CALICUT UNIVERSITY – FOUR-YEAR UNDER GRADUATE PROGRAMME (CU-FYUGP)

BSc CHEMISTRY

Programme	B.Sc Chemistry				
Course Title	**INORGANIC CHEMISTRY-II**				
Type of Course	**MAJOR**				
Semester	**4**				
Academic Level	**200-299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Classification of elements to different blocks, Comparative study of s and p block elements based on electronic configuration and atomic size, General idea about transition and inner transition elements, Concept of coordinate bond, Differences between double salts and complexes, Ligands, Coordination number. Concept of catenation and polymerization. Theoretical and practical knowledge about volumetric analysis.				
Course Summary	This course explains characteristics of s, p, d and f block elements. It also gives an insight into various theories in coordination compounds. It explores the application of inorganic chemistry in daily life. It covers practical application of complex formation in quantitative analysis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To Elucidate the trends in physical and chemical properties of s and p block elements	U	C	Instructor- created exams/ Quizzes/assignments
CO2	To Evaluate the general characteristics of Transition and Inner Transition elements, their comparison and applications	U	C	Instructor- created exams/ Quizzes/assignments

CO3	To demonstrate knowledge of coordination chemistry, isomerism and theories of bonding in coordination compounds	U	M	Instructor- created exams/ Quizzes/assignments
CO4	To analyze different types of inorganic polymers their structures, properties and applications	An	C	Instructor- created exams/ Quizzes/assignments
CO5	To Appreciate the utility of inorganic compounds in day to day life	Ap	M	Instructor- created exams/ Quizzes/assignments
CO6	To Apply the knowledge of complex formation and gain hands on experience in in quantitative analysis with some day to day application	Ap	P	Group work /Viva Voce// Observation of practical skill

Detailed Syllabus:

Module	Unit	Content	Hrs	Mark
I	**s & p BLOCK ELEMENTS**		**15**	**33**
	1	s block General properties: Ionization Energy, Flame coloration, Photoelectric effect, Metallic character, Hydration energy.	2	
	2	p block elements: Comparative study- Halides, Sulfates, Carbonates and bicarbonates (solubility and thermal stability)	1	
	3	Oxidation number and inert pair effect, Comparison of Lewis acidity of boron halides.	2	
	4	Preparation, Properties, Structure and uses of Diborane, Boric acid, Borazine and Boron nitride, Structure of $AlCl_3$	3	
	5	Structure and bonding of oxides of N (N_2O, NO, N_2O_3,NO_2,N_2O_4,N_2O_5) and S (SO_2 and SO_3)	2	
	6	Oxo acids of P (H_3PO_2, H_3PO_3, H_3PO_4) and Cl (HOCl, $HOCl_2$, $HOCl_3$,$HOCl_4$) (Structure and Acid strength), Colour and Bond Dissociation energy of halogens.	1	
	7	Interhalogen compounds: Preparation, Properties, Uses and Structure (One example each for AB,AB_3,AB_5 and AB_7 types), Electropositive character of iodine, Pseudo	3	

		halogen: Comparison of Pseudo halogen (Cyanogen as example) and halogens and structure of Poly halide ions.		
	8	Noble gases: Isolation of noble gases: Dewar's method-Separation by charcoal adsorption method, Uses of He, and Ne	1	
II		**TRANSITION AND INNER TRANSITION ELEMENTS**	**8hr**	17
	9	Electronic configuration and General characteristics, Ionization energy, Colour, Magnetic properties, Reducing properties, Catalytic properties.	**2**	
	10	Non-stoichiometric compounds, Complex formation and Alloy formation. Comparison of 3d, 4d and 5d transition series. Important application of transition metals. Isopoly and heteropoly anions of W and Mo.	**2**	
	11	Lanthanides and Actinides- Electronic configuration and General properties. Isolation of Lanthanides from monazite sand, Separation by ion exchange method.	**2**	
	12	Magnetic properties. Lanthanide contraction, causes and consequences. Industrial importance of Lanthanides. Comparison of Actinides & Lanthanides [Mention only].	**2**	
III		**COORDINATION CHEMISTRY**	**15 hr**	**33**
	13	IUPAC Nomenclature of complexes, Types of ligands: (mono, bi, tri, tetra, hexa, ambidentate, chelate and macrocyclic ligands), Isomerism-Structural and Stereoisomerism,	**2**	
	14	Review of Werner's theory and Sidwick concept of coordination-EAN rule,	**1**	
	15	Factors affecting stability of complexes, Application of coordination complexes in quantitative and qualitative analysis.	**2**	
	16	Theories of bonding, VBT (valence bond theory), Geometry of coordination numbers 4 & 6, Limitation of VBT.	**2**	
	17	Crystal field Theory: CFT-splitting of d orbitals in Octahedral and Tetrahedral complexes. CFSE of low spin and high spin octahedral complexes- Normal and inverse	**3**	

		spinel compounds, Factors affecting crystal field splitting, Spectrochemical series.		
	18	CFT-splitting of d orbitals in Tetragonal and Square planar Complexes. Magnetism (spin only magnetic moment) and Colour (d-d transition), Distorted octahedral complexes-Jhan-Teller theorem, CFSE calculation and its applications, Merits and demerits of CFT.	**5**	
IV		**INDUSTRIALLY IMPORTANT INORGANIC COMPOUNDS AND THEIR APPLICATION IN DAILY LIFE**	**7 hr**	**15**
	19	Inorganic Polymers: Homochain Polymers and Heterochain Polymers.	**1**	
	20	Structure and Applications of Silicones, Silicates, Zeolites, Phosphazenes, Preparation, Properties and Structure of di and tri phosphonitrilic chlorides, SN compounds: Preparation Methods, Properties and Structure of S_2N_2,, S_4N_4 and $(SN)_x$,,	**3**	
	21	Refractory materials: Borides and Carbides, Inorganic fertilizers: Essential Nutrients to plants- Nitrogenous, Phosphate and Potash fertilizers-Examples with formula, Rocket Propellants: Classification with examples.	**2**	
	22	Cement: Ingredients, Setting of cement, Role of gypsum Glass: Varieties of glass.	**1**	
V		**INORGANIC CHEMISTRY PRACTICAL II: COMPLEXOMETRIC TITRATIONS AND INORGANIC PREPARATIONS**	**30 hr**	
		From Section A Minimum of 3 experiments must be done and from Section B Minimum 3 experiments must be done **Section A** **Complexometry** 1. Estimation of magnesium 2. Estimation of Zinc 3. Determination of hardness of water 4. Determination of COD of water samples **Section B** **Inorganic preparations:** (a) Ferric alum,		

		(b)Nickel (II) dimethylglyoximate, (c)Tetraammine copper (II) sulfate, (d)Potash alum **Open Ended:** Any two experiments related to complexometry can be selected by the teacher		

References :

1. B.R. Puri L.R. Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, New Delhi,2010.

2. S. Prakash, G. D. Tuli, S. K. Basu, R. D.Madan, Advanced Inorganic Chemistry,5th Edn.,Vol.I,S Chand,2012.

3. J.D. Lee, Concise Inorganic Chemistry,5th Edn.,Wiley India Pvt.Ltd.,2008.

4. R. Gopalan, V.Ramalingam, Concise Coordination Chemistry, 1st Edn.,Vikas Publishing House, New Delhi,2001.

5. G. S. Manku ,Theoretical Principles of Inorganic Chemistry. McGraw-Hill Education; New edition (1 August 1982)

6. M.C. Day, J.Selbin,Theoretical Inorganic Chemistry,East West Press,New Delhi,2002.

7. J. E. Huheey, E.A.Keitler,R.L.Keitler,Inorganic Chemistry-Principles of Structure and Reactivity,4TH Edn.,Pearson Education, New Delhi,2013.

8. M.N. Greenwood, A. Earnshaw, Chemistry of elements, 2nd Edn., Butterworth,1997.

9. B.K. Sharma, Industrial chemistry, 11th Edn., Goel publishing House, Meerut, 2000.

10. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.

11. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.

Further Reading

1. W.U.Malik, G.D.Tuli, R.D. Madan, selected Topics in Inorganic Chemistry, S. Chand and Co., New Delhi,2010(Reprint)

2. F.A.Cotton,G.Wilkinson,Advanced Inorganic Chemistry,6TH Edn.,Wiley India Pvt.Ltd., New Delhi,2009.

3. James E. House, Inorganic Chemistry, academic press, 2008.

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3			-	2	2	3				2		1
CO 2	3		-	-	2	2	3				1	1	2
CO 3	3	-		-	-	-	2		1		1		2
CO 4	3	-			3	3	3		2	1	2		2
CO 5	2		-	-	3	2	2		1	1	2	2	2
CO 6	2	-	2		3	3	2		2	1	3	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Practical exam (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/ viva/seminar	Practical skill evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

CALICUT UNIVERSITY – FOUR-YEAR UNDER GRADUATE PROGRAMME (CU-FYUGP)

BSc. CHEMISTRY

Programme	B. Sc. Chemistry				
Course Title	**ORGANIC CHEMISTRY-II**				
Type of Course	**MAJOR**				
Semester	**IV**				
Academic Level	**200 - 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Concept of isomerism: Types of isomerism - constitutional isomerism (chain, position and functional) 2. Basic idea about organic addition reactions, substitution and elimination reactions, aromatic substitution reactions etc.				
Course Summary	The concepts of chirality, Optical isomerism, Relative and absolute configuration and racemic mixture and its separation are included in the first module. The course is designed to provide a comprehensive understanding of addition, substitution and elimination reactions of organic chemistry. The practical component of the course helps to acquire skills in organic synthesis and Column chromatographic techniques.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To understand the concepts of chirality, optical isomerism and relative and absolute configuration.	U	C	Seminar presentation /Assignment
CO2	To provide a comprehensive understanding of addition reactions in organic chemistry, To understand the mechanisms and stereochemistry of addition reactions.	Ap	P	Class test /Quiz /Assignment

CO3	Understanding the mechanism and stereochemical aspects of substitution reaction at sp3 carbon.	An	P	Seminar Presentation / Instructor created exam
CO4	To provide a comprehensive understanding of elimination reactions.	U	C	Instructor-created exams / Home Assignments
CO5	Examine the mechanisms and factors influencing aromatic substitution reactions.	Ap	P	Assignment /Seminar presentation /Class test
CO6	Execute practical lab techniques in organic synthesis. Acquire skills in conducting column Chromatography for the separation mixtures. Chromatography for the separation mixtures.	Ap	P	Lab work /Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours	Marks
I	**Stereochemistry II**		13	29
	1	Optical Isomerism: Optical activity – Concept of chirality – Chirality in organic molecules.	2	
	2	Enantiomers, Diastereomers and Meso compounds.	2	
	3	Optical isomerism in glyceraldehyde, lactic acid and tartaric acid.	1	
	4	Relative and absolute configuration - DL system, RS system of nomenclature for acyclic optical isomers with one and two asymmetric carbon (Amino acids ,Tartaric acids)– sequence rules. Erythro and threo representations (basic idea only)	4	
	5	Racemic mixture – Resolution methods (Chemical and biochemicals methods)	2	
	6	Enantiomeric excess, Optical purity. Common approaches in asymmetric synthesis. (mention only)	2	
II	**Addition reactions**		12	27

	7	Addition reactions to carbon-carbon multiple bonds: Origin of reactivity, regioselectivity (Markownikov's and anti-Markownikov's additions) and stereoselectivity of addition reactions	2	
	8	Examples of addition reactions: hydrogenation, halogenation, hydrohalogenation, hydration, oxymercuration-demercuration,	2	
	9	hydroboration-oxidation, epoxidation, dihydroxylation, ozonolysis.	1	
	10	Addition to C≡C: Mechanism, reactivity, regioselectivity (Markownikov's and anti-Markownikov's additions) and stereoselectivity	3	
	11	Reactions: Complete hydrogenation, Partial hydrogenation, Electrophilic addition of halogens and hydrogen halides, Ozonolysis	2	
	12	Acidity of alkynes – test for terminal alkynes – Oxidation– (Ozonolysis and reaction with alkaline $KMnO_4$). Chemistry of the tests for unsaturation: Bromine water and Baeyer's reagent test.	2	
III	**Substitution and Elimination Reactions**		10	21
	13	Nucleophilic substitution reactions: Substitution at sp^3 centre (systems: alkyl halides and alcohols)- Origin of reactivity, SN1, SN2 with stereochemical aspects, types of leaving groups (Oxygen-based and halogen-based).	3	
	14	Effects of substrate structure, solvent, nucleophile, and leaving group on Nucleophilic aliphatic substitution reactions.	3	
	15	Elimination reactions: E1, E2 & E1CB mechanisms. formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann), and stereoselectivity;	3	
	16	competition between substitution and elimination reactions. Syn elimination	1	
IV	**Aromatic Substitution Reactions**		10	21
	17	Aromatic Electrophilic Substitution: Mechanism of nitration, halogenation, sulphonation, Friedel-Crafts alkylation, and acylation	3	

	18	Synthesis of Aspirin. Ring activating and deactivating groups- Orientating effect of common substituents in aromatic electrophilic substitution.	2	
	19	Electrophilic substitution reactions of Phenols (bromination, nitration and sulphonation)	2	
	20	Preparation of phenolphthalein and Fluorescein	1	
	21	Aromatic nucleophilic substitution: Bimolecular displacement mechanism	1	
	22	Elimination-addition (benzyne intermediate) mechanism.	1	
V	PRACTICALS		30	
	I	1. Separation of binary mixture using solvent extraction (strong acid neutral, basic+neutral and weak acid+neutral compound combinations) 2. Bromination of Cinnamic acid (Green method-Bromide -Bromate mixture) 3. Preparation of dibenzal acetone 4. Nitration of acetanilide 5. Reduction of ethyl acetoacetate by yeast and measurement of optical rotation. 6. Drawing structures using software. 7.Visualization of SN2 reaction using software	24	
		Open Ended: 1.Making models of enantiomers and diastereomers	6	

References:

1. R. T. Morrison, R. N. Boyd, Organic Chemistry, Pearson Education, New Delhi.
2. I. L. Finar, Organic Chemistry, Vol. I, Pearson Education, New Delhi.
3. M. K. Jain, S. C. Sharma, Modern Organic Chemistry, Vishal Publishing Company Co.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, A Textbook of Organic Chemistry, Vikas Publishing House.
5. P. Y. Bruice, Essential Organic Chemistry, 3rd Edn., Pearson Education, 2015.

6. John McMurry, Organic Chemistry, 5th Edn., Thomson Asia Pvt. Ltd.
7. C. N. Pillai, Organic Chemistry, Universities Press.
8. Vogel's practical organic chemistry.
9. John McMurry, Eric Simanek, Fundamentals of organic chemistry, 6th Edn., Thomson India Edition.
10. Chemistry for Pharmacy Students: General, Organic and Natural Product Chemistry, S D Sarkar and L Nahar, John Wiley and sons, Ltd.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	-	-	-	-	-	2		2		2		1
CO 2	2	2	-	-	2	-	3		1		2		1
CO 3	2	-		-	-	2	2		1		2		1
CO 4	2	-		1	-	-	3		1		2		1
CO 5	3		-	-	-	-	2		1		2		1
CO 6	-	-	3		-	-	3		3		2	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Quiz / Assignment/ Quiz/ Discussion / Seminar

Midterm Exam

Programming Assignments (20%)

Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/viva/seminar	Practical skill Evaluation	End Semester Examinations
CO 1		✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

CALICUT UNIVERSITY – FOUR-YEAR UNDERGRADUATE PROGRAMME (CU-FYUGP)

BSc CHEMISTRY

Programme	B.Sc Chemistry				
Course Title	**PHYSICAL CHEMISTRY –II: CHEMICAL THERMODYNAMICS, KINETICS AND SURFACE CHEMISTRY**				
Type of Course	**MAJOR**				
Semester	**IV**				
Academic Level	**200-299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	[Prerequisites: NCERT or equivalent chemistry syllabus of XI and XII, https://onlinecourses.swayam2.ac.in/nce24_sc07/preview Fundamentals of Chemical Thermodynamics. Path function and state function - Thermodynamic terms for defining System - Surroundings - Types of systems]				
Course Summary	We witness, feel and create physical and/or chemical change(s) everyday. What drives these changes? This course deals with the principles of chemical thermodynamics and chemical kinetics to answer these questions. The subject matter covered will enable the student to understand the relation between heat, work, temperature, and energy. Here, the various tools to evaluate chemical systems in equilibrium and rates of chemical reactions are also introduced. Further, the concept of catalysis and its importance in industrial processes is also included in this course.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To Understand the fundamental concepts of	U	F	Assignments/Quiz/Seminars

	thermodynamics and identify it with the real world			
CO2	To apply thermochemical principles to chemical reactions	Ap	C	Work out problems/assignments/Test
CO3	To apply the concept of kinetics and catalysis to various chemical and physical processes	Ap	C	Work out problems/assignments/Test
CO4	To interpret kinetic data using graphical representations and evaluate the rate of a reaction	An	P	Quiz/Discussion
CO5	To evaluate the surface area of catalysts using various adsorption isotherms	Ap	P	Quiz/Discussion
CO6	To apply the theories of kinetics and adsorption through laboratory experiments	C	P	Lab work/Viva voce exams

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Module	Unit	Content	Hrs (45+30)	Marks
I	**FIRST LAW OF THERMODYNAMICS AND THERMOCHEMISTRY**		**15**	**33**
	1	Intensive and extensive properties - Steady state and equilibrium state. Concept of thermal equilibrium	**1**	
	2	Zeroth law of thermodynamics. Intensive, extensive and state variables (state functions), Introduction to partial derivatives and line integrals, Euler theorem, Exact and Inexact	**3**	

		differential, Illustration of exact differential using molar volume of ideal gas.		
	3	First law of thermodynamics – Concept of heat (q), work, internal energy(U) and enthalpy (H) - Heat capacities at constant volume and at constant pressure & their relationship - Expansion of an ideal gas under isothermal and adiabatic conditions - Work done in reversible isothermal and adiabatic expansion.	**4**	
	4	Joule-Thomson effect- significance of term $(dU/dV)_T$ - Liquefaction of gasses - Derivation of the expression for Joule Thomson coefficient – Inversion temperature.	**3**	
	5	Thermochemistry: Heat changes during physical and chemical changes. Hess's Law.	**2**	
	6	Temperature dependence of reaction enthalpies- Kirchoff's law. Bond dissociation energies. Resonance energy from thermochemical data.	**2**	
II	**SECOND & THIRD LAWS OF THERMODYNAMICS**		**10**	**21**
	7	Limitations of first law and Need for the second law – Kelvin and Clausius statements. Carnot's theorem and Heat engine and its efficiency.	**2**	
	8	Concept of Entropy. Calculation of entropy change for reversible and irreversible processes. Statement of first law in terms of entropy. Entropy change during the isothermal mixing of ideal gasses.	**2**	
	9	Energy functions (Gibbs free energy (G) and Helmholtz energy (A)) and their variation with T and P.	**2**	
	10	Maxwell's relations. Gibbs-Helmholtz equation - Criteria for spontaneity and equilibrium - Significance of Clausius inequality.	**2**	
	11	Partial molar free energy - Concept of chemical potential - Gibbs-Duhem equation.	**1**	
	12	Third law of thermodynamics - Nernst heat theorem - Statement of third law.	**1**	
III	**CHEMICAL KINETICS**		**15**	**33**
	13	Rate of a reaction - Factors influencing the rate of a reaction- Concentration, Temperature, Surface area and Catalyst - Rate law - Order and molecularity -	**2**	
	14	Derivation of rate constants for first, second (with same and different reactants), third (with same reactants only) and zero	**4**	

		order reactions with examples. Data interpretation including graphical representations		
	15	Half-life period (derivation for first and n^{th} order reactions) - Methods to determine the order of a reaction.	**1**	
	16	Effect of temperature on reaction rates - Arrhenius equation - Determination and significance of Arrhenius parameters	**1**	
	17	Theories of reaction rates - Collision theory - Derivation of rate equation for bimolecular reactions using collision theory - Transition state theory - Expression for rate constant based on equilibrium constant and thermodynamic aspects – Eyring equation (derivation not required)	**5**	
	18	Unimolecular reactions - Lindemann mechanism.	**2**	
IV	**SURFACE CHEMISTRY, ADSORPTION AND CATALYSIS**		**5**	**11**
	19	Solid surfaces, microstructure and elementary idea about microscopic techniques for studying the surface of solids (SEM, TEM, STM, AFM)	**1**	
	20	Physisorption, Chemisorption. Adsorption isotherms – Langmuir, Freundlich and BET (No derivation required). Determination of Surface area, Particle size and surface area, Activated charcoal and its uses	**2**	
	21	Homogeneous and heterogeneous catalysis - Theories of homogenous and heterogenous catalysis with examples	**1**	
	22	Enzyme catalysis - Michaelis-Menten equation (derivation not required). Application of enzyme technology for environmental, medical, agricultural, and industrial benefits.	**1**	
V	**PHYSICAL CHEMISTRY- PRACTICALS-2**		**30**	
		A minimum of 5 practical experiments out of which TWO EACH from sections 1 and 2 must be performed and reported. For plots/graphs, suitable softwares may be used and printed hard copies may be presented. Practical records may be in handwritten or computer-typed printed form. Section 1 1. Determination of rate constant of the Acid Hydrolysis of ethyl acetate 2. Determination of effect of temperature on the rate of acid hydrolysis of ethyl acetate 3. Determination of order of the reaction between crystal violet dye and NaOH (or Fuchsin and NaOH) by using	 **3** **3** **3**	

		a colorimeter/spectrophotometer 4. Kinetics studies of reaction between $KMnO_4$ and Oxalic acid 5. Open ended Section 2 6. Adsorption of oxalic acid on activated charcoal and thereby determining the adsorption isotherm. 7. Observation of decolourisation of a suitable dye on activated charcoal or filter paper via visual or colorimetry/spectrophotometry 8. Verification of Hess's law by using Mg, MgO and HCl reactions. 9. Effect of Mn2+ catalyst on reaction kinetics of $KMnO_4$ vs Oxalic acid 10. Open ended	**3** **3** **3** **3** **3** **3** **3**	
		References **Module I and II** 1. Physical Chemistry: Thermodynamics, Structure and Change, 10th Edition, P. Atkins and J. de Paula, (W. H Freeman and Company, New York) 2. D. A. McQuarrie, J. D. Simon, Physical Chemistry – A Molecular Approach, (Viva, 2001.) 3. T. Engel, P. Reid, Thermodynamics, Statistical Thermodynamics & Kinetics, Pearson Education, Inc: New Delhi, 2007. 4. J. Rajaram, J. C. Kuriacose, Chemical Thermodynamics, Pearson Education, New Delhi, 2013. **Module III and IV** 5. Physical Chemistry: Thermodynamics, Structure and Change, 10th Edition, P. Atkins and J. de Paula, (W. H Freeman and Company, New York) 6. K. Laidler, Chemical Kinetics, 3rd Edn., Pearson Education, New Delhi, 2004. **Module V** 7. Findlay's Practical Physical Chemistry, Ninth Edition, Revised and Edited by B P Levitt, (Longman, London, 1973)		

		8. Advanced Physical Chemistry: Practical Guide, C. Arora and S. Bhattacharya, Bentham Books, UAE, 2022 9. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publications, Meerut, 2008.. 10. R. C. Das, B. Behra, Experiments in Physical Chemistry, Tata McGraw Hill, New Delhi, 1983 ***Further reading*** 11. F. Daniels, R. A. Alberty, Physical Chemistry, 5th Edn., John Wiley and Sons, Canada, 1980. 12. 1. B. R. Puri, L. R. Sharma, M. S. Pathania, Principles of Physical Chemistry, 46th Edn., Vishal Publishing Company, New Delhi, 2013. 13. G. M. Barrow, Physical Chemistry, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006. 14. F. Daniels, R. A. Alberty, Physical Chemistry, 5th Edn.,John Wiley and Sons, Canada, 1980. 15. D. P. Shoemaker, C. W. Garland, Experiments in Physical Chemistry, McGraw-Hill Book Company, New York, 1962. 16. W. G. Palmer, Experimental Physical Chemistry, Cambridge University Press, Cambridge, 2009		

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
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CO 2	3	2	-	-	3	2	3	2	1	-	2	-	1
CO 3	3	2	-	-	3	2	3	2	1	-	2	-	1
CO 4	3	2	-	-	3	3	3	2	1	-	1	-	1

CO 5	3	2	-	1	3	3	3	2	1	-	3	-	1
CO 6	3	-	2	3	3	3	3	2	1	2	3	2	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Practical exam (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment /viva	Practical skill evaluation	End Semester Examinations
CO 1		✓		✓
CO 2		✓		✓
CO 3	✓			✓
CO 4	✓			✓

CO 5	✓	✓		✓
CO 6	✓	✓	✓	✓