Department of Chemistry
B.Sc Physical Sciences

Total Credits									24					600

Semester 3

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A7	Inorganic Chemistry-III		3		2	3		1	4	25	50	5	20	100
CC-A8	Organic Chemistry-III		3		2	3		1	4	25	50	5	20	100
CC-A9	Physical Chemistry-III		3		2	3		1	4	25	50	5	20	100
Minor/ Vocational Course(s)														
MIC-3	One from Pool		3		2	3		1	4	25	50	5	20	100
Multidisciplinary Course(s)														
MDC-3	One from Pool		2		2	2		1	3	15	35	5	20	75
Skill Enhancement Course(s)														
SEC-3	One from Pool		2		2	2		1	3	15	35	5	20	75
Total Credits									22					550

Semester 4

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A10	Inorganic Chemistry-IV		3		2	3		1	4	25	50	5	20	100
CC-A11	Organic Chemistry-IV		3		2	3		1	4	25	50	5	20	100
CC-A12	Physical Chemistry-IV		3		2	3		1	4	25	50	5	20	100
Minor/ Vocational Course(s)														
MIC-4	One from Pool		3		2	3		1	4	25	50	5	20	100
Ability Enhancement Course(s)														
AEC-4	One from Pool		2			2			2	15	35			50
Value-added Course(s)														
VAC-3	One from Pool		2			2			2	15	35			50
Total Credits									20					500

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240/CHE/CC401

COURSE DETAILS:

Course Title	Physical Chemistry-IV
Semester	Semester-IV
Course Code	CC-A12
Course ID	
Total Credits	04 (Lecture: 03, Tutorial: 0, Practical: 01)
Total Marks	100
Marks Distribution	Theory External: 50 Theory Internal: 25 Practical External: 20 Practical Internal: 05

COURSE CURRICULUM DELIVERY WEEKLY DISTRIBUTION:

Total Hours per Week: 5	
Lectures (L) Hours per Week: 3	Practicals (P) Hours per Week: 2

COURSE OBJECTIVES:

- To introduce fundamental thermodynamic principles and provide mathematical treatment of thermodynamic relationships.
- To explain the First and Second Laws of Thermodynamics, and their applications in energy conservation and entropy analysis.
- To develop an understanding of thermodynamic functions such as enthalpy, entropy, Gibbs free energy, and their interrelationships.
- To familiarize students with chemical equilibria concepts, equilibrium constants, and the effects of external parameters on equilibrium.
- To introduce the laws of photochemistry, their applications, and the significance of photochemical reactions in chemical and biological systems.

COURSE OUTCOMES:

- Apply mathematical methods to analyze thermodynamic properties and processes involving exact and inexact differentials.
- Explain and differentiate between reversible and irreversible processes and apply the First and Second Laws of Thermodynamics.
- Analyze thermochemical changes and evaluate thermodynamic functions such as enthalpy, entropy, and Gibbs free energy for various processes.
- Solve problems related to chemical equilibria, equilibrium constants, and predict system behavior using the Le Chatelier principle.
- Demonstrate an understanding of photochemical laws, quantum yields, and photochemical processes, including their role in real-world applications.

DETAILED CONTENT OF COURSE:

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Theory & Practical Syllabus:

Total Contact Hours: 45 (Theory) + 30 (Practical)

Unit	Topics	Contact Hours
I	**Chemical Thermodynamics - I** Mathematical treatment of thermodynamics: Including exact and inexact differentials, partial derivatives, Euler's reciprocity, and the cyclic rule. Reversible and irreversible processes: Explaining the concepts and differences between these types of thermodynamic processes. First and Second Laws of Thermodynamics: Discussing the principles of energy conservation and entropy. Thermochemistry: Analyzing the heat changes associated with chemical reactions and physical processes. Thermodynamic functions: enthalpy, entropy, and Gibbs free energy: Discussing their properties, significance, and applications. Relationships between thermodynamic functions: Exploring the connections and dependencies among different thermodynamic quantities.	15
II	**Chemical Thermodynamics – II** Partial molar quantities: Explaining the concept and its application in solutions and mixtures. Dependence of thermodynamic parameters on composition: Analyzing how variables like temperature and pressure affect these parameters. Gibbs-Duhem equation: Discussing its derivation and applications in thermodynamic systems. Chemical potential: Explaining its significance and role in determining the direction of chemical processes.	8
III	**Chemical Equilibria** Law of mass action: Describing the relationship between the concentrations of reactants and products at equilibrium. Equilibrium constants (K_p, K_c, K_x, and K_n): Discussing their definitions, units, and calculations. Effect of temperature on equilibrium: Analyzing the temperature dependence and its implications for reaction conditions. Le-Chatelier principle: Explaining the principle and its applications in predicting the response of equilibrium systems to changes in conditions.	8
IV	**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, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.	14
V	**Practicals:** 1. Determination of the enthalpy change of a reaction using a calorimeter. 2. Determination of the entropy change of a reaction from equilibrium constant measurements.	30

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	3. Determination of the free energy change of a reaction from cell potential measurements. 4. Determination of the heat capacity of a solid using calorimetry. 5. Determination of the heat of neutralization of a strong acid with a strong base. 6. Determination of the heat of solution of a sparingly soluble salt. 7. Measurement of enthalpy of fusion of a solid. 8. Determination of enthalpy of vaporization of a liquid.	

COURSE EVALUATION METHODS

Theory Exams: Total Marks: 75 (External: 50 + Internal: 25)

Internal Assessment: 25 Marks	• Class Participation: 05 Marks • Seminar/Presentation/ Assignment: 05 Marks • Mid Term Exam: 15 Marks
External Assessment: 50 Marks (02 Hours)	• End Term Exam: 50 Marks

Practical Exam: Total Marks: 25 (External: 20 + Internal: 05)

Internal Assessment: 05 Marks	• Class Participation: 05 Marks
External Assessment: 20 Marks (02 Hours)	• End Term Practical Exam: 10 Marks • Lab record: 05 Marks • Viva Voce: 05 Marks

Instruction for End Term Theory Exam:

The Examiner is requested to set nine questions in total, selecting two questions from each section. Question-1 will be a compulsory question consisting short answer type questions covering all the units of the syllabus. All questions should carry equal marks. Log table and non-programmable calculator is allowed.

Recommended Textbooks:

Theory:

1. Physical Chemistry – P.W. Atkins and J. de Paula, Oxford University Press.
2. Thermodynamics for Chemists – S. Glasstone, East-West Press.
3. Principles of Physical Chemistry – Puri, Sharma, and Pathania, Vishal Publishing Co.
4. Chemical Thermodynamics – R.P. Rastogi and R.R. Misra, Vikas Publishing House.
5. Thermodynamics and Statistical Mechanics – M.W. Zemansky and R.H. Dittman, McGraw Hill.
6. Physical Chemistry: A Molecular Approach – D.A. McQuarrie and J.D. Simon, University Science Books.
7. Introduction to Photochemistry – A. Cox and T. Camp, McGraw Hill.

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8. Photochemistry and Photophysics – J. G. Calvert and J.N. Pitts, Wiley.
9. Essentials of Physical Chemistry – B.S. Bahl, G.D. Tuli, and Arun Bahl, S. Chand Publishing.
10. Modern Physical Chemistry – G.H. Barrow, McGraw Hill.
11. Principles of Thermodynamics – J.R. Partington, Butterworths.

Practical:

1. "Experiments in Physical Chemistry" by C. N. R. Rao and U. C. Agarwala
2. "Practical Physical Chemistry" by B.S. Bahl and Arun Bahl

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240/CHE/CC402

COURSE DETAILS:

Course Title	Organic Chemistry-IV
Semester	Semester-4
Course Code	CC-A11
Course ID	
Total Credits	04 (Lecture: 03, Tutorial: 0, Practical: 01)
Total Marks	100
Marks Distribution	Theory External: 50 Theory Internal: 25 Practical External: 20 Practical Internal: 05

COURSE CURRICULUM DELIVERY WEEKLY DISTRIBUTION:

Total Hours per Week: 5	
Lectures (L) Hours per Week: 3	Practicals (P) Hours per Week: 2

COURSE OBJECTIVES:

- Develop an understanding of the nomenclature, classification, preparation methods, and reaction mechanisms of nitro compounds and nitriles.
- Explore the physical and chemical properties of nitrogen-containing functional groups, focusing on their reactivity in various reaction conditions.
- Learn the basic principles of NMR spectroscopy, including chemical shifts, spin-spin coupling, and interpretation of spectra for simple organic molecules.
- Study the synthesis, structure, and reactivity of organometallic compounds such as Grignard reagents, organolithium, and organozinc compounds.

COURSE OUTCOMES:

- Students will be able to explain the preparation, classification, and reaction mechanisms of nitro compounds and nitriles, including their synthetic applications.
- Analyze the physical and chemical properties of nitrogen-containing functional groups under different reaction conditions.
- Interpret proton NMR spectra, including chemical shifts, coupling constants, and spectral features of simple organic molecules.
- Apply the principles of NMR spectroscopy to identify and characterize organic compounds.
- Demonstrate knowledge of the synthesis, structure, and reactivity of key organometallic compounds like Grignard reagents, organolithium, and organozinc compounds in organic synthesis.

DETAILED CONTENT OF COURSE:

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- **Theory & Practical Syllabus:**
- **Total Contact Hours: 45 (Theory) + 30 (Practical)**

Unit	Topics	Contact Hours
I	**Nitrogen Containing Functional Groups-II** **Nitro compounds** (Aliphatic and Aromatic): Nomenclature, classification and general methods of preparation: from alkyl halides, alkanes, oxidation of amines and oximes and diazonium salts. Properties: Physical properties, discussion on the following reactions with mechanism: Reaction with alkali and its synthetic applications, condensation reaction, Mannich reaction, Hydrolysis, Reduction-electrolytic reduction, reduction in acidic, basic and neutral medium (for aromatic compounds), reaction with nitrous acid, Electrophilic substitution-Halogenation, nitration and sulphonation reaction, and Nucleophilic substitution on the ring.	11
II	**Nitrogen Containing Functional Groups-III** **Nitriles**: Introduction, Nomenclature and uses. Preparation from the following reactions: Dehydration of amides and aldoximes, substitution reaction in alkyl halides and tosylates, from Grignard reagents and from dehydrogenation of primary amines. Properties: Physical properties, discussion on the following reactions with mechanism: Reaction with Grignard reagent, hydrolysis, addition reaction with HX,NH_3, reaction with aqueous ROH, Reduction reactions-catalytic reduction and Stephen's reaction, Condensation reactions-Thorpe Nitrile Condensation.	11
III	**NMR Spectroscopy** Basic principles of nuclear magnetic resonance, spectrum, number of signals, peak areas, magnetic equivalent and nonequivalent protons, positions of signals, chemical shift and factors influencing it, shielding and deshielding of protons, Spin-Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds. Discussion of PMR spectra of the molecules: ethyl bromide, n-propyl bromide, isopropyl bromide, 1,1-dibromoethane, ethanol, acetaldehyde, ethyl acetate, toluene, benzaldehyde and acetophenone. Applications of NMR for identification of simple organic molecules.	12
IV	**Organometallic Compounds** Grignard reagents: Synthesis, structure and chemical reactions. Organolithium compounds: Synthesis and chemical reactions. Organozinc compounds: Synthesis and chemical reactions. Organocopper: Synthesis and chemical reactions.	11
V	**Practical** 1. Systematic qualitative analysis of organic compounds possessing monofunctional groups: amide, amines, halo-hydrocarbons and carbohydrates (Including Derivative preparation). 2. Identification of simple organic compounds NMR spectroscopy	30

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		(Spectra to be provided). 3. *m*-Dinitrobenzene from nitrobenzene (use 1:2 conc. HNO_3 -H_2SO_4 mixture if fuming HNO_3 is not available). 4. Selective reduction of m-dinitrobenzene to m-nitroaniline. 5. Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC).	

COURSE EVALUATION METHODS

Theory Exams: Total Marks: 75 (External: 50 + Internal: 25)

Internal Assessment: 25 Marks	• Class Participation: 05 Marks • Seminar/Presentation/ Assignment: 05 Marks • Mid Term Exam: 15 Marks
External Assessment: 50 Marks (02 Hours)	• End Term Exam: 50 Marks

Practical Exam: Total Marks: 25 (External: 20 + Internal: 05)

Internal Assessment: 05 Marks	• Class Participation: 05 Marks
External Assessment: 20 Marks (02 Hours)	• End Term Practical Exam: 10 Marks • Lab record: 05 Marks • Viva Voce: 05 Marks

Instruction for End Term Theory Exam:

The Examiner is requested to set nine questions in total, selecting two questions from each section. Question-1 will be a compulsory question consisting short answer type questions covering all the units of the syllabus. All questions should carry equal marks. Log table and non-programmable calculator is allowed.

SUGGESTED BOOKS

1. Gilchrist, T.L. (1997),Heterocyclic Chemistry, Pearson Education.
2. Ram V. J.; Sethi, A.; Nath, M.; Pratap, R.; (2019), The Chemistry of Heterocycles (Nomenclature and Chemistry of three to five membered Heterocycles), Elsevier publication.
3. Ram V. J.; Sethi, A.; Nath, M.; Pratap, R.; (2019), The Chemistry of Heterocycles (Chemistry of six to eight membered N, O, S, P and Se heterocycles), Elsevier publication.
4. Pavia, D.L. Introduction to Spectroscopy, Cengage learning (India) Pvt. Ltd.
5. Kemp, W. (1991), Organic Spectroscopy, Palgrave Macmillan.
6. Practical: 1. Vogel, A.I. (2012), Quantitative Organic Analysis, Part 3, Pearson.

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7. Mann, F.G.; Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
8. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's Textbook Of Practical Organic Chemistry, 5th Edition, Pearson.
9. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

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240/CHE/CC403

COURSE DETAILS:

Course Title	**Inorganic Chemistry-IV**
Semester	**Semester-4**
Course Code	**CC-A10**
Course ID	
Total Credits	**04 (Lecture: 03, Tutorial: 0, Practical: 01)**
Total Marks	**100**
Marks Distribution	**Theory External: 50** **Practical External: 20** **Theory Internal: 25** **Practical Internal: 05**

COURSE CURRICULUM DELIVERY WEEKLY DISTRIBUTION:

Total Hours per Week: 5	
Lectures (L) Hours per Week: 3	**Practical (P) Hours per Week: 2**

COURSE OBJECTIVES:

1. To study the oxoacids and properties of oxygen and halogen families.
2. To understand the periodic trends and properties of d-block elements.
3. To explore the structures and properties of transition metal compounds.
4. To learn the nomenclature, isomerism, and bonding theories of coordination compounds.
5. To understand advanced concepts like crystal field theory and Jahn-Teller effects in coordination chemistry.
6. To develop practical skills in titrations, spectrophotometry, and complex characterization.

COURSE OUTCOMES:

By the end of the course, students will be able to:

1. Explain the structures and properties of oxoacids, hydrogen peroxide, and interhalogen compounds.
2. Compare the periodic trends and magnetic/spectral properties of d-block elements.
3. Analyze structures and bonding in compounds like TiO_2, $VOCl_2$, and $Ni(CO)_4$.
4. Apply IUPAC rules for coordination compound nomenclature and identify isomerism.
5. Use crystal field theory to explain splitting patterns in transition metal complexes.
6. Perform complexometric titrations and spectroscopic characterization of coordination complexes.

DETAILED CONTENT OF COURSE:

Theory & Practical Syllabus:

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Total Contact Hours: 45 (Theory) + 30 (Practical)

Unit	Topics	Contact Hours
I	**Chemistry of oxygen family and halogens** Oxygen family (16th group): Oxy acids of sulphur – structure and acidic strength, Hydrogen Peroxide–properties and uses. Halogen family (17th group): Interhalogen compounds (their properties and structures), Hydra and oxy acids of chlorine – structure and comparison of acid strength, cationic nature of Iodine.	11
II	**Chemistry of d-block elements** Definition of transition elements, position in the periodic table, General characteristic properties of d-Block elements, Comparison of properties of 3d elements with 4d and 5d elements with reference only to ionic radii, oxidation state, magnetic and spectral properties. Structures & properties of some compounds of transition elements – TiO_2, $VOCl_2$, $FeCl_3$, $CuCl_2$ and $Ni(CO)_4$.	11
III	**Coordination compounds – Part I** Coordination Compounds and double salts; IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination numbers 4 and 6, Chelate effect, Werner's theory and Valence Bond Theory (VBT) of transition metal complexes and its limitations.	11
IV	**Coordination Chemistry – Part II** Limitations of valence bond theory, an elementary idea of crystal-field theory, spectrochemical series, d-orbital splitting in octahedral and tetrahedral complexes, pairing energies, factors affecting the magnitude of crystal field splitting, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar complexes.	12
V	**Practical** 1. Complexometric titrations: Determination of Mg^{2+}, Zn^{2+} by EDTA. 2. To verify Beer - Lambert law for $KMnO_4$ /$K_2Cr_2O_7$ and determine the concentration of the given $KMnO_4$ /$K_2Cr_2O_7$ solution. 3. Characterization of complexes using infrared spectroscopy (Tetraamminecarbonatocobalt (III) ion, Potassium tris(oxalate)ferrate(III))	30

COURSE EVALUATION METHODS

Theory Exams: Total Marks: 75 (External: 50 + Internal: 25)

Internal Assessment: 25 Marks	• Class Participation: 05 Marks • Seminar/Presentation/ Assignment: 05 Marks • Mid Term Exam: 15 Marks
External Assessment: 50 Marks (02 Hours)	• End Term Exam: 50 Marks

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Practical Exam: Total Marks: 25 (External: 20 + Internal: 05)

Internal Assessment: 05 Marks	• Class Participation: 05 Marks
External Assessment: 20 Marks (02 Hours)	• End Term Practical Exam: 10 Marks • Lab record: 05 Marks • Viva Voce: 05 Marks

Instruction for End-Term Theory Exam:

The Examiner is requested to set nine questions in total, selecting two questions from each section. Question-1 will be a compulsory question consisting of short answer type questions covering all the units of the syllabus. All questions should carry equal marks. Log table and non-programmable calculator is allowed.

SUGGESTED BOOKS

1. "Inorganic Chemistry" by J.D. Lee
2. "Inorganic Chemistry" by Gary L. Miessler, Paul J. Fischer, and Donald A. Tarr
3. "Inorganic Chemistry" by Catherine Housecroft and Alan G. Sharpe
4. "Inorganic Chemistry" by Duward Shriver, Peter Atkins, Tina Overton, and Jonathan Rourke
5. "Quantitative Inorganic Analysis" by A. I. Vogel
6. "Practical Pharmaceutical Chemistry - Part I: Qualitative Analysis" by K. A. Pathan and S. J. Shaikh