M.SC.,
INORGANIC CHEMSITRY

MODEL SYLLABUS

AUGUST- 2022

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,
CHENNAI – 600 005

Vision

Reputable teaching – learning and research organization nationally and internationally in the area of chemical sciences with special emphasis on Inorganic chemistry filed. By doling out the competitive trained chemists for assisting the chemical world, industries and stake holders. The mission and vision of the organization help in preparation of strategic plan.

Mission

- To be one of the well recognized Department in the field of Inorganic Chemistry for higher learning in India and the world in terms of producing skilled, employable chemists, researchers, teachers and entrepreneurs
- To provide the state-of-art research facility to carry out pioneering research in the cutting-edge of Inorganic chemistry
- To carry out key projects to solve field base problems
- Endow with student centric learning facilities for the development of overall personality of learner
- To collaborate with national and international reputed institutions/Universities for academic excellence and skill-filled research

Programme Outcomes (POs)

After completion of M.Sc. in Inorganic Chemistry successfully, the student will able to:

1. To endow our students with advanced knowledge and skills in different area of chemistry with special emphasis on the Inorganic chemistry filed.
2. To equip students to meet current industrial needs toward the development of eco-friendly protocols/procedures for chemical process in the industry.
3. To provide sound knowledge and experimental skills to synthesize and analyze the chemicals/advanced materials need for the society.
4. Analyze the inorganic chemistry problems critically to achieve sustainable solutions for energy and environment in the society.
5. Demonstrate the rational scientific approach for the development of advanced and novel inorganic solid materials for various applications, which needed for modern society.
6. To equip students to critically evaluate the practice, theories and rules based empirical evidence through rational scientific approach to achieve knowledge development in Inorganic Chemistry.
7. To create the ability to work effectively with diverse team and facilitate cooperative effort as a member/team leader to achieve deliverable outcome in projects.
8. To create the ability to identify ethical issues related to work and avoid unethical behaviours such as committing plagiarism, not adhering to intellectual property rights and adopt specific objectives and truthful action in all aspect of work.

9. To equip the students with more capable to use computational tools, software's and database relevant to inorganic chemistry field.

10. The effective communication skills both orally and writing using appropriate tools in the all the aspects of inorganic chemistry will be demonstrated.

Programme Specific Outcomes

Upon successful completion of M.Sc. Chemistry programme, the student will be able to

- Demonstrate comprehensive knowledge and problem solving skills, which is paramount importance for the development of new applications of inorganic chemistry
- To congregate the deeper understanding and critical knowledge to build strong foundation in structure, bonding and properties of transition metal complexes, organometallic compounds and p-type elements based inorganic cage molecules
- To motivate the students to prepare competitive examination, benchmark standard in writing, communications, and ethics to disseminate results of studies undertaken in inorganic chemistry
- To emphasize on integrating various disciplines of science and apply disciplinary knowledge in the interdisciplinary areas of chemistry to solve the critical problem in inorganic chemistry with well defined solutions
- Apply appropriate advanced techniques, tools and methodologies to achieve the evidence-based solution for national and international problems related to inorganic chemistry
- To get sound knowledge and transferable skills in cutting-edge-area of inorganic chemistry, which empower the student for employment opportunities in academia and research laboratories

M.Sc. INORGANIC CHEMISTRY Curriculum

(For the students admitted during the academic year 2021-22 onwards)

Semester	Course Code	Title of the Course	Core/ Elective/ Soft skill	Credits
I	CHE C001	Fundamentals of Analytical Chemistry	Core	3
	CHE C101	Coordination and Nuclear Chemistry	Core	3
	CHE C201	Stereochemistry and Organic Reaction Mechanism	Core	3
	CHE C301	Thermodynamics and Chemical Kinetics	Core	3
	CHE C202	Organic Chemistry Practical-I	Core	3
	CHE C302	Physical Chemistry Practical-I	Core	3
	CHE E001	Electronics and Computers for Chemists	Elective	3
	UOSM115	Lab Safety and First Aid	Softskill	2
	UOMS117	Chemistry Databases-SciFinder, Mandeleef, Scopus, Web of Science and Google Scholar	Softskill	2
II	CHE C002	Analytical Instrumentation	Core	3
	CHE C102	Main Group Elements and InorganicPolymers	Core	3
	CHE C203	Organic Reaction Mechanism	Core	3
	CHE C303	Quantum Chemistry and Group Theory	Core	3
	CHE C003	Analytical Chemistry Practical-I	Core	3
	CHE C103	Inorganic Chemsitry Practical-I	Core	3
	CHE E302	Macromolecular Chemistry	Elective	3
	UOMS116	Fire Safety and Firefighting	Softskill	2
	UOMS147	Software packages for Chemists-MATLAB, ORIGIN AND CHEMDRAW	Softskill	2
	UOMI001	Internship	Internship	2
III	CHE C601	Physical Methods in Chemistry	Core	4
	CHE C104	Inorganic Chemistry Practical – II	Core	3
	CHE C105	Inorganic Chemistry Practical – III	Core	3
	CHE E601	Biological Chemistry	Elective	3
	CHE E602	Photochemistry and Nanomaterials	Elective	3
		Elective from Other School	Elective	3
IV	CHE C106	Transition Metal Chemistry	Core	4
	CHE C107	Organometallic Chemistry	Core	4
	CHE C108	Project	Core	6
	CHE E603	Novel Reagents in Organic Synthesis	Elective	3
	CHE E004	Electroanalytical Chemistry	Elective	3
		Total Credits		91

SCHEME OF VALUATION

CORE PAPERS
CREDITS – 3 or 4; MARKS – 100
Marks Distribution:
Internal – 40 Marks
External – 60 Marks

ELECTIVE PAPERS (No Practicals)
CREDITS – 3; MARKS - 100
Marks Distribution:
Internal – 40 Marks
External – 60 Marks

INTERNSHIP
CREDITS – 2; MARKS – 50
Marks Distribution:
Internal – 12 Marks
External – 38 Marks

PROJECT WORK & Viva Voce
CREDITS – 6; MARKS – 100
Marks Distribution:
Project Work & Viva voce (75 Marks)
Thesis (25 Marks)

Semester -1	CHE C101	COORDINATION AND NUCLEAR CHEMISTRY	L	T	P	C
Core/Elective /Supportive	Core		4	0	0	3
Pre-requisite	Students must know about the fundamental terms of coordination chemistry, Werner's theory, Valence Bond Theory, basics of nucleus, nuclear particles and nuclear forces.		Syllabus Version			R-2021

Course Objectives:

The main objectives of this course are to:

- Know about the structure, properties and bonding nature of coordination compounds
- Illustrate the basic concept of theories of coordination complexes
- To impart the basic knowledge on Atomic states, microstates and term symbol
- Understand orgel and Tanabe Sugano diagrams for prediction of absorption band
- Illustrate different types of nuclear models and their features
- Describe nuclear reactions and their energies
- Study the applications of nuclear chemistry in various fields

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Understand and compare different theories involve in the coordination complexes	K1-K2
2	Interpret the electronic and magnetic properties of coordination compounds based on CFT	K2-K4
3	Knowledge on the modern M. O theory and its application in conscious understanding of bonding of metal complexes	K2-K5
4	Calculate nuclear spin, I value of elements	K3-K4
5	Differentiate different nuclear reactions and to determine activity by various techniques	K5-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	STRUCTURAL ASPECTS AND CRYSTAL FIELD THEORY	20 hours

Crystal field theory - crystal field splitting patterns in octahedral, tetrahedral, tetragonal, square planar, geometries – CFSE, Factors affecting CFSE– Interpretation of electronic spectra and magnetic properties – Spectrochemical series – Jahn-Teller effect; Effect of chelation and stability of complexes – Thermodynamic aspects of complex formation –Determination of stability constants by spectrophotometric, polarographic and potentiometric methods – Hard and soft acids and bases

UNIT:2	MOLECULAR ORBITAL THEORY	20 hours

Theoretical failure of the Crystal Field Theory - Nephelauxetic effect - Evidences for the metal-ligand orbital overlap; the ligand field theory; Molecular Orbital - application of group theory to tetra coordinate and hexa coordinate systems - M.O. theory as applied to non-bonding and anti-bonding complexes – Calculation of Dq, B and β parameters. Colour of transition metal complexes, types of

electronic spectra - d-d transition, Charge transfer spectra, selection rule and its relaxation, Term states for d^n ions, energy diagram, - Orgel and Tanabe- Sugano diagrams – Spin-Orbit coupling		
UNIT:3	**NUCLEAR CHEMISTRY**	**20 hours**
Models of nucleus – Modes of radioactive decay: orbital electron capture: nuclear isomerism, internal conversion, Nuclear reaction: Types, reactions, cross section, Q-value, threshold energy, compound nucleus theory, High nuclear reactions, nuclear fission and fusion reactions as energy sources; direction reactions, photonuclear and thermo nuclear reactions, detection and determination of activity by cloud chamber, nuclear emulsion, bubble chamber, G.M counter – Scintillation and Cherenkov counters. Application of radioactivity in the chemistry -Structure determination and mechanism of electron transfer reactions, Determination of solubility of a sparingly soluble salt, medical field, age determination and in agriculture, Neutron activation analysis, isotopic dilution analysis, radiometric titrations, Nuclear reactors, the breeder reactor, nuclear reactors in India		
	Total Lecture hours	**60 hours**

Text Book(s)	
1.	F.A. Cotton & G. Wilkinson - Advanced Inorganic Chemistry, 3rd and 4th Ed., John Wiley
2.	Huheey, J.W. - Inorganic Chemistry, 4th Edition - Harper and Row
3.	J. D. Lee, Concise Inorganic Chemistry, 5th edition, John Wiley
4.	A. K. Das Vol. 1 & 2, Fundamentals of Inorganic Chemistry
5.	Gregory R Choppin; Jan-Olov Liljenzin; Jan Rydberg, Radiochemistry and Nuclear Chemistry, 3rd Edition, 2002, Butterworth-Heinemann
Reference Books	
1.	K.F. Purcell & J.C. Kotz - Inorganic Chemistry, Saunder Company
2.	S.F.A. Kettle - Coordination Compounds
3.	B.N. Figgis - Introduction to Ligand Fields
4.	A.B.P. Lever - Inorganic Electronic Spectroscopy, Elsevier
5.	C.J. Balehausen - Introduction to Ligand Field Theory, McGraw Hill, 1962.
6.	G. Friedlander, G. Herrmann (auth.), Attila Vértes, Sándor Nagy, Zoltán Klencsár, Rezső G. Lovas, Frank Rösch (eds.), HandBook of Nuclear Chemistry, 2011, springers
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	Coordination complexes : http://www.infocobuild.com/education/audio-video-courses/chemistry/CoordinationChemistry-IIT-Kharagpur/lecture-18.html
2.	Nuclear shell model: YouTube Videos: https://nptel.ac.in/courses/115/104/115104043/
3.	GM counters lecture Notes: https://qa.ff.up.pt/rq2020/Bibliografia/etc/geiger1.pdf

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	M	S	M	S	L	M	L	L
CO2	S	S	S	S	S	M	L	M	L	L
CO3	M	M	S	S	M	M	L	S	M	L
CO4	S	S	S	S	S	S	M	S	L	L
CO5	S	S	L	M	M	L	S	L	M	L

*S-Strong; M-Medium; L-Low

Semester-I	**CHE E101**	**INORGANIC REACTION MECHANISM**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Elective**		**3**	**0**	**0**	**3**
Pre-requisite	Students should aware about basic knowledge of formation of metal ligand complexes, bonding and geometries and stabilities. Student should also know the basics of chemical bonding including metal carbon bond formation.		**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this course are to:

- Describe the efforts of inorganic and organometallic chemists to apply old principles and develop new ones in an incredible set of contexts
- Illustrates how ligands influence the stability, structural and reactivity properties of central metal atoms
- Describe various reaction pathways for mechanism of formation of various geometrics of metal ligand complexes
- Give knowledge on the theory of electron transfer process from simple molecules to complex molecules
- Understand various theory on the stability of organometallic compounds and their reactivity with nucleophile and electrophilic compounds

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Know most common and important futures of oxidation of metals complexes and its lability and inertness in the aspect of kinetics and thermodynamic of the coordination complexes	K1-K2
2	Understand the formation of metal complexes bonding and to able to study the various reaction mechanism involved in inorganic complex along with trans influence of ligands	K2-K5
3	Gain more knowledge on the electron transfer/redox reactions in various metal complexes and understand the Marcus-Hush theory, to become familiar with some applications of photochemical reaction of coordination compounds	K3-K5
4	Comprehend the potential new ligands and predict the binding	K2-K4

	affinity to its target	
5	Able to elucidate the different types of application in metal complexes and its reaction mechanism of different metal complex concerned reactions in organometallic chemistry	K3-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	**INERT AND LABILE METAL CHEMISTRY**	**20 hours**

Reactivity of metal complexes – Inert and labile complexes – Explanation of lability on the basis of valence bond and crystal field theories – Metal ion catalysed reactions and reaction mechanism, induced reactions and their characteristics, applications – kinetics and mechanism of induced reaction in metal complexes, – Stabilization of unusual oxidation states in solution – Survey of oxidation states with various electronic configuration of transition metals and inner-transition metals

UNIT:2	**SUBSTITUTION REACTIONS IN COORDINATION COMPLEXES**	**20 hours**

Reaction pathways – mechanisms of substitutions in octahedral complexes – Dissociative (D), Associative (A), and Interchange (I) mechanisms – Aquation (acid hydrolysis) – Acid catalyzed aquation reactions, Anation reactions. Base hydrolysis, CB mechanism in octahedral complexes – Substitution reactions in square planar complexes, trans effect, theories and applications – Isomerisation and racemisation reactions of coordination complexes; Electron transfer reactions or redox reactions – two electron transfer reactions, Inner sphere and outer sphere processes, electron exchange reactions, complementary reactions and non complementary reactions, Marcus-Hush theory and photochemical reactions

UNIT:3	**BASIC CONCEPTS OF ORGANOMETALLIC COMPOUNDS AND REACTION MECHANISM**	**20 hours**

Definition of Electron counting–Types of ligands and their classifications in organometallic compounds, Hapto-nomenclature –16 and 18 electron rule and its limitations – Metal carbonyls – Metal π-cyclic compounds; Oxidative addition, reductive elimination, insertion migration and rearrangement –salient features and evidences, ligand protonation, electrophilic and nucleophilic attack on ligands – C-H activation -ortho metalation and cyclometalation, Fluxional behaviour of metal complexes

Total Lecture hours	**60 hours**

Text Book(s)

1.	Huheey, J.E. - Inorganic Chemistry, 4th Edition, Harper and Row
2.	Basolo, F. and Pearson, R.G. - Mechanism of Inorganic Reactions, Wiley Eastern
3.	Purcell, K.F. and Kotz, J.C. - Inorganic Chemistry, Saunders
4.	D.F. Shriver and P.W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edition, 2010
5.	J. D. Lee, Concise Inorganic Chemistry, Oxford University Press, 5th Edition, 2014
6.	F.A. Cotton and G. Wilkinson Advanced inorganic Chemistry, John Wiley & Sons, 6th Edition, 1999

Reference Books	
1.	Nyholm, R.S. and Tobe M.L., - The stabilisation of oxidation state of the Transition metals, Advances in Inorganic and Radiation Chemistry, Volume 5 (1963)
2.	(a) J. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, University: Science Books, Sausalito, CA, 2010
3.	G. L. Miessler, P. J. Fischer, D. A. Tarr, Inorganic Chemistry, 5th edn, Pearson, Upper Saddle River, NJ, 2014
4.	R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, Vol. 4, John Wiley & Sons, Inc., Hoboken, NJ, 2005
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=ez40OIQrP60
2.	https://www.dalalinstitute.com/wp-content/uploads/Books/A-Textbook-of-Inorganic-Chemistry-Volume-1/ATOICV1-3-1-Inert-and-Labile-Complexes.pdf
3.	https://link.springer.com/chapter/10.1007%2F978-1-4419-9276-5_6
4.	https://www.schoollearningresources.com/PDF/_Lectures%208-10(1).pdf

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	M	S	M	S	L	M	L	M
CO2	S	S	L	S	S	M	L	M	L	L
CO3	S	M	S	M	L	M	L	S	M	L
CO4	S	S	L	S	S	S	M	S	L	S
CO5	S	S	S	M	M	L	S	L	L	L

*S-Strong; M-Medium; L-Low

Semester -II	**CHE C102**	**MAIN GROUP ELEMENTS AND INORGANIC POLYMERS**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Core**		**4**	**0**	**0**	**3**
Pre-requisite	Students should have basic knowledge about unit cell, lattice points, radius ratio, basic solid structures and polymers		**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this course are to:

- Provide introduction and overview of fundamental properties of solids
- Illustrate the importance of having defects in solids
- To interpret electrical, optical and magnetic properties of ionic solids
- Describe band theory and free electron theories
- Explain semiconductors, superconductor and magnetic properties of various compounds
- Explain different types, synthesis, structural features and applications of

silicates, silicones, isopoly and heteropoly acids of transition metals

- Make students to acquire the methods of preparation, nature of bonding, properties, applications of sulphur nitrogen and phospohorus nitrogen compounds
- Explain preparation, properties, reactivity and application of various borane compounds

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Learn different equations related to lattice energy calculation and analyze the structures adopted by different ionic crystals. Students are expected to explain the unique properties of solids due to various types of defects	K1-K4
2	Analyze physical properties such as electrical, magnetic and optical aspects of solids and properties of superconductors and semiconductors	K4-K6
3	Compare the trends in the synthesis and properties of main group elements and discuss the chemistry of Si, S, N and P based inorganic polymers	K2-K5
4	Understand the chemistry and applications of boranes, carboranes and metalloboranes	K2-K3
5	Elucidate various methods of synthesis, properties and applications of polymetallate anions, isopoly and heteropoly acids of transition metal ions	K3-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

UNIT:1	**STRUCTURE OF SOLIDS**	**20 hours**

Basics of structure of ionic solids – Dissolution of Ionic Solids – Derivation of Born-Lande and Born-Mayer equations-Kapustinski's modification - entropy of solution and its significance, lattice energy – Structure of rutile, fluorite antifluorite, zinc blende, wurttzite, cadmium iodide and nickel arsenide, spinels and inverse spinels - defects in solids, non-stoichiometric compounds.

Electrical, magnetic and optical properties of solids – free electrons and band theory – semiconductors – superconductors – Ionic conductivity in solids - Solid electrolytes - types of magnetic behaviour, dia, para, ferro, antiferro and ferrimagnetism; Hysterisis – solid state lasers – inorganic phosphors – ferrites – garnets

UNIT:2	**Si, S, N AND P BASED INORGANIC POLYMERS**	**20 hours**

Chemistry of silicon – classification and structure of silicates and silicones – Synthesis, structure, reactivity and application of polysilanes – Preparation, structure, properties, reactivity and applications of sulphur nitrogen compounds- Phosphorus nitrogen compounds

UNIT:3	**HIGHER BORANES AND POLYOXOMETALATES**	**20 hours**

Chemistry of boron and its isotopes, neutron Capture Therapy – Preparation and structure of borane and higher boranes – STYX numbers – Wade's and Wade's - Mingo's rule – Preparation, structure, properties and reactivity of carboranes, metalloborane and metallocarboranes – Isopoly acids of Vanadium, Chromium, Molybdenum and Tungsten – Heteropoly acids

	Total Lecture hours	60 hours

Text Book(s)	
1.	Cotton, F.A. and Wilkinson, L - Advanced Inorganic Chemistry 3rd and 4th Edition, John Wiley
2.	Earnshaw and Greenwood - Chemistry of Elements
3.	Huheey, J.E., - Inorganic Chemistry, 2nd Edition, Harper and Row, 1976
4.	Concise Inorganic Chemistry, J.D.Lee
5.	Solid State Chemistry and applications- A.R. West (John Wiley and Sons)
6.	Principles of the Solid State- H.V. Keer (Wiley Eastern Limited)
Reference Books	
1.	Hanney, N.D. - Solid State Chemistry, Prentice Hall, 1967
2.	Greenwood, N.N. - Ionic Crystals, Lattice Defects and Non-Stoichiometry, Butterworths, 1968
3.	A.F. Wells - Structural Inorganic Chemistry
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://nptel.ac.in/courses/104/104/104104101/
2.	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy16/
3.	https://www.britannica.com/science/fluorocarbon-polymer
4.	http://homes.nano.aau.dk/fp/uke/pdf/chapter12.pdf
5.	https://www.dalalinstitute.com/books/a-textbook-of-inorganic-chemistry-volume-1/isopoly-and-heteropoly-acids-and-salts-of-mo-and-w-structures-of-isopoly-and-heteropoly-anions/
6.	https://www.britannica.com/science/coordination-compound/Isopoly-and-heteropoly-anions

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	S	M	M	M	M
CO2	S	S	S	S	M	M	S	M	L	L
CO3	M	M	S	M	S	M	L	L	M	S
CO4	S	S	S	S	S	S	M	S	L	L
CO5	M	S	L	L	M	L	S	L	M	M

*S-Strong; M-Medium; L-Low

Semester -II	**CHE C103**	**INORGANIC CHEMISTRY PRACTICAL - I**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Core**		**0**	**0**	**6**	**3**
Pre-requisite	Basic knowledge on inorganic salts and metal chelated complexes		**Syllabus Version**			**R-2021**
Course Objectives:						

The main objectives of this practical course is able to:

- Identify individual two common and rare cations, respectively, present in the given mixture of inorganic salts and reactions behind it through semi micro qualitative analysis
- Develop the skill for systematic qualitative analysis with strong theoretical backround
- To develop the skill for the estimation of various metal cations from the mixtures through complexometric titrations

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	The students will develop the key technical skill related to the quantitative determination of various metal ions through complexometric titrations	K3-K4
2	Learn the lab discipline and maintain high standards of professional and scientific ethics in the laboratory	K1-K3
3	Learn quick identification of nature of any unknown metal ions	K1-K4
4	Develop the skill to prepare various unknown solutions and reagents for their respective experiments	K2-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

	(A) QUANTITATIVE ANALYSIS	**30 hours**

Complexometric titrations using EDTA - Estimation of zn, Ca, Ni, Mg and Hardness and softness of water

	(B) QUALITATIVE ANALYSIS	**30 hours**

Semimicro qualitative analysis of mixtures containing two common and rare cations.

The following are the rare cations are included:
Tl, Mo, W, Se, Te, Ce, Th, Ti, Zr, V, Be, U and Li.

Note: Examination to be conducted for six hours and to consist of Part-I Semi-micro qualitative analysis of one mixture containing three rare cations along with one common cations.

	Total Lecture hours	**60 hours**

Text Book(s)

1.	Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, Arthur Israel Vogel, Arthur Israel Vogel, G. Svehla, 1979.
2.	V.V. Ramanugam, Inorganic semimicro qualitative analysis, 3rd edition, National Publishing company, 1974.
3.	A Text Book of Quantitative Inorganic Analysis- A.I. Vogel 6thedition Longman
4.	Concise Inorganic Chemistry, J.D.Lee
5.	Inorganic Synthesis- R.A. Rowe and M.M. Jones (1957)5, 113 – 116.

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	S	M	L	L	L	M	L	L
CO2	L	L	L	M	L	L	M	S	S	S
CO3	M	M	S	M	S	M	L	L	M	S
CO4	S	M	S	L	L	L	S	L	M	L

*S-Strong; M-Medium; L-Low

Semester -II	UOMS 147	SOFTWARE PACKAGE FOR CHEMISTS - MATLAB, ORIGIN and CHEMDRAW	L	T	P	C
Core/Elective /Supportive	SOFTSKILS		2	0	0	2
Pre-requisite	Basic knowledge on spread sheets, simple matrix formation, programming and chemical structures		Syllabus Version			R-2021

Course Objectives:

The main objectives of this practical course is able to:

- Understand the basic principles of MATLAB, programming and plotting
- Illustrates various plotting functions and formulate the graphs with various fitting analysis
- Draw the simple chemical structure to complex structure and mechanism of various chemical reactions

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Equip the students with deep knowledge on the matrix programming for various chemical process and convert respective data functions into plots	K1-K3
2	Learn various mathematical functions for various plot functions including 3D plots and gain knowledge on the peak fitting, which is applicable for data analysis	K3-K6
3	Develop the skill to draw various chemical compounds, which is applicable for their projects and research fields	K3-K5

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

UNIT:1	MATLAB	15 hours

Basic concepts of MATLAB – Important functions – Addition, multiplication and subtraction of 2x2, 3x3 and 5x5 matrix – Programming in MATLAB – Plot functions and programming – 2-D plots (two vectors) and 3-D plots with three vectors – Additional 2D plots

UNIT:2	ORIGIN	15 hours

Spread sheets – Basic of origin – various mathematical functions for plotting, statistical calculations – Drawing of various plots and its functions – Background correction for various plots – Plot fitting, linear, exponential, Gaussian and LorenTzian with multiple peak fitting – Bar chats- 3D plotting – error bars in plotting

UNIT:3	CHEDRAW	15 hours

Basic concepts of chemdraw – Functions – various arrows used in the chemical equations – concept of drawing of chemical equations – Concepts of valance of atoms in a molecules– Drawing of simple molecules, macro molecules, inorganic complex, organometallic complex, peptides and dendrimers – drawing of catalytic cycles and organic reaction mechanism

	Total Lecture hours	45 hours

Text Book(s)

1.	Amos Gilat, MATLAB: An Introduction with Applications, 4ed , 2012
2.	S.N. Alam, S.S. Alam, Understanding Matlab: A Textbook for Beginners, 2019, Dreamtech Press

3.	Jake Woods, Chemdraw Professional (Tutorial User Guide) Kindle Edition, 2019.
4.	https://www.originlab.com/doc/Tutorials

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	L	S	M	L	L	L	M	L	L
CO2	L	L	L	M	L	L	M	S	S	L
CO3	L	M	L	L	M	M	L	L	S	L

*S-Strong; M-Medium; L-Low

Semester -II	**UOM I001**	**INTERNSHIP**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**INTERNSHIP**		**2**	**0**	**0**	**2**
Pre-requisite	Basic practical skill gained from two semesters		**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this practical course is able to:

- Provide the industrial visit and learn the possible instrumental techniques, which will be useful for their projects and research
- Learn the basic analysis of the simple compounds to develop their analytical skills

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Be trained simple analytical testing for compound of interest	K4
2	Develop the basic understanding of the various instrumental methods	K2

3	Gain the infrastructure of the industries and institutes/Universities in the across the country, which help them to prosper their life in future	K6
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		
	INTERNSHIP	**45 hours**
Students can opt for training program in an appropriate industry/ corporate / Government or public sector / reputed universities/research institutes across the country for a minimum of three months. Prior registration is mandatory for internship through student adviser / programme coordinator with the permission from the consent organization where students will undergo the internship is required and the same shall be evaluated for grading		
	Total Lecture hours	**45 hours**

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	S	M	M	L	L	L	M	L	L
CO2	L	S	L	M	L	L	M	S	S	L
CO3	L	S	L	L	M	M	L	L	S	L

*S-Strong; M-Medium; L-Low

Semester -III	**CHE C101**	**PHYSICAL METHODS IN CHEMISTRY**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Core**		**4**	**0**	**0**	**4**
Pre-requisite	Students should know about the fundamental aspects on spectroscopy and their importance in the characterization of chemical compounds. Basic knowledge on UV-Vis, IR, NMR and Mass spectroscopic techniques will be advantageous.		**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this course are to:

- To provide the deep understanding of electronic structural changes of metal coordination complexes upon interaction with visible light
- To understand basic theory and instrumentation involved in the origin of spectroscopy
- Understand UV, IR, NMR and Mass spectra and their significance in the characterization of organic compounds
- Illustrate the basic principle of splitting of spectral line of inorganic complexes in the presence of magnetic field upon interaction with electromagnetic radiation
- To understand role of spectroscopy (UV, IR, NMR & Mass spectroscopy) to determine the structure of organic compounds

- To learn ESR and their importance in the characterization of radicals
- To understand basic theory & instrumentation involved with analytical techniques for characterization and imaging

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Interpretation of various absorption band in the visible, IR and microwave region to understand the structural bonding, geometry and reactivity of inorganic coordination complexes	K1-K4
2	To understand the basic concept, interpretation and application of electronic spectra of hydrogen and many electron atoms also to derive angular momentum of many electron atoms and term symbols of atoms	K2-K4
3	Knowledge of crystal, vibrational, thermal, ATR and imaging modes to characterize chemical compounds	K3-K4
4	Understand basic theory as well as instrumentation techniques for recording UV, IR, NMR, ESR, MS, XRD, Raman, Mossbauer and Thermal spectra of chemical compounds	K2-K5
5	Interpretation of UV, IR, NMR, TGA, DSC, XRD, Raman, Mossbauer, ESR and MS spectra of compounds to understand their structural characteristics	K2-K6

K1-Remember; K2-Understand; K3-Apply; K4-Analyze; K5-Evaluate; K6-Create

UNIT:1	**ELECTRONIC SPECTROSCOPY (PHYSICAL & INORGANIC CHEMISTRY)**	**18 hours**

Spectra of hydrogen and many electron atoms, angular momentum of many electron atoms, term symbols, spectra of many electron atoms- Zeeman effect. Spectra of diatomic molecules, Representation of electronic states through potential energy diagrams-Frank Condon principle.

Intensities of electronic transitions- theoretical treatment of absorption intensities, transition dipole moment integral, oscillator strength, selection rules parity, spin and symmetry considerations, Factors inducing forbidden transitions vibronic and spin orbit coupling, polarization bands.

Spectra of formaldehyde, butadiene and benzene –group theoretical discussion.

Electronic spectra of inorganic complexes – Selection rules (Laporte, orbital and spin selection rules), band intensities, band widths, spectra in solids, spectra of aqueous solutions of d^1-d^9 ions in O_h and T_d environments

UNIT:2	**MOSSBAUER & RAMAN SPECTROSCOPY, X-RAY AND THERMAL METHODS OF ANALYSES (ANALYTICAL CHEMISTRY)**	**18 hours**

Mossbauer spectroscopy: Introduction, principle, instrumentation, recoil energy, Doppler effect, number of MB signals, isomer shift, quadrupole splitting, magnetic hyperfine splitting applications to ^{57}Fe, ^{119}Sn and ^{129}I compounds

Raman Spectroscopy: SERS, SERRS. ATR techniques – UV, IR, Raman. Principle & application of ORD and CD in the identification of complexes. 3D, 4D & 5D NMR imaging techniques; X-ray diffraction – Bragg equation, space groups and point groups, diffraction methods. Thermal methods of analysis – TGA, DTA and DSC – Principle and applications

UNIT:3	**NUCLEAR MAGNETIC RESONANCE (ORGANIC CHEMISTRY)**	**18 hours**

Origin of NMR spectrum-Nuclear spin states – NMR active nuclei – Nuclear magnetic moment–Larmor equation – Absorption of energy and Resonance – Population density of nuclear spin states. Saturation phenomena – Relaxation mechanisms, Bloch equation (only significance and derivation not required). Comparison of CW and FT instrument–Chemical shift - Standards in NMR – Shielding and De-shielding – Factors affecting chemical shift – electronegativity, hybridization, hydrogen bonding - anisotropic effect – double, triple bond, aromatic compounds and carbonyl compounds. Spin-spin coupling – splitting origin and rules – factors affecting coupling constant: cis, trans, gem, ortho, meta, para coupling – exchange with deuterium. Vicinity of the proton, Long range coupling, Karplus equation and curve. ^{1}J, ^{2}J, ^{3}J, ^{4}J and ^{5}J coupling in NMR, order of NMR spectrum. Spin systems: Two interacting nuclei: A2, AB, AX, AA'BB', dd, pair of doublet, AB quartet. Three interacting nuclei: AMX, ABX, ABC systems (only pattern is required). Simplification of complex NMR spectra-Lanthanide shift reagents, CIDNP and NOE. Basic principles and applications of VT NMR & MRI.

^{13}C NMR – difficulties in recording ^{13}C NMR: Homo nuclear and heteronuclear coupling. Decoupling technique: SFORD and Off Resonance decoupled spectrum identification of various types of carbon using ^{13}C NMR. APT & DEPT spectra (DEPT-45, DEPT-90 and DEPT-135). ^{19}F NMR Precessional frequency and heteronuclear coupling. Identification of organofluoro compounds (CF3CO2Et and CF3CH2OH) using NMR. ^{31}P NMR – Chemical shift and heteronuclear coupling. Identification of organophosphorus compounds such as (CH3)3P, (C2H5O)2P=O and Ph3P. P-P bond in NMR. Basic principles of 2D NMR (COSY, NOSEY, HSQC & HMBC)

Unit:4	**UV, IR, MS (ORGANIC CHEMSITRY) & ESR (INORGANIC CHEMSITRY)**	**18 hours**

Electronic absorption-Beer-Lamberts law, Types of electronic excitation. Chromophore and Auxochrome-Bathochromic and Hypsochromic shifts. UV-vis spectra of simple organic compounds such as alkenes, phenols, anilines, carbonyl compounds and 1,3-diketones. Woodward and Fieser rule for calculation of λ-max values of dienes and unsaturated ketones.

Infrared Spectra: Identification of functional groups in Organic Compounds, Finger print region. Inter and Intramolecular hydrogen bonding

Origin, basics and bloc diagram of Mass spectrum-Various types of Ionization techniques-Stability of Molecular ions, Meta stable ions. Base peaks and Isotope peaks. Fragmentation patterns of organic molecules such as benzenes, phenyl halides, phenols, benzyl alcohols, benzyl halides, aliphatic alcohols, aliphatic as well as aromatic aldehydes, ketones, acids, esters and amides. Fragmentation patterns of aliphatic/aromatic nitro and amine compounds. Fragmentation patterns of heterocyclic compounds (furan, pyrrole and pyridine only). McLafferty rearrangements of organic molecules.

Structural determination of Organic Compounds using UV, IR, NMR and Mass Spectra.

ESR Spectra of d^1-d^9 Transition Metal Complexes with examples. Interpretation of g in cubic, axial and rhombohedral geometries. Calculation of g values with simple examples. Intensities of '$g_{\parallel}$ and $g_{\perp}$ peaks. Evidence for Metal-Ligand Bond Covalency-Cu(II)- Bis –Salicylaldimine, Bis-Salilcylaldoximato copper(II)$[(NH_3)_5CoO_2CoNH_3)_5]^{5+}$,Cu(II)-diethyldithiophosphinate, Vanadyldithiophsphinate, Copper(II) tetraphenylporphyrin, Co(II)- phthalocyanine, $K_2[IrCl_6]$. Interpretation of 'g' and 'A' values from esr spectral data in- i) MnF_6^{4-}, ii)

CoF_6^{4-}, and CrF_6^{3-}.		
	Total Lecture hours	**72 hours**
Text Book(s)		
1.	Chang, R (1971); Basic Principles of Spectroscopy, McGraw Hill, ISBN-13:978-007010517	
2.	Banwell, C. N.; McCash, E. M (1994); Fundamentals of Molecular Spectroscopy, IVth Ed, McGraw Hill, ISBN 0-07-707976-0	
3.	Kemp, W. (2016); Organic Spectroscopy, 3rd Ed, Palgrave	
4.	Kalsi, P. S (2016); Spectroscopy of Organic Compounds, 7th Ed, New Age International	
5.	Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Ed, Wiley	
6.	Jag Mohan (2016); Organic Spectroscopy Principles & Applications, 3rd Ed, Narosa Publishing House	
Reference Books		
1.	Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4	
2.	Russell S. Drago, R. S (2016), Physical Methods for Chemists, II Ed	
3.	Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K (2006); Inorganic Chemistry: Principles of Structure and Reactivity, IVth Ed, Pearson Education	
4.	Skoog, D. A; Holler, F.; Crouch, S (2017); Principles of Instrumental Analysis, 7th Ed, Brooks/Cole publisher	
5.	Ebsworth, E. A. V.; Rankin, D. W. H.; Craddock, S (1986); Structural Methods in Inorganic Chemistry, Wiley-Blackwell, ISBN-13: 978-0632015924	
6.	Willard, H. H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F. A. Jr. (2004); Instrumental methods of analysis CBS Publishers & Distributors; 7th Ed, ISBN 13: 9780534081423	
7.	Macomber, R. S (1998); A complete introduction to Modern NMR Spectroscopy, John Wiley, ISBN: 0-471-15736-8	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1.	https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod2.pdf	
2.	https://www2.chemistry.msu.edu/courses/cem351/FS16_HUANG/Lecture_Presentation/Ch_10_Lecture_Presentation.pdf	
3.	https://www.slideshare.net/siraj174/sir-aj-nmr-spectroscopy-lecture	
4.	http://web.iyte.edu.tr/~serifeyalcin/lectures/chem305/cn_1.pdf	
5.	https://www.youtube.com/watch?v=qtpVfccYEHE&t=98s	
6.	http://www.digimat.in/nptel/courses/video/104106122/L54.html	
7.	https://pubs.rsc.org/en/content/articlelanding/2018/cs/c6cs00565a	
8.	https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Magnetic_Resonance_Spectroscopies/Electron_Paramagnetic_Resonance/EPR%3A_Application	

Mapping with Programme Outcomes*										
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	L	S	S	M	M	L	L	L	L
CO2	S	M	S	M	L	S	L	M	M	L
CO3	S	M	L	M	S	M	L	L	M	L
CO4	L	S	M	S	M	L	M	M	S	L
CO5	L	M	S	M	L	M	S	L	M	L

*S-Strong; M-Medium; L-Low

Semester-III	**CHE C104**	**INORGANIC CHEMISTRY PRACTICAL – II**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Core**		**0**	**0**	**6**	**3**
Pre-requisite	Basic knowledge on volumetric and complexometric titrations and gravimetric analysis.		**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this practical course is able to:

- Learn theory behind the solubility and extraction of various ores and alloys
- Design experimental procedure on ores and alloys
- Interpret the results and demonstrates the skill of chemical analysis of different ores and alloys compounds

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Develop the skills for gravimetric and volumetric analysis of ores and alloys	K3-K4
2	Acquire the skills to present the experimental datas and determine the percentage purity of various metal and compounds in the ores and alloys	K1-K3
3	Learn various separation and analytical techniques for the separation and estimation of metal and compounds	K2-K4
4	An imparting knowledge on quantitative inorganic analysis of ores, alloys helps to design the analysis of various compound mixtures in industries	K5-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

	(A) ANALYSIS OF ORES	**30 hours**

Composition and analysis of Dolomite, Bauxite, Ilminite, galena, pyrites, and pyrolusite for their major constituents using one of the standard methods of analysis and determination of purity of corresponding metal or metal oxides

	(B) ANALYSIS OF ALLOYS	**30 hours**

Composition, Properties, uses and analysis of : Brass, Bronze Solder, Stainless Steel and Silver coin for their major constituents using one of the standard methods of analysis determination of purity of corresponding metals.

	Total Lecture hours	60 hours
Text Book(s)		
1.	Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, G. Svehla, Vogel's qualitative Inorganic analysis, VI Edition, Orient Longman, 1987.	
2.	V.V. Ramanugam, Inorganic semimicro qualitative analysis, 3rd edition, National Publishing company, 1974.	
3.	J. Basset, R.C. Denney, G.H. Jeffery and J.Mendham Vogel's Text book of quantitative inorganic analysis, IV Edition, ELBS, 1985.	
4.	D.N. Grindley, An advanced course in practical Inorganic Chemistry, Butterworths, 1964.	
5.	W.G. Palmer, Experimental Inorganic Chemistry, Van Nostrand Reinhold Co.,London, 1972.	

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	L	L	M	L	M	L	L
CO2	S	M	L	M	L	S	M	S	S	M
CO3	M	M	S	M	S	M	L	L	M	S
CO4	S	S	S	L	M	L	S	L	M	L

*S-Strong; M-Medium; L-Low

Semester-III	**CHE C105**	**INORGANIC CHEMISTRY PRACTICAL - III**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Core**		**0**	**0**	**6**	**3**
Pre-requisite	Knowledge on bonding and theory coordination complexes and principles of various instrumentation techniques		**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this practical course is able to:

- Motivate the students to understand the basic principles and synthetic skill for the preparation of various metal ligand coordination complexes
- Gain familiarity with a variety of instrumental techniques to understand the bonding and geometry of metal complexes
- Provide the basic knowledge for the interpretation of required instrumental datas to understand the structure and bonding of metal complexes
- Develop the ability of scientific communications through oral quizzes, written reports and presentations.
- Learn the technical skill for the crystallization of metal coordination complexes

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:		
1	Students will gain experience in some scientific methods employed in basic and applied inorganic chemistry	K1-K3
2	The skills in writing neat experimental procedures and instrumental methods applied in analytical and practical task of inorganic chemistry will be developed	K3-K6
3	Gaining experience in various synthetic methods for the metal coordination complexes will enable the student to design the advanced materials need for the society	K2-K4
4	Students will learn the key instrumental techniques would greatly assist them to solve the complex problem in their research filed	K5-K6
5	The laboratory skills and interdependent working culture during the practical session will enable the students to work in diverse team to achieve deliverable outcome in a assigned research/project	K3-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

	INORGANIC CHEMISTRY PRACTICAL III	**60 hours**

1. Chromatographic techniques; paper, thin layer and ion exchange chromatographic methods for the separation and estimation of inorganic compounds.
2. Study of Complex compounds:

A. Synthesis and analysis of complex compounds and use of spectroscopic techniques (IR, NMR, ESR, MS, UV) for characterization of complex

1. Sodium hexanitrocobalt (III)
2. Tris (ethylenediamine) cobalt (III) chloride
3. Chloropentammine cobalt (III) chloride
4. Bis (acetylacetanato) copper (II)
5. Hexamminecobalt (III) chloride
6. Hexamminenickel (II) chloride
7. Bisthiocyanato (S) pyridine Mn (II)
8. Bisthiocyanato (S) pyridine Cu (II)
9. Bis(ethylenediamine) Cu(II) chloride
10. Tris(ethylenediamine) Ni(II) chloride

B. Determination of composition and formation constants by absorption. pH - metric andpolarographic techniques, magnetic susceptibility measurement

	Total Lecture hours	**60 hours**

Text Book(s)

1.	Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, G. Svehla, Vogel’s qualitative Inorganic analysis, VI Edition, Orient Longman, 1987.
2.	Chemistry Experiments for Instrumental Methods:- D.T. Sawyer, W.R. Heinemanand J.M. Beebe.
3.	J. Basset, R.C. Denney, G.H. Jeffery and J.Mendham Vogel’s Text book of quantitative inorganic analysis, IV Edition, ELBS, 1985.
4.	D.N. Grindley, An advanced course in practical Inorganic Chemistry, Butterworths, 1964.
5.	W.G. Palmer, Experimental Inorganic Chemistry, Van Nostrand Reinhold

	Co.,London, 1972.

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	s	M	M	M	M	S	S
CO2	S	M	S	M	L	S	M	S	S	M
CO3	M	M	M	M	S	M	L	L	M	S
CO4	S	S	S	L	M	L	S	L	M	L
CO5	S	M	S	M	L	S	M	S	S	M

*S-Strong; M-Medium; L-Low

Semester -1	**CHE E601**	**BIOLOGICAL CHEMISTRY**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Elective**		**4**	**0**	**0**	**3**
Pre-requisite	Student able to understand the role of bio-organic compounds. Students should know about the fundamental aspects on biological system, mechanism, kinetics and analytical tools.		**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this course are to:

- To understand the function of carbohydrate in biological chemistry, determination of ring size and study of starch and cellulose
- To understand the significances of amino acids, proteins nucleic acids in biological system.
- Illustrate the importance of the various elements in the biological system and to gain more insights into the binding of metal complexes with biomacromolecules and transport and storage mechanism involving in the metalloenzymes.
- To understand the role of heavy metals in the human body- therapeutic and toxicity levels.

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	To learn about structural and functions of carbohydrates, lipids, membranes, amino acids, proteins, antibiotics and vitamins	K1-K5
2	Understand structure and biological importance of RNA and DNA	K2-K4
3	Understand the key function of metal ions such as Fe, Co, Ni, Zn and Cu in living system, particularly in transports (energy and O_2), storage, electron- and proton transfer, hydrolysis, etc. which are taking place at the active site of metalloproteins and enzymes	K1-K4
4	Toxicity of metals and their effects in the biological system	K1-K4
5	To evaluate toxicity of drugs used in cancer and radiodiagnosis	K5-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	BIO-ORGANIC CHEMISTRY	15 hours

Carbohydrates: Pyranose and furanose forms of aldo-hexose and ketohexose-methods used for the determination of ring size-conformation of aldo-hexopyranose-structure and synthesis of lactose and sucrose. A brief study of starch and cellulose.

Lipids and Membranes: Molecular structure of lipids. Fatty Acids, Triglycerides. Types of membrane lipids

Amino acids and Proteins: Amino acids and Protein structure, Analysis of N-terminal and C-terminals in a polypeptide. Sanger method, Edman degradation and Enzymatic analysis. Primary, secondary and tertiary structure of proteins. Structure of collagen, myoglobin and haemoglobin.

Nucleic acids: Chemistry of nucleic acids, nucleosides and nucleotides – Structure RNA and DNA and their biological importance.

Biomolecules: Antibiotics and vitamins: A detailed study of structure, and stereochemistry of penicillin, cephalosporin. Chemistry and physiological action of ascorbic acid, thiamin, riboflavin and pyridoxine – Elementary aspect of vitamin A, E, K and B12

UNIT:2	BIO-INORGANIC CHEMISTRY	15 hours

Essential and trace metal ions: Enzymes - Nomenclature and classification – Coenzymes - Vitamin B12, Carboxypeptidase and Superoxide dismutase – Heme-enzyme - Peroxidase and catalases. Oxygen carriers: Hemeproteins - Hemoglobin, myoglobin - Structure Oxygenation and stereochemistry - Bohr effect. Non-heme oxygen carriers - Hemerythrin and hemocyanin. Nitrogen fixation: Introduction, types of nitrogen fixing microorganisms. Nitrogenase enzyme - Metal clusters in nitrogenase - redox property - Dinitrogen complexes - transition metal complexes of dinitrogen - nitrogen fixation via nitride formation and reduction of dinitrogen to ammonia. Biological redox systems: Cytochromes -Classification, cytochrome a, b and c. Cytochrome P- 450. Transport of electrons: Iron-Sulphur Proteins: Rubredoxins and Ferredoxins, Structural and Spectral features of Iron-Sulphur Proteins. Photosynthesis and chlorophyll's

UNIT:3	BIO-PHYSICAL CHEMISTRY	15 hours

Thermodynamics and biology-Basic concepts of structure and functionality-membranes-structure, function transport properties, aspects of electrochemical phenomena – active transport, ionophores, biological energy storage systems – stepwise mechanism of photosynthesis versus potential. Enzymes - Nomenclature and classification, chemical kinetics, the free energy of activation and the effects of catalysts, kinetics of enzyme catalyzed reactions – Michaelis - Menten equation - Effect of pH, temperature on enzyme reactions, Factors contributing to the catalytic efficiency of enzymes. Membranes - Phase Equilibria, Donnan effect, Donnan Potential, Phase transition in Lipid bilayers, Free energy determination for ATP hydrolysis from sodium-potassium pump, Allosteric effects – Monod-Wyman-Changeux Theory, Assigning of Statistical weights for Helix-Coil transition in proteins, Study by spectroscopic methods

UNIT:4	BIO-ANALYTICAL CHEMISTRY	15 hours

Essentials of trace elements and chemical toxicology: Trace elements in biological system. Metal ion toxicity - classes of toxic metal compounds– detoxification. Metals in medicine: Anti-arthritis drugs – Au and Cu in rheumatoid arthritis – Li in psychiatry – Pt, Au and metallocenes in anti-cancer drugs- metals in radio diagnosis, radio therapy and magnetic resonance imaging. Transport and storage

of metals: Mechanism – Fe, Cu, Zn and V storage and transport – metallothioeins. Molecular mechanism of iron transport across the membrane – sodium and potassium ion pumps. Pollution studies – Effluent and water treatment		
	Total Lecture hours	**60 hours**
Text Book(s)		
1.	Zubay, G, L. (1997); Biochemistry, 4th edition, Brown (William C.) Co	
2.	Nelson, D, L Lehninger, A, L Cox M, M. (2008); Principles of Biochemistry, 5th Edition, New York: W.H. Freeman	
3.	John McMurray, (2008); Organic Chemistry, 8th edition, Brooks/Cole	
4.	Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Ed, Pearson	
5.	Williams D. R. (1976); Introduction to Bioinorganic Chemistry, Thomas, ISBN-13 : 978-0398034221	
Reference Books		
1.	Kaim, W, Schwederski, B, Klein, A. (2013); Bioinorganic chemistry: Inorganic Elements in the chemistry of life, 2nd edition, Wiley	
2.	Das Asim K. (2007); Bioinorganic Chemistry, 1st edition, Books and Allied (P) Limited	
3.	Mugherjee G. N, Arabinda D, (1993); Elements of Bioinorganic Chemistry, 4th Edition, U. N. Dhur & Sons Pvt. Ltd	
4.	Satake M. Mido Y. (1996); Bioinorganic Chemistry, ISBN 81-7141-301-1, Discovery Publishing House, New Delhi	
5.	Eichorn, G, (1973); Inorganic Bio-Chemistry Vol. I and II, IV Ed, Elsevier	
6.	Zhimin, T, (2008); Analysis of Cytotoxicity of Anticancer Drugs, VDM Verlag Dr. Mueller E.K.ISBN: 9783639063486, 3639063481	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1.	https://www.youtube.com/watch?v=iuW3nk5EADg	
2.	https://www.youtube.com/watch?v=aeC7M9PDjQw	
3.	https://www.youtube.com/watch?v=DhwAp6yQHQI	
4.	https://www.youtube.com/watch?v=ZqoX2W1N6l0	
5.	https://www.youtube.com/watch?v=lsNalwRnaq0&list=PLbMVogVj5nJSHhL_cMKfzLv556ddrIT90	
6.	https://www.youtube.com/watch?v=pXztk04J7u0&list=PLFW6lRTa1g83-gUOcT3ay875UG3a9Mu11	
Course Designed By:		

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	M	L	M	M	M	M	M	L	M
CO2	L	M	L	S	L	M	L	M	M	M
CO3	L	L	M	S	L	L	M	L	L	M
CO4	L	L	L	M	L	M	L	M	L	L
CO5	M	L	M	M	L	L	M	L	L	S

*S-Strong; M-Medium; L-Low

Semester -III	CHE E602	PHOTOCHEMISTRY AND NANOMATERIALS	L	T	P	C
Core/Elective/Supportive	Elective		4	0	0	3
Pre-requisite	Students are expected to have basic idea about photochemistry, various reactive intermediates generated during chemical reactions and organometallic complexes. They should know about the basic quantum chemistry to understand preliminary idea of Nanomaterials and its property		Syllabus Version			R-2021

Course Objectives:

The main objectives of this course are to:

- To recall and understand the fundamental concepts of photochemistry and principles of fluorescence spectroscopy for investigating photophysical phenomena.
- Illustrate different photochemical reactions of coordination and organometallic complexes
- Knowledge on the faster reaction kinetics studies.
- To know various techniques employed for the capturing of reactive transient species in a reaction
- Basic understanding of size dependent properties in nanoscale materials
- Describe about nano systems, their properties, synthetic methods, structure and applications
- To make them learn different analytical techniques of microscopy to characterize nano materials

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Distinguish different photochemical processes such as fluorescence, phosphorescence, non-radiative decay etc.	K2-K3
2	Understand the effect of environments like solvents, neighbouring molecules on photochemical decay processes of molecules	K1-K2
3	Quantify the parameter of decay kinetics after photo-excitation	K3-K4
4	Compare photolytic techniques induced by light and ionizing radiation	K3-K5
5	Elucidate various methods of synthesis, properties and applications of nano materials	K5-K6
6	To illustrates the basic components of an artificial photosynthetic system assembled in different ways	K3-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	PHOTOPHYSICAL PHENOMENA	20 hours

Fundamentals of photochemistry – photochemical laws – emission of radiations – types of photophysical pathways – delayed fluorescence – basic instrumentation of steady-state and time-resolved fluorometer – fluorescence emission, solvent and environmental effects, red-edge effects, effects of intermolecular photophysical processes on emission – static and dynamic quenching, Stern-Volmer kinetics – emission anisotropy – electron transfer probes – energy transfer in multiple

acceptors		
UNIT:2	**PHOTOCHEMISTRY OF INORGANIC COMPLEXES**	**20 hours**
Inorganic photochemistry – photoredox and isomerization process – Photo substitution reactions– photosensitization reactions – photochemistry in energy conversion, application of metal complexes in solar energy conversion; organometallic photochemistry –photochemical reactions in metal carbonyls; Photochemical techniques – flash photolysis – lasers in photochemistry; radiation chemistry – primary processes – track effects – dosimetry – pulse radiolysis		
UNIT:3	**NANOSCALE MATERIALS**	**20 hours**
Definition of a nano system - classification of nanoscale materials - dimensionality and size dependent phenomena – Quantum effect – Nanoscale effects in size dependent variation in mechanical, physical and chemical, magnetic, electronic transport, reactivity – Methods of preparation. Top to down and Bottom up approach – Mechanical, Physical and Chemical methods; Structural characterization; different types of electronic spectroscopy – Elemental composition; Electron spectroscopies – Morphological characterization – Electron microscopy; SEM – TEM – Force microscopies; Application of nanoscale materials		
	Total Lecture hours	**60 hours**

Text Books	
1.	Physical Chemistry: D.W. Ball
2.	Flash photolysis and pulse radiolysis- R.V. Bensasson, E. J. Land and T. G. Truscott, Pergamon Press
3.	Fundamentals of photochemistry- K. K. Rohtagi and Mukherjee, New Age International (P) Ltd. Publishers
4.	The exploration of Supramolecular systems and Nanostructures by photochemical techniques, Volume 78, Paola Ceroni editor, Springer
5.	Nanomaterials: An introduction to synthesis, properties and application, Dieter Vollath, WILE-VCH, 2008
6.	Adamson, A. W-, and Fleischauer, P. D., (Editors) “Concepts of Inorganic Photochemistry," Wiley-Interscience, New York, 1975.
Reference Books	
1.	Theoretical Chemistry by S. Glasston
2.	Modern Aspects of Inorganic Chemistry-H.J. Emeleus and A.G. Sharpe
3.	Fundamentals of Radiation Chemistry- A. Mozumder, Academia Press
4.	Nanostructures & Nanomaterials: Synthesis, Properties &Applications” G. Cao, Imperial College Press, 2004
5.	Balzani, V., and Carassiti, V. “Photochemistry of Coordination Compounds,” Academic Press, New York, 1970
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=hIHNUVBvVkU
2.	H. Hennig, D. Rehorek, R.D. Archer. Photocatalytic systems with light-sensitive coordination compounds and possibilities of their spectroscopic sensitization—an overview. Coordination Chemistry Reviews 1985, 61, 1-53
3.	https://nptel.ac.in/courses/104/103/104103069/
4.	https://nptel.ac.in/courses/104/105/104105038/
5.	https://onlinecourses.nptel.ac.in/noc21_cy04/preview
6.	https://nptel.ac.in/courses/104/106/104106077/

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	S	S	M	M	S	L	L	L
CO2	S	L	M	S	S	M	S	L	L	L
CO3	S	S	M	S	S	S	M	L	L	L
CO4	S	S	S	S	S	S	S	L	M	L
CO5	S	S	L	M	M	L	S	L	S	L

*S-Strong; M-Medium; L-Low

Semester-IV	**CHE C106**	**TRANSITION METAL CHEMISTRY**	**L**	**T**	**P**	**C**
Core/Elective /Supportive		**Core**	**4**	**0**	**0**	**4**
Pre-requisite		Students should know the various types of ligands including chelating ligands and their approach to metal ions to form complexes.	**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this course are to:

- Provide more basic and uncomplicated knowledge about inorganic metal complex and their reactivity towards the ligand and metal interaction
- Perceptive of how ligands play the vital role in the metal complex stability, structural and reaction pathway of metal species
- Motivate critical thinking and analytical skills to solve knowledge in the aspects of inorganic chemistry in metal complexes.
- Demonstrate the ability to design and synthesis of various ligand and their interaction with metal core
- Cram the magnetic property in metal complex in the part of magnetochemistry and derive the Van vlek's equations

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Demonstrates most common and important futures of oxidation of metals complexes and nature of inert and lability in terms of kinetics and thermodynamic aspects of complexes formation reactions and their mechanisms	K1-K2
2	Understanding the formation of metal complexes and their mechanism involved with trans influence of ligand. In addition, to describe the stability of metal complexes by the use of formation constants and to calculate thermodynamic parameters	K2-K5
3	Demonstrate broad knowledge of descriptive electron transfer/redox reactions in various metal complex formation reaction and understand fundamental aspect of Marcus-Hush theory its applications in photochemical reaction of coordination compounds	K1-K4

4	Design and tailor various types of chelating ligands and its binding affinity to the target metal and provide the basic concepts of ligands design and synthesis its application in various fields	K3-K6
5	Derive the spin, orbit and spin-orbit magnetic dipole moment for various metal ions and complexes and understand the orbital quenching in A, T and E terms	K3-K5

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	**INERT AND LABILE METAL CHEMISTRY**	**18 hours**

Reactivity of metal complexes – Inert and labile complexes – Explanation of lability on the basis of valence bond and crystal field theories – Metal ion catalysed reactions and reaction mechanism, induced reactions and their characteristics, applications – kinetics and mechanism of induced reaction in metal complexes, – Stabilization of unusual oxidation states in solution – Survey of oxidation states with various electronic configuration of transition metals and inner-transition metals.

UNIT:2	**SUBSTITUTION REACTIONS IN COORDINATION COMPLEXES**	**18 hours**

Reaction pathways – mechanisms of substitutions in octahedral complexes – Dissociative (D), Associative (A), and Interchange (I) mechanisms – Aquation (acid hydrolysis) – Acid catalyzed aquation reactions, Anation reactions. Base hydrolysis, CB mechanism in octahedral complexes – Substitution reactions in square planar complexes, Ttans effect, theories and applications – Isomerisation and racemisation reactions of coordination complexes; Electron transfer reactions or redox reactions – two electron transfer reactions, Inner sphere and outer sphere processes, electron exchange reactions, complementary reactions and non complementary reactions, Marcus-Hush theory, photochemical reactions

UNIT:3	**LIGAND DESIGN**	**18 hours**

Geometrical consequences of the metal ion and the donor atoms – Reactive versus and ancillary ligands, cooperative ligands – extension of ligand coordination by reaction at donor and non-donor atoms - template reactions, kinetics and thermodynamics – chelating agents which bind to two metal atoms. Macrocyclic effect - Design and synthesis of various chelating and macrocyclic ligands. Principles of synthesis of ligand design – dendrimers

UNIT:4	**MAGNETOCHEMISTRY**	**18 hours**

Van Vlek's equation, Magnitude of magnetic moments - experimental determination, quenching of orbital angular momentum, magnetic properites of A, E and T ground terms, effect of spin orbit coupling antiferromagnetic interactions in di- and polynuclear transition metal complexes, magnetic behaviour of lanthanides and actinides- ferro, ferri and antiferromagnetic interaction in solids – anomalous magnetic moments, magnetic exchange coupling and spin crossover

	Total Lecture hours	**72 hours**

Text Book(s)

1.	Huheey, J.E. - Inorganic Chemistry, 4th Edition, Harper and Row.
2.	Basolo, F. and Pearson, R.G. - Mechanism of Inorganic Reactions, Wiley Eastern
3.	Purcell, K.F. and Kotz, J.C. - Inorganic Chemistry, Saunders
4.	D.F. Shriver and P.W. Atkins, Inorganic Chemistry, Oxford University Press,

	5th Edition, 2010
5.	J. D. Lee, Concise Inorganic Chemistry, Oxford University Press, 5th Edition, 2014
6.	B.N. Figgis - Modern Coordination Chemistry Ed. by Lewis & Wilkins (Unit IV)
7.	Bourdeax, E.A. and Mulay, M.N., - Theory and application of Molecular Paramagnetism, John Wiley
8.	F.A. Cotton and G. Wilkinson Advanced inorganic Chemistry, John Wiley & Sons, 6th Edition, 1999
Reference Books	
1.	Nyholm, R.S. and Tobe M.L., - The stabilisation of oxidation state of the Transition metals, Advances in Inorganic and Radiation Chemistry, Volume 5 (1963)
2.	(a) J. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, University; Science Books, Sausalito, CA, 2010
3.	G. L. Miessler, P. J. Fischer, D. A. Tarr, Inorganic Chemistry, 5th edn, Pearson, Upper Saddle River, NJ, 2014
4.	D.S.C. Blade and Hartshon, A.J., - Ligand, Design and Synthesis Coord. Chem. Rev.9 (1972) 219
5.	Nyholm., R.S. and Tobe. M.L., - The Stabilization of oxidation states of the transition metals, Advanced Inorganic and Radiation Chemistry, 5 (1963).
6.	R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, Vol. 4, John Wiley & Sons, Inc., Hoboken, NJ, 2005
7.	Maabs, F.D. and Machin, D.T., Magnetism and Transition Metal Complexes
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=ez40OIQrP60
2.	https://www.dalalinstitute.com/wp-content/uploads/Books/A-Textbook-of-Inorganic-Chemistry-Volume-1/ATOICV1-3-1-Inert-and-Labile-Complexes.pdf
3.	https://link.springer.com/chapter/10.1007%2F978-1-4419-9276-5_6
4.	https://www.youtube.com/watch?v=_eak-XY3Vx8
5.	https://onlinecourses.nptel.ac.in/noc20_cy19/preview

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	S	S	S	M	L	M	L	S
CO2	S	S	S	S	M	S	M	M	L	L
CO3	S	S	M	S	M	L	L	S	L	S
CO4	M	S	S	M	S	S	M	S	M	L
CO5	S	M	S	M	M	L	S	L	S	M

*S-Strong; M-Medium; L-Low

Semester -1V	**CHE C107**	**ORGANOMETALLIC CHEMISTRY**	**L**	**T**	**P**	**C**
Core/Elective /Supportive	**Core**		**4**	**0**	**0**	**4**
Pre-requisite	Students must aware of fundamentals of		**Syllabus**			**R-2021**

	organometallic compounds such as 16 and 18 electron rule, basic terms such as σ-donor, π-donor, π-acceptor ligands.	**Version**	

Course Objectives:

The main objectives of this course are to:

- Know about the nomenclature and bonding of organometallic compounds
- Understand the synthesis and structure of complexes with σ- donor, cyclic π-donors and π acceptor ligands
- Study the vibrational spectra of metal carbonyl and metal nitrosyl complexes
- Study the fluxional nature of organometallic compounds
- Describe applications of organometallic compounds as catalyst
- Know the mechanism of Wilkinson's hydrogenation, oxo process, Fischer-Tropsch process etc.

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Recall nomenclature and classification of organometallic compounds	K1-K2
2	Differentiate and compare complexes with σ- donor, cyclic π-donors and π acceptor ligands	K2-K3
3	Differentiate and identify linear and bent modes of metal nitrosyl complexes	K3-K4
4	Demonstrate industrially important catalysis reactions	K4-K5
5	Apply concepts while handling highly reactive chemicals	K5-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	**COMPLEX WITH σ- BOND**	**18 hours**

Nature of bonding in organometallic compounds and coordination complex– Types of ligands and their classifications in organometallic compounds, Hapto-nomenclature –16 and 18 electron rule and its limitations – Carbon σ- donor: Synthesis, nature of bond, structure, reactivities and applications of alkyl Li, Mg, Al and Zn, Cd

UNIT:2	**COMPLEXES WITH CYCLIC π DONORS**	**18 hours**

Synthesis, nature of bond, structure, reactivities and applications of olefins, acetylenes, π-allyl and dialkene, Cyclobutadiene, cyclopentadiene, benzene, cycloheptatriene and cyclo octatetraene – Metallocenes and sandwich complexes – Classification of fluxional organometallic Compound, mechanism and analysis of fluxionality in compounds

UNIT:3	**COMPLEXES OF π - ACCEPTOR LIGANDS**	**18 hours**

Mono-and polynuclear metal carbonyls: preparation, structure and reactivity, carbonylate anions and carbonyl hydrides, carbonyl halides, vibrational spectra of metal carbonyls – Nitrosyls*:* Mono -polynuclear nitrosyl complexes; linear, bent and bridging nitrosyl, cyano complexes – Phosphine, Arsine and cyanide complexes: Complexes of trivalent P and As derivatives. Methods of synthesis and structure

UNIT:4	**CATALYSIS**	**18 hours**

Oxidative addition, reductive elimination, insertion-migration reactions –

Hydrogenation of olefins - Hydroformylation of olefins - oxidation of olefins to aldehydes and ketones - polymerization of alkenes - Cyclooligomerization of acetylene and Fischer-Tropsch process – isomerization – water gas shift reaction and supported organometallic catalysis		
	Total Lecture hours	**72 hours**
Text Book(s)		
1.	F.A. Cotton & G. Wilkinson - Advanced Inorganic Chemistry, 3rd and 4th Ed., John Wiley.	
2.	Huheey, J.W. - Inorganic Chemistry, 4th Edition - Harper and Row.	
3.	K.F. Purcell & J.C. Kotz - Inorganic Chemistry, Saunder Company	
4.	Coats et al. - Organometallic compounds, Vol. I and II.	
5.	A. K. Das Vol. 5 & 6, Fundamentals of Inorganic Chemistry	
Reference Books		
1.	Robert H. Crabtree, The Organometallic Chemistry of the Transition Metals, 7th edition, Wiley.	
2.	Shaw, B.L. and Tucker, N.L. - Organotransition metal compounds and related aspects ofhomogeneous catalysis in comprehensive Inorganic Chemistry, Vol.4. Bailer, J.C. et. al (Eds) Pergamon.	
3.	Zuckermann, H., - Basic Organometallic Chemistry, Walter de Gruyter and Co.	
4.	Wade, K., - Structure and bonding pattern in cluster Chemistry in Advances in Inorganic Chemistry and Radiochemistry 18 (1976) 1.	
5.	Wilkinson, Stone and Abel (eds) - Comprehensive Organometallic Chemistry, Volume 1	
6.	Edward Maslowsky Jr., Vibrational Spectra of Organometallics, Theoretical and Experimental Data	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1.	Organometallic chemistry : https://nptel.ac.in/courses/104/101/104101079/	
2.	Introduction to organometallic chemistry : https://nptel.ac.in/courses/104/108/104108062/	
3.	Advanced transition metal chemistry: https://freevideolectures.com/course/4311/nptel-advanced-transition-metal-organometallic-chemistry	
Course Designed By:		

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	S	M	M	S	L	M	M	L
CO2	S	M	S	M	S	M	L	L	M	L
CO3	S	M	S	S	S	S	M	L	L	L
CO4	S	S	S	S	S	S	S	M	L	M
CO5	S	S	S	S	M	M	S	L	L	M

*S-Strong; M-Medium; L-Low

Semester -IV	CHE E603	NOVEL REAGENTS IN ORGANIC SYNTHESIS	L	T	P	C
Core/Elective/Supportive	ELECTIVE		4	0	0	3
Pre-requisite	Students should learn about the basics of metal-catalyzed organic synthesis, including understanding mechanism, role of catalyst and other additives. In addition, students must be aware of the difference in the reaction mechanism involving typical organic reaction Vs carbon-metal catalyzed reaction.		Syllabus Version			R-2021

Course Objectives:

The main objectives of this course are to:

- To understand various types of metal-catalyzed organic syntheses, including Ring Closing Metathesis, synthesis of cyclic and acyclic molecules, new carbon-carbon & C-N bond formation and C-H activation
- To know utility of silicon compounds in the generation of reactive diene like ortho-quinodimethane and its application
- To understand the mechanism and synthetic application of trifluoromethylation using Ruppert-Prakash reagent
- To study the correlation between structure, properties and reactivity of various types metal carbon bond compounds
- Understanding the homogeneous and heterogeneous metal-carbon bond catalyzed reactions and their mechanism

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Metal-catalyzed organic reactions and their synthetic utility	K1-K4
2	Study the various types of carbon-carbon formation reactions and synthesis of cyclic and acyclic frameworks	K2-K5
3	To study specific reaction by comparing theoretical and/or experimental data	K2-K4
4	To get new ideas or innovation in the field of organometallic chemistry and their applications in organic synthesis	K1-K6
5	To design suitable organometallic compounds for activation of highly stable and symmetrical molecules such as CO_2 and methane for the synthesis of industrially important intermediates/compounds	K3-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1 **15 hours**

Application of following d & p block elements in organic synthesis: Synthetic utility of Samarium iodide, Ruthenium (Ring Closing Metathesis-RCM) Zirconium (Schwartz's reagent) and Cobalt (Pauson-Khand reaction and Nicholas reaction) in organic synthesis. Asymmetric Reformatsky reaction using Samarium. Homogeneous hydrogenation. Application of Titanium in organic synthesis – Mc Murry coupling. Tin in organic synthesis. Use of – Bu_3SnH and Tin mediated carbon-carbon bond formation in the synthesis of cyclic and acyclic molecules

UNIT:2		15 hours
Role of Palladium and Nickel catalyst in organic reactions. Both Pd(0), Ni(0) and Pd(II), Ni(II) complexes are included. Typical reaction involving Heck, Negishi, Suzuki-Miyaura, Kumada, Sonogashira, Stille and Hiyama coupling for the carbon-carbon bond formation. Buchwald-Hartwig coupling for the carbon- heteroatom bond formation reactions. Transition-metal catalyzed C-H bond activation in organic synthesis		
UNIT:3		**15 hours**
Silicon compounds. Use of trimethylsilyl chloride and t-butyldimethylsilyl chloride as a productive group. Use of trimethylsilyl iodide and trimethylsilyl cyanide. Vinylsilanes-Silyl Peterson olefination reaction. Trichloro silane and triethyl silane as reducing agents. Role of trimethylsilyl group in the generation of reactive diene like ortho-quinodimethane. Generation and reactions of α and β silyl-carbanions. Conjugate addition using lithium organocuprates (Gilman's reagent) 1,2 vs 1,4 addition. Umpolung-aldehyde ketone and acid synthesis from 1,3 dithiane. Trifluoromethylation using Ruppert-Prakash reagent		
UNIT:4	**BONDING AND APPLICATIONS OF METAL CARBONYL COMPOUNDS**	**15 hours**
Metal carbonyl reactions-substituted metal carbonyls, cis-labilising effect, metal-metal bonded carbonyl and cluster-insertion reaction-CO insertion, CO_2 insertion, SO_2 insertion, methyl migration, phenyl migration, carbon hydrogen bond activation-Oxo reaction, Wacker process and Reppe synthesis-photochemical reaction of metal carbonyls-Chromium, Manganese, Iron, Rhenium and Ruthenium. Oxidative addition-Hydrogen, organic halides-Fischer Tropsh process		
	Total Lecture hours	**60 hours**

Text Book (s)	
1.	Colvin, E. W. (1981); Silicon in Organic Synthesis, 1st Edition, Elsevier
2.	Carruthers, W. (2015); Modern Methods of Organic Synthesis, 4th Edition, Cambridge University Press
3.	Smith,M, (2016); Organic Synthesis, 4th Edition, Academic Press
4.	Huhee, J. E, (2014); Inorganic Chemistry, 4th Edition, Pearson
5.	Purcell K. F, Kotz, J. C. (1980); Inorganic Chemistry, 1st Edition, Thomson Learning
Reference Books	
1.	Weber, W. P. (1983); Silicon Reagents for Organic Synthesis, Springer-Verlag, ISBN 978-3-642-68661-0
2.	Tsuji, J. (2004); Palladium Reagents and Catalysts, Wiley, ISBN: 978-0-470-85032-9
3.	Hegedus, L. S. (2009); Transition Metals in the Synthesis of Complex Organic Molecules, 3rd Edition, University Science Books
4.	Crabtree. R. H. (2019); The Organometallic Chemistry of the Transition Metals, Wiley
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=s8VqAqibrr8
2.	https://www.youtube.com/watch?v=YAkAKsHsLyU
3.	https://www.youtube.com/watch?v=8pqCeN7GoMc&list=PLbMVogVj5nJR65WP0IQaDCBtCRq_HAuI_

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	L	S	M	M	M	M	L	L
CO2	M	M	M	S	S	M	M	L	M	M
CO3	M	M	M	M	S	M	S	L	M	L
CO4	L	M	L	S	M	L	M	M	L	L
CO5	M	M	M	S	M	L	M	L	M	M

*S-Strong; M-Medium; L-Low

Semester-IV	**CHE E004**	**ELECTROANALYTICAL CHEMISTRY**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**ELECTIVE**	**3**	**0**	**0**	**3**
Pre-requisite		Basic knowledge of electrochemistry is essential	**Syllabus Version**			**R-2021**

Course Objectives:

The main objectives of this course are to:

- To learn the theory and basics of electrochemical techniques and their applications
- Design and functioning of electrochemical sensors
- Introduction to Electrochemical Impedance Spectroscopy
- Describe the theory and practical applications of voltametric techniques and polarography
- Understand the principles and applications of coulometry and electrogravimetry

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Working knowledge on sensors and electrochemical impedance spectroscopy	K1-K4
2	Types of electrodes and their functions	K3-K5
3	Electrical double layer and electrokinetic properties	K2-K4
4	Distinguish different types of voltametric and polarographic techniques	K2-K5
5	Interpret and apply electroanalytical techniques in research	K3-K4
6	Fundalmentals of corrosion and its prevention	K5-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	**ELECTRICAL DOUBLE LAYER, CORROSION AND ELECTROKINETIC APPLICATIONS**	**15 hours**

Electrical double layer – Electrode - electrolyte interface, Types of interfaces, thermodynamics of electrified interfaces, derivation of electrocapillary phenomena, Point of Zero Charge (PZC), Lippmann equation, estimation of surface charge and surface excess and Gibbs adsorption. Structure of electrified interfaces, Helmholtz-Perrin, Gouy – Chapman and Stern models, specific

adsorption. Corrosion - Thermodynamic criteria of corrosion of metals – Dry and wet corrosion, homogenous (Wagner and Traud's) and heterogenous theories, classification of corrosion –Uniform, Galvanic, Crevice, Pitting and Intergranular corrosion- Povrbaix diagram. Corrosion prevention - passivation and inhibitors. Electrokinetic phenomena - overview of Zeta Potential – Principles, Mechanism and applications. Conversion and storage of electrochemical energy. Fuel cells and Lithium-ion battery

UNIT:2	**POTENTIOMETRIC AND SENSING TECHNIQUES**	**15 hours**

Potentiometry - standard and formal potentials - Nernst equation. Types of electrodes -indicator and reference electrodes. Ion selective electrodes - crystalline and non crystalline electrodes - glass electrode for pH measurements, mechanism of electrode response and evaluation of selectivity coefficient, asymmetry potential, alkaline and acid errors, applications of ion selective electrodes. Chronoamperometry and Chronopotentiometry. Potentiometric titrations - manual and automatic titrators, titrations including differential methods titrations in non-aqueous systems, titrations with polarized electrodes. Bipoteniometry - principle, instrumentation and applications. Amperometric and Potentiometric sensors - Gas Sensors, Bio sensors. Impedance spectroscopy, RDE, RRDE, sensors

UNIT:3	**VOLTAMETRIC TECHNIQUES**	**15 hours**

Voltammetry–Polarography- DME, polarograms, currents in polarography, polarographic maxima, effect of dissolved oxygen and application to chemical analysis, amperometeric titrations, pulse polarography – normal and differential pulse, square wave polarography, stripping methods – cathodic and anodic stripping, linear sweep voltammetry, cyclic voltammetry, types of electrodes and chemically modified electrodes. Coulometric analysis - Theory, Faraday's laws, types of coulometres, coulometric titrations; Electrogravimetry – Theory, electrogravimetry, order of deposition, constant potential, constant current deposition and deposition of complex ions

	Total Lecture hours	**45 hours**

Text Book(s)

1.	Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition
2.	A. M. Bond, Modern polarographic methods in Analytical Chemistry, Marcel Decker Inc., 1980
3.	Principles of Instrumental Analysis – Douglas A. Skoog, F. Holler, Stanley Crouch, 7th Edn Brooks/Cole publish; 7th edition, 2017
4.	E. Gileadi, E. Kirowa- Eisner and J. Penciner, 3. Interfacial Electrochemistry : An Experimental Approach, Addison-Wesley Publishing Company, Massachusetts,1975.
5.	P.T. Kissinger and W.R. Heineman, 8. Laboratory Techniques in Electroanalytical chemistry, Marcel Decker Inc., 1984

Reference Books

1.	John O'M. Bockris, Amulya K. N. Reddy, "Modern Electrochemistry", Vol. I and II, Plenum Publishing, 2008
2.	John O' M.Bockris & A.K.N.Reddy, Modern Electrochemistry – Fundamentals of Electrodics,Plenum Publishers, New York, 2000.
3.	Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F.A. Jr., CBS Publishers &

	Distributors; 7th edition (2004).
4.	Modern polarographic methods in Analytical Chemistry- A. M Bond, Marcel Decker Inc., 1980
5.	Laboratory Techniques in Electroanalytical chemistry – P.T. Kissinger and W.R. Heineman, Marcel Decker Inc., 1984
6.	Chemical Instrumentation – H.A. Stoubel, Addison- Wesley, 1976 Stripping analysis – J. Wang, VCH Publication, 1985
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=3olOk_xNq8g

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	S	M	M	S	M	M	L	S
CO2	S	M	S	S	S	M	S	M	M	L
CO3	S	S	S	M	L	M	S	L	L	L
CO4	M	S	S	S	M	S	M	L	M	S
CO5	S	S	S	M	S	L	S	M	L	L

*S-Strong; M-Medium; L-Low