Integral University, Lucknow

Effective from Session: 2023-24							
Course Code	B020301T/CH232	**Title of the Course**	Chemical Dynamics & Coordination Chemistry	**L**	**T**	**P**	**C**
Year	Second	**Semester**	Third	3	1	0	4
Pre-Requisite	-	**Co-requisite**	-				
Course Objectives	Upon successful completion of this course, students should be able to describe the characteristics of the three states of matter and the different physical properties of each state of matter. Kinetic theory of gases, laws of crystallography, liquid state, and liquid crystals, conductometric, potentiometric, optical methods, polarimetry, and spectrophotometer techniques to study chemical kinetics and chemical equilibrium. After the completion of the course, students will be able to understand. Metal-ligand bonding in transition metal complexes, thermodynamic and kinetic aspects of metal complexes.						

Course Outcomes	
CO1	Students can explore the rate of reaction, order of reaction, concentration dependence, mathematical characteristics, and determination of reaction order, temperature effects, Arrhenius equation, activation energy, collision theory, transition state theory, rate constant expression, and thermodynamic aspects.
CO2	Students understand equilibrium constant, free energy, thermodynamic derivation of the law of mass action, Le-Chatelier's principle, reaction isotherm, reaction isochore-Clapeyron Clausius equation, phase terms (phase, component, degree of freedom), Gibbs phase rule derivation, phase equilibria of one component systems (water, CO_2, O_2), and phase equilibria of two component systems (solid-liquid equilibria, simple eutectic systems).
CO3	Students understand kinetic theory of gases, van der Waals equation, critical phenomena, PV isotherms, continuity of states, law of corresponding states, reduced equation of state, and Maxwell's distribution of molecular velocities. Furthermore, Students able to explore liquid state, intermolecular forces, structure of liquids, differences between solids, liquids, and gases; study liquid crystals, their classification, structure, and phases; investigate liquids in solids (gels), their classification, preparation, properties, and applications.
CO4	Student are knowing the fundamentals of Werner's theory of coordination complexes, ligand classification, ambidentate ligands, chelates, coordination numbers, IUPAC nomenclature (up to two metal centers), isomerism in coordination compounds (constitutional, stereo, geometrical, and optical), focusing on square planar and octahedral complexes.
CO5	Explore electronic spectra, d-d transitions, spectroscopic ground states, spectrochemical series, orgel-energy level diagrams, and the electronic spectrum of the $[Ti(H_2O)_6]^{3+}$ complex ion. Study magnetic properties, types of behavior, methods for determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μs and μ effective values, orbital contribution to magnetic moments, and applications of magnetic moment data for 3d-metal complexes.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Chemical Kinetics & Theories of chemical kinetics	i. Rate of a reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristics of simple chemical reactions: zero order, first order, second order, pseudo-order, half-life, and mean life; determination of the order of reaction: differential method, method of integration, half-life method, and isolation method. ii. Effect of temperature on rate of reaction; Arrhenius equation; concept of activation energy; Simple collision theory based on the hard sphere model, transition state theory (equilibrium hypothesis); Expression for the rate constant based on equilibrium constant and thermodynamic aspects (no derivation).	8	1
2	Chemical Equilibrium	Equilibrium constant and free energy; thermodynamic derivation of the law of mass action; Le-Chatelier's principle, reaction isotherm, and reaction isochore-Clapeyron Clausius equation and its applications.	7	2
3	Phase Equilibrium	Statement and meaning of the terms phase, component, and degree of freedom; derivation of Gibbs phase rule, phase equilibria of one component system—water, CO_2, and O_2 systems Phase equilibria of two component systems: Solid-liquid equilibria, simple eutectic (Bi-Cd, Pb Ag systems)	7	2
4	Kinetic theories of gases	i. *Gaseous State:* Postulates of the kinetic theory of gases: deviation from ideal behaviour, van der Waals equation of state. ii. *Critical phenomena:* PV isotherms of real gases, continuity of states, the isotherms of the Van der Waals equation, relationship between critical constants and Van der Waals constants, the law of corresponding states, reduced equation of state. iii. *Molecular Velocities:* Qualitative discussions of Maxwell's distribution of molecular velocities, collision number, mean free path, and collision diameter.	7	3
5	Liquid State	i. *Liquid State:* Intermolecular forces and the structure of liquids (a qualitative description) Structural differences between solids, liquids, and gases. ii. *Liquid crystals:* Difference between liquid crystal, solid, and liquid; classification and structure of the nematic and cholesterol phases. iii. Liquids in solids (gels): Classification, preparation, and properties, inhibition, general application.	7	3
6	Coordination Chemistry	Werner's theory of coordination complexes, classification of ligands, ambidentate ligands, chelates, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, and geometrical and optical isomerism in square planar and octahedral complexes.	8	4
7	Theories of Coordination Chemistry	i. Metal-ligand bonding in transition metal complexes, limitations of valance bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral, and square planner complexes, the John Teller effect, and factors affecting the crystal-field parameters. ii. *Thermodynamic and kinetic aspects of metal complexes:* a brief outline of the thermodynamic stability of metal complexes; the concept of hard and soft acids and bases and factors affecting their stability; the stability constants of complexes and their determination; substitution reactions of square planar complexes	8	4

8	Inorganic Spectroscopy and Magnetism	i. Electronic spectra of transition metal complexes Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, orgel-energy level diagrams for d1 and d9 states, and discussion of the electronic spectrum of the $[Ti(H_2O)_6]^{3+}$ complex ion. ii. Magnetic properties of transition metal complexes, types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ s and μ effective values, orbital contribution to magnetic moments, application of magnetic moment data for 3d- metal complexes.	8	5

Reference Books:
Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
Ball, D. W. Physical Chemistry Thomson Press, India (2007).
Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley 1995
Lee,J.D, Concise Inorganic Chemistry 4th Edition ELBS,1977
Douglas,B, McDaniel ,D and Alexander,J ,Concepts of Models of Inorganic Chemistry, John Wiley & Sons; 3rd edition , 1994
Shriver,D.E Atkins,P.W and Langford, C .H, Inorganic Chemistry ,Oxford University Press, 1994.
Porterfield, W.W, Inorganic Chemistry,Addison Wesley 1984.
Sharpe,A .G, Inorganic Chemistry, ELBS,3RD edition ,1993; Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
Miessler,G.L,Tarr,D.A, Inorganic Chemistry, 2nd edition , Prentice Hall, 2001; Bahl and Bahl, Essential of Physical Chemistry, S.Chand
R Gopalan& V Ramalingam, Concise Coordination Chemistry, Vishal publishing house; Tn Srivastva and Pc Kampoj, Systematic Nalytical Chemistry, Shoban Lal Nagin Chand
e-Learning Source:
https://swayam.gov.in/
https://www.coursera.org/learn/physical-chemistry
https://www.mooc-list.com/tags/physical-chemistry
https://www.openlearning.com/courses/introduction-to-physical-chemistry/
https://www.my-mooc.com/en/categorie/chemistry
https://onlinecourses.swayam2.ac.in/nce19_sc15/preview
https://swayam.gov.in/
https://www.coursera.org/browse/physical-science-and-engineering/chemistry

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	1	1	-	-	-	-	-	-	-	-	1	-	-	1	1
CO2	3	2	1	2	-	-	-	-	-	-	-	-	1	-	-	2	1
CO3	2	3	1	1	-	-	-	-	-	-	-	-	1	-	-	2	1
CO4	3	3	2	2	-	-	-	-	-	-	-	-	2	-	-	1	1
CO5	2	2	1	1	-	-	-	-	-	-	-	-	1	-	-	1	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation1

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2023-24							
Course Code	B020302P/CH234	**Title of the Course**	Physical Analysis	**L**	**T**	**P**	**C**
Year	Second	**Semester**	Third	-	-	4	2
Pre-Requisite	-	**Co-requisite**	-				
Course Objectives	Students who successfully complete this course should be able to calibrate instruments and prepare solutions of various concentrations, estimate components through volumetric analysis, as well as perform dilatometric experiments: one- and two-component phase equilibrium experiments.						

Course Outcomes	
CO1	Students able to demonstrate proficiency in the following concepts: calibration of laboratory equipment; dilution of solutions, including the conversion of 0.1 M to 0.001 M solutions; Understanding of the molecular concept and concentration units, including molecular weight, formula weight, and equivalent weight, and knowledge of various concentration units.
CO2	Students can determine experimentally the surface tension and viscosity of a pure liquid or solution.
CO3	Students identify boiling points of five organic compounds with boiling points under 180 °C.
CO4	Student becomes able to determine the transition temperature of the substance using thermometric or dialometric methods.
CO5	Students learn the solutes' effect on critical solution temperature and construct phase diagrams.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Strengths of Solution	i. Calibration of fractional weights, pipettes, and burettes. Preparation of standard solutions. ii. Dilution: 0.1 M to 0.001 M solutions. iii. Mole Concept and Concentration Units: Mole Concept, molecular weight, formula weight, and equivalent weight. iv. Concentration units: Molarity, Formality, Normality, Molality, Mole fraction, Percent by weight, Percent by volume, Parts per thousand, Parts per million, Parts per billion, pH, pOH, milli equivalents, Milli moles	20	1
2	Surface Tension and Viscosity	i. Determination of the surface tension of a pure liquid or solution ii. Determination of the viscosity of a pure liquid or solution	10	2
3	Boiling point and Transition Temperature	i. Boiling point of common organic liquid compounds (any five): n-butyl alcohol, cyclo-hexanol, ethyl methyl ketone, cyclo-hexanone, acetylacetone, isobutyl methyl ketone, isobutyl alcohol, acetonitrile, benzaldehyde, and acetophenone [The boiling points of the chosen organic compounds should preferably be within 180 °C.] ii. Transition Temperature: Determination of the transition temperature of the given substance by thermometric or dialometric method (e.g. $MnCl_2.4H_2O$ or $SrBr_2.2H_2O$)	20	3, 4
4	Phase Equilibrium	i. To study the effect of a solute (e.g., NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g., phenol-water system) and to determine the concentration of that solute in the given phenol-water system. ii. To construct the phase diagram of a two-component (e.g., diphenylamine-benzo-phenone) system by the cooling curve method.	10	5

Reference Books:

G. D. Christian, Analytical Chemistry, 6th Ed. John Wiley & Sons, New York (2004).

D.C. Harris, Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman (2016).

E. Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990).

J. A. Kent, (ed) Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi, (1997).

Pani, B. Textbook of Environmental Chemistry, I.K. International Publishing House, (2017).

A. K. De, Environmental Chemistry, New Age International Pvt, Ltd, New Delhi (2012).

S. M .Khopkar,., Environmental Pollution Analysis, New Age International Publishe (2010)

e-Learning Source:

https://www.labster.com/chemistry-virtual-labs/

https://www.vlab.co.in/broad-area-chemical-sciences

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	1	1	-	-	-	-	-	-	-	-	-	1	2	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-	-	2	2	-	-
CO3	3	2	2	2	-	-	-	-	-	-	-	-	-	2	3	-	-
CO4	2	3	1	2	-	-	-	-	-	-	-	-	-	1	1	-	-
CO5	2	2	2	1	-	-	-	-	-	-	-	-	-	1	1	-	-

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2023-24							
Course Code	B020401T/CH239	**Title of the Course**	Quantum Mechanics and Analytical Techniques	**L**	**T**	**P**	**C**
Year	Second	**Semester**	Fourth	3	1		4
Pre-Requisite	-	**Co-requisite**	-				
Course Objectives	The students learn about the atomic structure, elementary quantum mechanics, wave function and its significance; the Schrodinger wave equation and its applications; Molecular orbital theory, basic ideas – Criteria for forming molecular orbitals from atomic orbitals; Molecular Spectroscopy, Rotational Spectrum, vibrational Electronic Spectrum: photochemistry and kinetics. Analytical chemistry plays an enormous role in our society, such as drug manufacturing, process control in industry, environmental monitoring, medical diagnostics, food production, and forensic surveys. It is also of significant importance in different research areas. Analytical chemistry is a science that creates and develops knowledge to improve chemical analysis to respond to increasing or new demands.						

Course Outcomes	
CO1	Students will be able to explore new areas of research in both chemistry and the allied fields of science and technology. This is especially in elementary quantum mechanics.
CO2	Students will be able to function as members of an interdisciplinary problem-solving team in molecular spectroscopy.
CO3	Students will be skilled at problem solving, critical thinking, and analytical reasoning as applied to scientific problems. This is done with the help of various spectroscopic techniques.
CO4	Students will learn how to determine the structure of organic molecules using IR, NMR, and mass spectroscopic techniques.
CO5	To develop the basic skills required for purification, solvent extraction, TLC, and column chromatography.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Elementary Quantum Mechanics	Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. de-Broglie hypothesis. Heisenberg uncertainty principle, Hamiltonian Operator. Schrödinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one-dimensional box. Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions. Molecular orbital theory, basic ideas – Criteria for forming MO from AO, construction of MO by LCAO- H_2^+ ion, calculation of energy levels from wave functions, physical picture of bonding and anti-bonding wave functions, concept of σ, σ^*, π, π^* orbitals and their characteristics.	10	1
2	Molecular Spectroscopy	Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom	5	2
3	Rotational Spectrum, Vibrational Spectrum and Raman spectrum	i. Diatomic molecules, Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect. ii. Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups. iii. Concept of polarizability, pure rotational and pure vibrational, Raman spectra of diatomic molecules, selection rules. Electronic Spectrum: Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules.	10	3
4	UV-Visible Spectroscopy	Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules. Types of electronic transitions, λ max, chromophores and auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; application of Woodward Rules for calculation of λ max for the conjugated dienes: alicyclic, homoannular and heteroannular; extended conjugated systems distinction between cis and trans isomers (Cis and trans stilbene).	5	3
5	Infrared Spectroscopy (IR Spectroscopy)	Fundamental and non-fundamental molecular vibrations; Hooke's law selection rule, IR absorption positions of various functional groups (C=O, OH, NH, COOH and nitrile), Effect of H- bonding, conjugation, resonance and ring size of cyclic ketones and lactones on IR absorptions; Fingerprint region and its significance; application in functional group analysis and interpretation of I.R. Spectra of simple organic compounds. Identification of the Carbonyl group in Ketones, Aldehydes, Carboxylic acids, Esters, and Amides using IR Spectroscopy.	8	4
6	1H-NMR Spectroscopy (PMR)	NMR Spectroscopy: introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; choice of solvent and internal standard; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of first-order multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR; anisotropic effects in alkene, alkyne, aldehydes and aromatics; NMR peak area, integration; relative peak positions with coupling patterns of common organic compounds; interpretation of NMR spectra of simple	8	4

		compounds. Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules such as Ethanol, Ethyl acetate, acetone, acetaldehyde, dimethylformamide, Cis and trans 1,2- dimethyl cycloprpanone, propene, vinyl chloride, acetophenone, benzaldehyde, phenol, Toluene and ethyl benzene.		
7	Introduction to Mass Spectrometry	Principle of mass spectrometry, the mass spectrum, mass spectrometry diagram, molecular ion, metastable ion, fragmentation process, McLafferty rearrangement.	6	4
8	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. Chromatography: Classification, principle, and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution, and displacement methods.	8	5

Reference Books:

Alberty,R A, Physical Chemistry,4 theditionWiley Eastern Ltd ,2001; Atkins,PW,the elements of physical chemistry,Oxford ,1991

Barrow,G .M,International student Edition .McGraw Hill, McGraw-Hill,1973; Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley 1995

Lee,J.D, Concise Inorganic Chemistry 4th Edition ELBS,1977; Clayden, J., Greeves, N., Warren, S., Organic Chemistry, Second edition, Oxford University Press 2012.

Silverstein, R. M., Bassler, G. C., Morrill, T. C. Spectrometric Identification of Organic Compounds, John Wiley and Sons, INC, Fifth edition.

Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988; Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.; Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.

Mukherji, Singh,Kapoor, Organic Chemistry, Vol 1 and 2. New Age International 2014; Rl Madan, Chemsitry For Degree Students Elective Sem V/Vi As Per Cbs Quantum And Spectroscopy, S Chand Publishing

Y.R.Sharma, Elementary Organic Spectroscopy Vol 4, S Chand; Gurdeep Raj, Advanced Physical Chemsitry, Krishna Publishing

Pavia, D. L. et al. Introduction to Spectroscopy, 5th Ed. Cengage Learning India Ed.

K.L.Kapoor, A Textbook Of Physical Chemistry - Quantum Chemistry And Molecular Spectroscopy, Volume 4, Macmillan; Tn Srivastva And Pc Kampoj, Systematic Nalytical Chemistry, Shoban Lal Nagin Chand

e-Learning Source:

https://www.coursera.org/courses?query=chemistry&languages=en

https://www.mooc-list.com/tags/physical-chemistry

https://www.coursera.org/learn/physical-chemistry

https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2017/

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Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	1	-	-	-	-	-	-	-	-	1	-	-	1	1
CO2	3	2	1	2	-	-	-	-	-	-	-	-	2	-	-	1	1
CO3	2	3	2	3	-	-	-	-	-	-	-	-	3	-	-	3	3
CO4	3	3	2	3	-	-	-	-	-	-	-	-	2	-	-	2	2
CO5	3	3	2	2	-	-	-	-	-	-	-	-	2	-	-	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation1

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2023-24							
Course Code	B020402P/CH241	**Title of the Course**	Instrumental Analysis	**L**	**T**	**P**	**C**
Year	Second	**Semester**	Fourth			4	2
Pre-Requisite	-	**Co-requisite**	-				
Course Objectives	Students will be able to perform, design, interpret, and document laboratory experiments using critical thinking and scientific inquiry. This is at a level suitable to succeed in an entry-level position in the chemical industry or a chemistry graduate program.						

Course Outcomes	
CO1	Students will be able to explore new areas of research in both chemistry and allied fields of science and technology, basically in molecular weight determination.
CO2	Students will be able to function as members of an interdisciplinary problem-solving team in spectrophotometer.
CO3	Students will be skilled in problem solving, critical thinking, and analytical reasoning as applied to scientific problems, especially spectroscopy.
CO4	Students will gain an understanding of how to determine the structure of organic molecules using IR and NMR spectroscopic techniques.
CO5	To develop the basic skills required for purification, solvent extraction, TLC, and column chromatography.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Molecular Weight Determination	i. Determination of molecular weight of a non-volatile solute by Rast method/ Beckmann freezing point method. ii. Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) in aqueous solution at different concentrations by ebullioscopy.	15	1
2	Spectrophotometry	i. To verify Beer – Lambert Law for $KMnO_4/K_2Cr_2O_7$ and determining the concentration of the given solution of the substance from absorption measurement ii. Determination of pKa values of indicator using spectrophotometry.	15	2
3	Spectroscopy	i. Assignment of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C≡C, C≡N stretching frequencies; characteristic bending vibrations are included. Spectra to be provided). ii. Assignment of labelled peaks in the ^1H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern. iii. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).	15	3, 4
4	Chromatographic Separations	i. Paper chromatographic separation of following metal ions: Ni (II) and Co (II); Cu(II) and Cd(II) ii. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer Chromatography (TLC) iii. Separation and identification of the amino acids present in the given mixture by paper chromatography. Reporting the Rf values TLC separation of a mixture of dyes (fluorescein and methylene blue).	15	5

Reference Books:

Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009; Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.

Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004; Harris, D.C.Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016; Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.

Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.

Mikes, O. &Chalmes, R.A. Laboratory Handbook of Chromatographic &AlliedMethods, Elles Harwood Ltd. London.

Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

e-Learning Source:

https://www.youtube.com/watch?v=xHQM4BbR040&pp=ygUcc3BlY3Ryb3Bob3RvbWV0ZXIgZXhwZXJpbWVudA%3D%3D

https://www.youtube.com/watch?v=LbsNI3WgUso&pp=ygUMc3BlY3Ryb3Njb3B5

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	2	1	2	-	-	-	-	-	-	-	-	-	2	2	-	-
CO2	1	2	2	1	-	-	-	-	-	-	-	-	-	2	1	-	-
CO3	3	3	1	2	-	-	-	-	-	-	-	-	-	2	2	-	-
CO4	2	3	3	1	-	-	-	-	-	-	-	-	-	1	2	-	-
CO5	3	3	2	1	-	-	-	-	-	-	-	-	-	2	1	-	-

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**