NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

Minor in

INDUSTRIAL CHEMISTRY

SCHEME OF INSTRUCTION AND SYLLABI

(for all B.Tech. students)

(Effective from 2021-22)

DEPARTMENT OF CHEMISTRY

SCHEME OF INSTRUCTION

MINOR IN INDUSTRIAL CHEMISTRY

S. No.	Course Code	TITLE	L	T	P	Credits	Semester (to be offered)
1.	CYM01	General Chemistry	3	0	0	3	IV
2.	CYI311	Environmental Chemistry	3	0	0	3	IV
3.	CYI312	Statistical Treatment of Data and Quality Control in Chemical Analysis	3	0	0	3	V
4.	CYI313	Applied Chemistry	3	0	0	3	VI
5.	CYI364	Instrumental Analysis for Industrial Applications	3	0	0	3	VII
6.	CYM06	Project Work	0	0	6	3	VIII
					Total Credits	**18**	

DEPARTMENT OF CHEMISTRY

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledgefor mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Chemistry

VISION

Towards Serving as a Potential Hub of Knowledge in Chemical Sciences and Allied Areas So as to Uphold and Strengthen the Vision of the Institute as One among Many Pillars While Striving Continuously in Pursuit of Excellence in Chemical Education, Chemical Research, Chemical Industry and All Interfaces of Chemistry with Society

MISSION

- Imparting Total Quality Education in Basic and Applied Chemistry to Develop Innovative, Entrepreneurial and Environment Friendly Graduates of Chemical Sciences of International Standards.
- Offering Relevant Fundamental and Applied Attributes of Chemistry, the Central Science, to Engineering Students as an Integral Part of Technical Education.
- Promoting Chemical Industry and Societal Service Sectors towards Environment-Friendly and Green Chemical Protocols by Innovation and Research in Cutting Edge Areas of Chemical and Allied Sciences
- Augmenting the Country's Needs of Human Resources and Scientific Manpower in Basic and Advanced Chemistry through Learner-Centric and *Atma Nirbhar Bharath* Modern Education and Research.

Department of Chemistry:

Brief about the Department:

The Department of Chemistry was established in the year, 1959, as an integral part of the Regional Engineering College Warangal (RECW). Since its inception, the Department is rated as one of the most academically active Departments in the Institute. The Department has a two-year M.Sc. Chemistry with specializations in Organic and Analytical Chemistry and offers chemistry course to all branches of Engineering. A 5-Year Integrated M.Sc. Programme in Chemistry will commence from the Academic Year, 2021-22. The Department is actively engaged in research in cutting-edge areas of Chemistry and contemporary topics of Organic, Inorganic, Physical and Analytical and Computational Chemistry. It offers PhD program in all branches of Chemistry and cutting-edge areas of Chemistry. It had produced the highest number of PhDs to date from any single Department in not only NIT Warangal but also among any other NIT in the country. The faculty members of the Department are active in quality teaching, research, and out-reach programs. Many of them are carrying out sponsored R&D projects in frontier areas of Chemical Sciences and Technologies besides popularization of sciences among the school students and masses. The Department completed FIST project level 1 and now level 2 FIST program is currently under progress.

The Department houses various state-of-the-art facilities such as a 400 MHz NMR, X-Band ESR, FTIR, UV-Vis-NIR and Fluorescence Spectrometers, LC-HRMS Spectrometer, Gas Chromatographs, HPLC, Electrochemical Workstations, Advanced Molecular Modelling Chemistry Software, etc. besides access to ICP-OES, CD-ORD, Powder XRD, SEM, TGA-DTA-DSC, Fuel Cell Workstations, etc. As a part of continuing education and outreach activities, the Department has been organizing several National and International Conferences, Seminars, and Workshops.

DETAILED SYLLABUS

MINOR PROGRAME

Industrial Chemistry

Course Code: CYM01	GENERAL CHEMISTRY	Credits 3-0-0:3

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1** Understand some of the basic concepts of chemistry which are the stepping stones for advanced chemistry concepts
- **CO2** Acquire knowledge about the atomic structure and stoichiometry of chemical reactions
- **CO3** Understand the characteristics of bonds and the properties of elements
- **CO4** Understand the states of matter and structural aspects of crystals
- **CO5** Apply the basic concepts of organic chemistry in day to day life

Syllabus:

Chapter-1 Chemical bonding: Lewis structure, Valence Bond theory, hybridization, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules, Valence shell electron pair repulsion theory (VSEPR), Covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules and consequences of polarization, Ionic character in covalent compounds, Percentage ionic character from dipole moment and electronegativity difference, Qualitative idea of valence bond and band theories. Semiconductors and insulators, van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment.

Chapter-2 Co-ordination Chemistry: Jorgenson chain theory, Werner's theory, Nomenclature of coordination compounds, Stereochemistry of coordination compounds, coordination numbers of 4, 5 and 6, Various types of isomerism in coordination complexes, Theories of metal-ligand bonding in transition metal complexes- Valence bond theory of coordination compounds, high-spin and low- spin complexes, hybridization and structures of octahedral, tetrahedral and square- planar complexes-Limitations of valence bond theory, Crystal-field theory- Qualitative idea about d-orbital splitting in octahedral, tetrahedral and square planner complexes, explanation of magnetism, geometry and colour of coordination compounds, CFSE and its calculation in different stereo chemistries, Weak field and strong field, Low spin and high spin complexes, Pairing energy, Molecular orbital theory, LCAO rules, MOED of octahedral, tetrahedral and square-planar complexes.

Chapter-3 Physical Chemistry: States of Matter: Gaseous State: The gas laws, deviation of real gases from ideal behaviour (recapitulation)-compressibility factor (Z) van der Waals equation of state for real gases, discussion at different conditions and its limitation-other equations of state-Critical phenomenon, Andrew isotherms of CO_2 - van der Waals equation and critical state, derivation of relation between critical constants and van der Waals constants-critical compressibility factor-The law of corresponding states- liquefaction of gases. Liquid state: Vacancy theory of liquids, free volume in a liquid, Physical properties of liquids-Vapor pressure, heat of vaporisation, vapor pressure vs temperature curves of some common liquids; surface tension, effect of temperature on surface tension and its determination using stalagmometer, parachor and heptachlor related to structural elucidation, Viscosity, viscosity coefficient, effect of temperature on viscosity and its determination using Ostwald's viscometer, structure related to viscosity.

Solid State: Laws of crystallography-i. Law of constancy of interfacial angles ii. Law of symmetry-symmetry elements in crystals iii. Law of rationality of indices or intercepts, structure

of crystals-space lattice, unit cell, Bravais lattices and seven crystal systems, description of orientation of lattice plane by its miller indices, band theory of solids, energy band theory of conductors, semiconductors and insulators

Chapter-4 Phase Rule: Phase, components, Degree of freedom, conditions for Equilibrium between phases, Gibbs Phase rule, Phase equilibria of one component system- water system, Phase equilibria of two component system-simple Eutectic-Pb-Ag system-desilverisation of lead. **Colloids and Surface Chemistry**: Definition, classification, Properties of colloids-kinetic, optical and electrical properties (recapitulation)-solid in liquids (sols)-preparation, protective action-gold number, liquids in liquids (emulsions), types, preparation, emulsifier; liquid in solids (gel), classification, preparation and properties; applications of colloids, Micelles (surfactants) and reverse micelles: Definition, classification, mechanism of their formation, cleaning action of soap, critical micelle concentration and factors affecting it. **Surface chemistry**: Freundlich adsorption isotherm, Langmuir theory of unilayer adsorption isotherm, applications.

Chapter-5 Basics of Organic Chemistry: Concept of hybridization, resonance, orbital pictures of bonding (sp^3, sp^2, sp, C-C, C-N & C-O system). Inductive effect, bond polarization, and polarizability, steric inhibition of resonance. Hückel's rules for aromaticity & anti-aromaticity, homo-aromaticity. Concept of acids and bases: effect of structure, substituent and solvent on acidity and basicity.

Chapter-6 Basic reaction mechanism and intermediates: Mechanism classifications - ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism. **Reactive intermediates**: carbocation (carbenium and carbonium ions), carbanions, carbon radicals, carbenes, nitrenes- structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate (elementary idea). Functional group interconversion**:** halides, alcohols, phenols, ketones, aldehydes, carboxylic acids, ethers, derivatives of carboxylic acids, amines.

Learning Resources:

Text Books:

1. Concise Inorganic Chemistry, **J. D. Lee,** Wiley India, 2015, 5th Edition.
2. Unified Chemistry paper I and II, **O.P. Agarwal**, Jai Prakash Nath Publications, 2019, 3rd Edition.
3. Organic Chemistry, **R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee**, 7th Edition, Pearson Education.

Reference Books:

1. A textbook of Physical Chemistry, **K.L. Kapoor** Macmillan Publisher, 2019, Volume 1, 6th Edition.
2. Inorganic Chemistry: Principle of structure and reactivity, **Huheey, J. H.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K.**, Pearson Education India, 2006, 4th Edition.
3. Principles of physical chemistry, **Samuel H. Maron and Carl F. Prutton**, Oxford & IBH Publishing, 2017, 4th Edition.
4. Organic Chemistry**, I. L. Finar,** Vol-1, Pearson Education, 6th edition.

Course Code: CYI 311	Environmental Chemistry	Credits 3-0-0: 3

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1** Identify relationship between chemical exposure and effects on physiological systems
- **CO2** Understand causes and effects of environmental pollution and mitigation strategies
- **CO3** Apply basic chemical concepts to analyse chemical processes involved in different environmental problems
- **CO4** Describe water purification and waste treatment processes and the practical chemistry involved
- **CO5** Discuss local and global environmental issues based on the knowledge gained throughout the course

Syllabus:

Chapter-1 Chemistry of Atmosphere: Origin, composition and structure of atmosphere-particles, ions and radicals in the atmosphere, Greenhouse effect-Causes, consequences and abatement of Greenhouse effect-Ozone depletion- Causes, consequences and abatement of ozone depletion, Photochemical smog-Effects and control.

Chapter-2 Air Pollution-Monitoring and Control: Air sampling techniques-Sources and effects, of oxides of sulphur, oxides of nitrogen, oxides of carbon, monitoring of air pollutants by Instrumental methods, Monitoring and Control of particulate pollution- Monitoring of air pollutants by Instrumental methods, Control of air pollution by raw material change, process modification, adsorption, absorption and combustion methods.

Chapter-3 Water Pollutants and waste water treatment: Unique characteristics of water; Water and the Living Environment; Water and the Non-living Environment, The Different Types of Pollutants; Chemical Pollutants; Physical Pollutants; Physiological Pollutants; Thermal Pollution, Pollution indicators, Dissolved Oxygen; Biological Oxygen Demand; Chemical Oxygen Demand, Waste water: Constituents – Microorganisms, Solids, Inorganic constituents, Organic matter, Water Quality requirements, pH values of Wastes and Receiving water, Suspended solids, preliminary, primary, secondary, tertiary treatment, Waste water from some typical industries, sources, characteristics, effect and treatment.

Chapter-4 Soil chemistry: Nature and composition of soil, Acid base and ion exchange reactions in soil, macronutrients in soil, Micronutrients in soil, Nitrogen, phosphorous and potassium in soil, Fertilizers, wastes and pollutants in soil, Soil loss and degradation, Agriculture and health.

Chapter-5 Solid Waste Management and environmental impact assessment: Solid waste disposal and management: classification and origin, methods of solid waste disposal, Microbiology involved in solid waste disposal, Environmental Impact Assessment, Environmental Impact Assessment process in India-Environmental acts and rules.

Learning Resources:

Text Books:

1. Fundamental Concepts of Environmental Chemistry, **G.S. Sodhi**, Narosa publishing House, 2005, 2nd edition.
2. Waste water treatment, **M.N. Rao and A.K. Datta**, Oxford Publications, 2013, 3rd edition.

Reference Books:

1. Environmental Science and Engineering, **J. Glynn Henry and Garry W. Heinke**, Prentice-Hall, Inc., New Jersey, USA, 1996, 2nd edition.

Course Code: CYI 312	STATISTICAL TREATMENT OF DATA AND QUALITY CONTROL IN CHEMICAL ANALYSIS	Credits 3-0-0: 3

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1** Understand the importance of statistics in the chemical analysis
- **CO2** Identify the errors occurring in the measurements and related data treatment
- **CO3** Apply statistical tools for improving the quality of analytical measurements
- **CO4** Choose the appropriate analytical method for the calibration and proper use ofthe instruments
- **CO5** Develop a standard method for the optimization of experimental procedures in analytical chemistry

Syllabus:

Chapter-1 Errors in Data Analysis: Accuracy and Precision; Errors and Error Distributions; Propagation of error, signal vs noise, Statistical Treatment of Data; Gaussian Curve, Finite Data Analysis; Standard Deviation; Standard Deviation for Computed Results, Significant Figures and Rounding the Results. LOD and LOQ, Numerical Problems related to Chemical Analysis.

Chapter-2 Significance tests: Comparison tests - Q-test, z-test, t-test (normal t-test and t- set for means), F-test outliers.

Chapter-3 Quality Control in Chemistry: Quality control methods – Introduction, Control Charts – Shewart Charts for Mean values and Ranges, Numerical calculations.

Chapter-4 Analytical methods. Various types of analytical methods, Calibration of instruments, Calibration methods. Standard addition, External standard, Internal standard and dilution methods.

Chapter-5 Standard Method Development and Validation: Optimization of experimental procedures in analytical chemistry, response surfaces, specific examples.

Learning Resources:

Text Books:

1. Fundamentals of Analytical Chemistry, **Skoog D. A., West D M, Holler, F J and Crouch S R**, Saunders College Publishing, 2004, 8thEdn.
2. Waste water treatment, **M.N. Rao and A.K. Datta**, Oxford Publications, 2013, Third edition.

Reference Books:

1. Modern Analytical Chemistry, **David Harvey**, McGraw Hill-Education., 2000, International Edition.
2. Quality Assurance and Quality Control in the Analytical Chemical Laboratory, **Piotr Konieczka and Jacek Namiesnik**, CRC Press, 2009, 2nd Edition.

Online Resources:

1. Website reference links

Course Code: CYI 313	APPLIED ORGANIC CHEMISTRY	Credits 3-0-0: 3

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1** Apply the theoretical knowledge of organic chemistry for the synthesis of molecules with industrial importance
- **CO2** Use the knowledge of organic chemistry in paint, agriculture and cosmetic industry
- **CO3** Understand the essentials of organic chemistry in drug synthesis
- **CO4** Use the knowledge of organic chemistry for the development of sustainable synthetic processes
- **CO5** Apply the knowledge of organic chemistry in food industry

Syllabus:

Chapter-1 Paints, Varnishes and Soaps: **Paints & Varnishes:** Primary constituents of paints, Dispersion medium (solvent), binder Pigments, formulation of paints and varnishes. Requirements of a good paint. **Surface Coatings**: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives. **Soaps:** manufacture of soaps by hot and cold process, classification of soaps, cleansing of soap and classification of detergents (anionic and cationic).

Chapter-2 Fertilizers and Pesticides: **Fertilizers:** natural fertilizers, nitrogenous fertilizer (NH_4NO_3, urea), phosphatic fertilizer (superphosphate, TSP, polyphosphate), potash fertilizer (KCl, KNO_3, K_2SO_4), bio fertilizers. **Pesticides:** classification, structure of some important pesticides (DDT, BHC, allethrin and pyrethrin). **Insecticides:** Pesticides – classification of Insecticides, fungicides, herbicides as organic and inorganic – general methods of application and toxicity. Safety measures when using pesticides. **Insecticides**: Plant products – Nicotine, pyrethrin – Inorganic pesticides – borates. Organic pesticides – D.D.T. and BHC. **Fungicides and Herbicides:** Fungicide: Sulphur compounds, Copper compounds, Bordeaux mixture. Herbicides: Acaricides – Rodenticides. Attractants – Repellents. Preservation of seeds.

Chapter-3 Chemistry of Essential oils, Perfumes and Cosmetics: **Essential oil:** Definition–occurrences–Methods of production from plants–Steam distillation and expression method. **Perfumes:** Formulations–Requirements for a good perfume–Compositions of perfumes–classification of perfumery materials–animals-synthetic formulations– manufacturing and packaging process of perfumes. **Cosmetics:** Face cream–Sun screen lotion–shaving cream–composition and formulation–Uses and hazards, Sprayer–Hand lotion– nail lacquers–nail bleaches–hair oil–hair dyes–composition and formulations–Uses and hazards

Chapter-4 Chemistry of Drugs: Classification of drugs based on structure and action: Antibacterial: sulfa drugs, synthesis of sulfathiazole, sulfapyridine, Antibiotics: β-Lactam antibiotics and synthesis of penicillin, chloramphenicol, Antiviral drugs: Azidothimidine, acyclovir; Antipyretics: Paracetamol, Analgesics: Analgine, Non-steroidal anti-inflammatory drugs: Ibuprofen, Antimalarial: Chloroquine, Antacids: Ranitidine

Chapter-5 Introduction to Green Chemistry: Principles of green chemistry (12 principles), Green reagents (water and bio-based), solvents (green solvents eg. Water), and alternative reaction media (ionic liquids), multicomponent reactions, atom economy (examples: Diels-Alder reaction, Claisen rearrangement), sustainable organic chemistry

Chapter-6 Food Chemistry: **Flavouring agents:** Definition of flavours–Classification–Chemical composition–common characteristics–Formulations–Uses and hazards, Preserving agents, antioxidants, ***Sugar industry*****:** Double sulphitation process. Refining and grading of sugar. Saccharin: synthesis and use as a sugar substitute – aspartame (structure and synthesis). Ethanol: manufacture from molasses by fermentation.

Learning Resources:

Text Books:

1. Synthetic Organic Chemistry, **G. R. Chatwal and Gurudeep**, Himalaya Publishers, 2009.
2. Medicinal Chemistry, **Ashutosh Kar**, New Age Publications, 5th Ed. 2010
3. New trends in green chemistry: **V. K. Ahluwalia and M. Kidwai**, New Age Publications, 2004
4. Food Science, **Srilakshmi B**., New age International Pvt. Ltd. Publishers, III ed. 2003.

Reference Books:

1. Edition Polymers: Chemistry and Physics of Modern Materials, 3rd Edition, **John W. Nicholson**, Royal Society of Chemistry, 2012.
2. High-Performance Organic Coatings, Ed. by **A S Khanna**, Elsevier, 2008.
3. Green Chemistry: Theory and Practice. **P.T. Anastas and J.C. Warner**. Oxford University Press, 2000.
4. Food Chemistry, **H.-D. Belitz, Werner Grosch, Peter Schieberle**, 4th Edition, Springer Science & Business Media, 2009.

Course Code: CYI364	INSTRUMENTAL ANALYSIS FOR INDUSTRIAL APPLICATIONS	Credits 3-0-0:3

Course Outcomes:

At the end of the course, the student will be able to

- **CO1** Explain the theoretical principles behind the instrumental techniques and their applications.
- **CO2** Model concepts and techniques in instrumental analysis independently towards industrial applications.
- **CO3** Analyze instrumental results for deriving conclusions with relevance to experimental evidences.
- **CO4** Assess the appropriateness of an instrumental method for the analysis of samples in various formats and from complex matrices.
- **CO5** Design experimental methodology for determining analytes of interest of domestic and industrial applications.

Syllabus:

Chapter-1 UV-Visible Spectrophotometry and Fluorescence: Overview of bioorganic chemistry- historical connection between organic and biological chemistry; weak interactions in organic Beer-Lambert's law, Instrumentation of Absorption Spectrophotometer, Quantitative analysis, limitations, Enzyme linked immunosorbent analysis (ELISA), Molecular fluorescence, influencing factors, basic instrumentation, standardization, quantitative methods, Applications, Diagnostics of biomarkers.

Chapter-2 Thermoanalytical and Chromatography methods: Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications. Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC, Qualitative and Quantitative applications, Capillary Electrophoresis: Principle and application.

Chapter-3 Diffraction and Microscopic methods: X-ray absorbance and fluorescence, Principle, instrumentation, quantitative analysis. X-ray diffraction, Principle, Crystal structure and size analyses. Medical diagnostics, Analysis of geological samples and ores. SEM, Principle, Sample preparations, Surface morphology and particle size analysis, TEM, Principle, Sample preparation, Surface morphology, Structural determination of nanoparticles. Metal and non-metal nanocomposites, industrial materials.

Chapter-4 Atomic spectrometry, Electroanalytical methods, BET and DLS: Atomization, Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects. Analysis of geological samples and ores. Ion selective electrodes, Electrochemical sensors, Ion selective and Potentiometric sensors, Amperometry, Principles, Applications. BET- Principle, Pore width, particle size and surface area analysis, Dynamic light scattering – Principle, instrumentation and applications.

Learning Resources:

Text Books:

1. Principles of Instrumental Analysis, **Douglas A. Skoog, F. James Holler, Stanley R. Crouch**, Cengage Learning India, 7th edn., 2020.
2. Physical Methods for Chemists, **Russel S. Drago**, Saunders College Publishing, 2nd edn., 2016.

Reference Books:

1. Instrumental Methods in Food and Beverage Analysis (Developments in Food Science), **D L B Wetzel, George Charalambous**, Elsevier, 1998.
2. The Analysis of Controlled Substances (Analytical Techniques in the Sciences (AnTs), **Michael D. Cole**, Wiley, 2003.

Course Code: CYM06	Project	Credits 0-0-6:3

Course Outcomes:

At the end of the course, the student will be able to:

CO1 Develop the skill in obtaining data and to verify the purity of the samples

CO2 Apply the concept of physical chemistry to understand the distribution of a solute in two immiscible liquids

CO3 Understand the organic chemistry laboratory safety protocols and synthesis the compounds of industrial importance

CO4 Apply various purification methods in the separation of organic mixtures

CO5 Apply various chromatographic methods in the separation if organic compounds