, Antipyretic-& analgesics.
- Discuss the mode of action of antihypertensive & Contraceptive agents.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit I

15 Hrs

Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir, Remdesivir).

Unit II

15 Hrs

Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryltrinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine). Fermentation: Aerobic and

anaerobic. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Unit III

15 Hrs

Drug discovery, design and development. Stages of drug discovery, lead discovery, identification, validation and diversity of drug targets. Some novel molecular targets along with their pharmacodynamic agents: Polyketide synthase (Pks13), signal transducer and activator of transcription-3 (STAT-3) and sodium glucose cotransporter-2 (SGLT-2). Stereochemistry and drug action: Pharmacodynamic, pharmacokinetic (drug adsorption, metabolism, distribution and elimination) and toxicological aspects of stereoisomers (Geometrical, optical and conformational).

Unit IV

15 Hrs

Basic concepts, prodrugs of functional group, rationale and practical consideration of prodrug design. Rational versus analog approach of drug design. Combating drug resistance: Causes for drug resistance, strategies to combat drug resistance in antibiotics therapy, Genetic principles of drug resistance.

REFERENCE BOOKS

1. Abraham D. J., Burger's Medicinal Chemistry and Drug Discovery, John Wiley and Sons Inc., New York.
2. Block J. H. and Beale J. M., Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, Lippincott Williams and Wilkins, Philadelphia.
3. Lemke T. L., Williams D. A., Roche V. F. and Zito S. W., Foye's Principles of Medicinal Chemistry, Lippincott Williams and Wilkins, Philadelphia.
4. Vardanyan R. S. and Hruby V. J., Synthesis of Essential Drugs, Elsevier, Philadelphia.

Artificial Intelligence and Machine Learning in Chemistry	
Course Code: 25CYBS805	Continuous Evaluation: 40 Marks
Credits: 2	End Semester Examination: 60 Marks
L T P : 1 0 1	Course Type: Core Course (Minor)
Prerequisite: Basic Computer Knowledge	

COURSE OBJECTIVES (CO):

- The course is aimed at familiarization of students to modern scientific machine (programming) language i.e., Python, artificial intelligence (AI) & machine learning (ML) and their potential applications in chemistry.
- To provide elementary ideas of the techniques prevailing in the field of artificial intelligence (AI) and machine learning (ML).
- To understand their applications to research problems especially related to research and development of new materials and pharmaceutical compounds with desired properties.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Conversant with the Python Programming Language.
- Familiar with Elementary techniques of Artificial intelligence (AI) & Machine learning (ML)
- Apply techniques of AI & ML in basic problems of research in some important areas of research in Chemistry.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

Theory

15 Hrs

Introduction to basic programming in Python programming language, Jupyter notebooks, Google Colab platform and a number of common Python scientific libraries to process, analyze and visualize data and application of these skills to provide solutions to a variety of Chemistry based problems.

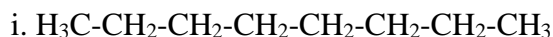
An overview of computationally readable and processible representation of molecules, e.g., SMILES, mol files. Chemical space and access to chemical databases. Statistical treatment of data: regression analysis and types of regression. Quantitative structure-activity relationship (QSAR) and quantitative structure-property relationships (QSPR).

An insight into Artificial Intelligence & Machine learning and potential areas of applications in chemistry. Dimensional reduction; Principal Component Analysis (PCA) and the importance and necessity of nonlinearity in Artificial Intelligence. Artificial Intelligence and deep learning clustering. A comprehensive overview of neural networks and generative adversarial networks. Genetic algorithm, basics of random mutation hill climbing (RMHC) and simulated annealing. Elementary idea of artificial neural networking in tabular form. Simple applications of Basin Hopping.

Practicals:**Credits: 01****(Laboratory periods: 30)**

Artificial Intelligence (AI) and Machine Learning (ML) based exercise on problems of interest to chemist

1. Travelling salesman problem and electrical circuit design (minimization of pathlength).
2. Genetic algorithm, in solving matrix form of linear equations
3. Non-linear least-square fitting problem.
4. Particle Swarm Optimization on the sphere function. Python Programming Language based Exercise
5. Write a program to output the structural formula of octane



6. Write a program to determine the hydrogen ion concentration, and hence the pH of the solution using the iterative weak acid approximation which determines the hydrogen ion concentration, by successive application of the formula

$$[\text{H}^+] = \sqrt{K_a(c - [\text{H}^+])n}$$

7. Use this program and considering the given data, determine the hydrogen ion concentration, and hence the pH of a 0.01 M solution of acetic acid [HAc].

i. Given $K_a[\text{HAc}] = 1.78 \times 10^{-5}$.

ii. Tolerance, $\text{TOL} = 1.E-10$. $[\text{H}^+]_0 = 0$

8. Write a program to predict the electronic configurations of the elements up to Undergraduate Programme in Chemistry (Hons) Page 142 of 211 University of Delhi Rutherfordium ($N = 104$) and modify your program to generate output the configurations, such that a noble gas configuration, is replaced by the noble gas symbol in square brackets.

9. A Python list containing the element symbols in order may be downloaded from scipython.com/ex/abb.

10. Considering the two stable isotopes of carbon, ^{12}C and ^{13}C and further the radioactive ^{14}C nucleus being present in nature only in trace amount (\sim order of parts per trillion). Write a program to calculate the relative amounts of C_{60} (buckminsterfullerene) having zero, one, two, three and four ^{13}C atoms, if natural isotopic abundance follows a binomial distribution, such that the probability of finding m ^{13}C atoms in a total of n carbon atoms is given by

11. QSAR based exercise on problems of interest to chemist.

FURTHER SUGGESTED READINGS

1. "Deep Learning in Chemistry" by Alexandre Tkatchenko, Klaus-Robert Müller
2. "Machine Learning in Chemistry" by David J. Livingstone
3. "Chemoinformatics: Basic Concepts and Methods" by Christoph Helma and Janna Hastings
4. "Artificial Intelligence for Drug Discovery, Precision Medicine, and Healthcare" by Mark Chang

5. "Applications of Artificial Intelligence in Chemistry" by Hugh M. Cartwright

LIVE PROJECTS & INDUSTRY VISIT	
Course Code: 25CYBS271/471	Continuous Evaluation: 60 Marks
Credits: 1	End Semester Examination: 40 Marks
Duration: Continuous	Course Type: Skill Enhancement Course

LIVE PROJECT COURSE OBJECTIVES

- To provide qualitative enhancements to the UG students of FSH.
- Offered live projects serve to enhance students employability attributes to make them job-ready.
- To provide experiential learning to students for an ability to work in a real-life work situation.
- To provide a learning ground for students to get an opportunity to apply what they have learned in classes to real-world scenarios. An opportunity to work in real constraints of resources, people factors and other organizational constraints. Classroom projects are primarily focused on singular concepts whereas live projects allow integrating knowledge across various functions.
- Live projects develop employment abilities in students and provide industry experience and insights.

LIVE PROJECT OUTCOMES

On completion of the live project(s), students will be

- Capable enough to exhibit strong foundation knowledge of domain area.
- Students can take a challenge and place better career development scenario in professional life.
- It gives a strong boost for experienced to take their career into next stage.
- Successful completion of live projects shows a better stand and technical expertise in domain area.

ASSESSMENT DETAILS

Assessment of Live Project(s) & Industrial visit include the following:

- Formative & summative assessment.
- During the final assessment students have to submit a hard copy of the project, the presentation has to be given by the students.
- Prototype or Working Model, in case of Live Project is taken up for it.
- Report on Project.
- Viva Voce.
- Final Presentation in front evaluation team.

PERIODIC MONITORING

DURATION →	Continuous Monitoring throughout the Project
EVALUATION PROCESS	<ol style="list-style-type: none"> 1. Student will prepare the report on the work done. 2. Student will prepare the presentation on the learning outcomes. 3. Student will give presentation about the learning achieved.
EVALUATION	<ul style="list-style-type: none"> ❖ Formative/Continuous Evaluation: 60 % ❖ End Semester Evaluation: 40 %

SIGNIFICANCE OF LIVE PROJECTS

Live projects play a significant role in providing real-time education to the students. During live projects, students are encouraged to identify the domain they want to work in and select the relevant project. They also get to meet working professionals or organizations and discuss with them about the project. In some institutions, live projects are considered as assignments and students get points for it. This is important as it helps the students during their placements.

SUMMER INTERNSHIP	
(Faculty of Science, Humanities & Social Science)	
Course Code: 25CYBS672	Continuous Evaluation: 60 Marks
Credits: 4	End Semester Examination: 40 Marks
Duration: 3 / 4 Weeks	Course Type: Skill Enhancement Course

COURSE OBJECTIVES

- To have qualitative improvements in the UG students of FSH.
- To provide experiential learning to students to work in the real-life situation.
- Expose the student to professional role models or mentors who will provide the student with support in the early stages of the internship and provide an example of the behaviours expected in the intern's workplace.
- Assist the student's development of employer-valued skills such as teamwork, communication and attention to detail.

COURSE LEARNING OUTCOMES

On completion of course, students will be

- Able to demonstrate various aspects of theory as well as practical.
- Able to build and expand network of professional relationships and contacts.
- Develop a solid work ethic and professional demeanour, as well as a commitment to ethical conduct and social responsibility.
- At the end of the course, a student will be competent in their domain area.

PROJECT IDENTIFICATION

- The internships will be conducted after examination of the 4 semesters.
- The Internship will be of 4 credits.
- Projects will be undertaken by the students in collaboration with Student-Faculty, NGO, Government Departments and Industries.
- Projects will be identified keeping in mind application of knowledge & skills, relevance of project in terms of expectation of society.
- Allocation of the project to the students with active participation of students, faculty and concern authorities.

MONITORING OF THE PROJECTS

- Project should be supervised by faculty mentor and place where students is undertaking the project.
- Effective monitoring of project progress undertaken by the students through by digital technologies.
- Active involvement of industry & faculty supervisor.
- Weekly monitoring of the project through Faculty mentor & Industry person.
- All the project has to analyze in-depth and the outcome of the project should be identified

ASSESSMENT DETAILS

Assessment of SIP include the following:

- Formative & submissive assessment three times during the internship.
- During the final assessment students have to submit a hard copy of the project, the presentation has to be given by the students.
- Report on Project taken up.
- Viva Voce.
- Final Presentation in front of the industry experts and Faculty mentor.

PERIODIC MONITORING

Student will be monitored on periodic basis, both by the In-charge at the Industry and the Faculty In-charge. The Industry In-charge will submit the Mid-Term and End-Term Evaluation report. However, the faculty In-charge will take periodic presentation to keep a check on the progress.

DURATION→	3 to 4 Weeks (After 4th Semester End Term Examination)
EVALUATION PROCESS	4. Student will prepare the report on the work done. 5. Student will prepare the presentation on the learning outcomes. 6. Student will give presentation about the learning achieved.

EVALUATION	❖ Formative/Continuous Evaluation: 60 % ❖ End Semester Evaluation: 40 %
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EVALUATION PARAMETER FOR SUMMER INTERNSHIP PROJECT (SIP)

1. Evaluation Parameter for Formative Assessment (Summer Internship Project)

Continuous Assessment will perform by respective faculty & Industry coordinators within stipulated timeperiod. Evaluation Parameter classified as follows:

S. No.	Basis of Evaluation Parameter with Time frame	Marks
1.	Synopsis Presentation (Week 1 st)	15
2.	Relevance and linkage of the Identify issue with functional area of discipline (Week 1 st)	10
3.	Survey of Literature (Week 2 nd)	10
4.	Research Methodology & Data collection (3 rd to 4 th Week)	15
5.	Overall understanding of the area of study (3 rd to 4 th Week onwards)	10
	Total Marks	60

2. Evaluation Parameter for End Term Assessment (Summer Internship Project)

S. No.	Basis of Evaluation Parameter	Marks
1.	Quality Of Content Design	10
2.	Identification of Contemporary Issue	10
3.	Innovation in learning Process	10
4.	Presentation of Content & Delivery Mechanism	10
	Total Marks	40

List of Multidisciplinary Courses (MDC)

Cat.	Code	Course Name	L	T	P	Credits
MDC I	23MDCXXX	Renewable Energy Sources	3	0	0	3
	23MDCXXX	Hybrid Electric Vehicle	3	0	0	3
	23MDCXXX	IPR in Business	3	0	0	3
	23MDCXXX	Library Information Sciences & Media Literacy	3	0	0	3
	23MDCXXX	Management Process & Organizational Behaviour	3	0	0	3
MDC II	23MDCXXX	Introduction to Bio-engineering	3	0	0	3
	23MDCXXX	Introduction to Robotics	3	0	0	3
	23MDCXXX	Psychology and Emotional Intelligence	3	0	0	3
	23MDCXXX	Indian Economy	3	0	0	3
	23MDCXXX	Creating an Entrepreneurial Mind	3	0	0	3
MDC III	23MDCXXX	Arduino based programming	3	0	0	3
	23MDCXXX	Electoral Literacy in India	3	0	0	3
	23MDCXXX	Personal Financial Planning	3	0	0	3
	23MDCXXX	Interior Design	3	0	0	3

List of Ability Enhancement Courses (AEC)

Total : 9 (3*3) Credits		
Sl. No.	Course Name	Credits
1	Functional English-I	3
2	Functional English-II	3
3	Hindi/German/French	3
4	Live Project-I	4
5	Live Project-II	4
6	Summer Internship	4

List of Skill Enhancement Courses (SEC)

Courses on Soft Skills						
S. No.	Code	Course Name	L	T	P	Credits
1	23SS151	Effective Communication Skills	0	0	2	1
2	23SS252	Teamwork & Interpersonal Skills	0	0	2	1
3	23SS353	Presentation Skills	0	0	2	1
4	23SS454	Professional Skills	0	0	2	1
5	23AR555	Aptitude & Reasoning	0	0	2	1

Courses on Technical Skills						
S. No.	Code	Course Name	L	T	P	Credits
1	23SS101	Digital Literacy & IT Skills	0	0	2	1
2	23SS202	Advanced Excel Skills	0	0	2	1
3	23SS303	Statistical Analysis with SPSS	0	0	2	1
4	23SS404	R language programming	0	0	2	1
5	23SS505	Programming with MATLAB	0	0	2	1

List of Value-Added Courses (VAC)

Total : 6 (2*3) Credits					
University Pool (Common to all UG Students)					
Sl. No.	Course Name				Credits
1	Indian Constitution & Polity	2	0	0	2
2	Environment Protection & Sustainable Development	2	0	0	2
3	Sports, Yoga & Fitness	0	0	4	2
NOTE:					
1. All the Courses are compulsory for the students.					
2. Students should be encouraged to enroll for NSS/NCC					