VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE (HONOURS)

MAJOR IN INDUSTRIAL CHEMISTRY

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes

(CCFUP), 2023 & NEP, 2020

VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN INDUSTRIAL CHEMISTRY
(under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	3rd	V	SEMESTER-V							
			Major-8	INCHMJ08	T: Introduction to Chemical Engineering and Mass Transfer Operations; P: Practical	4	3-0-1	15	60	75
			Major-9	INCHMJ09	T: Fluid Mechanics and Heat Transfer; P: Practical	4	3-0-1	15	60	75
			Major-10	INCHMJ10	P: Industrial Instrumentation and Process Control; P:Practical	4	3-0-1	15	60	75
			Major Elective-01	INCHDSE1	T: Concept of heavy Inorganic Chemicals & petrochemicals & Industrial and Environmental pollution;	4	3-1-0	15	60	75
			Minor-5 (Disc.-I)	INCMIN05	*To be decided (To be taken from other Discipline)*	4	3-0-1/ 3-1-0	15	60	75
			Semester-V Total			20				375
		VI	SEMESTER-VI							
			Major-11	INCHMJ11	T: Advanced Numerical Analysis and Advanced Reaction kinetics; P: Practical	4	3-0-1	15	60	75
			Major-12	INCHMJ12	T: Petroleum Chemistry; P: Practical	4	3-0-1	15	60	75
			Major-13	INCHMJ13	T: Green Chemistry;	4	3-1-0	15	60	75
			Major Elective-02	INCHDSE2	T: Analytical methods in Chemistry; P:Practical	4	3-0-1	15	60	75
			Minor-6 (Disc.-II)	INCMIN06	*To be decided (To be taken from other Discipline)*	4	3-0-1/ 3-1-0	15	60	75
			Semester-VI Total			20				375
			YEAR-3			40				750
			Eligible to be awarded Bachelor of Science in Industrial Chemistry *on Exit*			126	Marks (Year: I+II+III)			2325

MJ = Major, MI = Minor Course, DSE = Discipline Specific Elective Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical

SEMESTER-V

MAJOR (MJ)

MJ-8: Introduction to Chemical Engineering and Mass Transfer Operations Credits 04 (FM: 75)

MJ-8T: Introduction to Chemical Engineering and Mass Transfer Operations (Theory) Credits 03

Course contents: (45Lectures)

Unit-I: Distillation: Boiling and distillation, vapor-liquid equilibria, Rault's law & Henry's law, relative volatility, azeotropic mixtures, flash distillation, steam distillation, vacuum distillation, fractional distillation, plate columns (Bubble cap, Sieve plate & Valve plate).

Unit-II: Gas Absorption: Definition, examples, comparison of absorption and distillation, conditions of liquid- gas equilibrium, solution criteria for gas absorption, mechanically agitated vessels. Packed columns, and plate columns, (Characteristics of tower packing, Types of packing) merits of plate & packed tower.

Unit-III: Evaporation: Types of evaporators, jacketed, horizontal and vertical tube evaporators, forced circulation evaporations, entrainment separators (upturned, deflector type, tangential type), effect of scale formation, and multiple effect evaporators.

Unit-IV: Filtration: Filtration, Rate equation, Filter media and filter aid, Classification of filters, filter press, Industrial Filters-Sand filter, Plate & frame filter, Leaf filter, Rotary filter and Centrifugal Filtration.

Unit-V: Sedimentation: Batch and continuous sedimentation, Thickeners, Separation of solids based on specific properties. Clarification equipments. Cyclones. Froth flotation and Jigs.

Unit-VI: Mixing: Mixing, Types of mixing problems, Mixing liquids with liquids, mixing liquids with solids, Mixing solids with solids, Mixing viscous masses.
Conveyors and elevators - Introduction Belt conveyor, Conveyor, Screw conveyor, Pneumatic conveyor.

Unit-VII: Separation: Size reduction and size separation, Primary and secondary crushers, Fine grinders, Methods of operating crusher, Size separation of solids, Industrial screens, Air separation method, Size separation by laws of setting.

Unit-VIII: Extractions: Liquid equilibrium, Extraction with reflux, Extraction with agitation, equipment, it's use and performance, continuous contact equipment, agitator extractors, packed spray extractors, Leaching, flow sheets of solid-liquid extraction, continuous leaching, counter current extraction. Leaching and liquid liquid extraction, Factors affecting rate of leaching and extraction, Industrial extractors, leaching of cellulose material and fine solids, mechanical agitators. Batch and continuous type equipments liquid extractor, solvents for extraction.

Unit-IX: Drying: General Principles (Significance, moisture content), Rate of drying (Constant & falling rate period, factors affecting drying), Drying equipments, Tray dryers, Rotary dryers, Single Drum dryer & Spray dryers.

Unit-X: Crystallization: Growth of Crystal, saturation, nucleation super saturation, (Mier's theory), Caking of crystals, effect of impurities, Classification of crystallizers, Agitated tank, Swenson walkers, Krystal, Oslo, continuous vacuum crystallizers.

MJ-8P: Introduction to Chemical Engineering and Mass Transfer Operations (Practical)

Credits 01 (30 hrs.)

Practical:

1. **Unit Process:** One or two Examples of each of the following unit process- Nitration, Sulphonation, Friedel-Crafts, reaction, esterification, hydrolysis, oxidation, halogenations, chlorosulphoneation reduction, Polymeryzation, reaction of diazonium salts.
2. Simple laboratory techniques: Crystallization, fractional, crystallization, distillation, fractional distillation, boiling point diagram. Preparation of standard solution: Primary & Secondary standards, determination of H2SO4 & H3PO4 in a mixture.
3. Extraction processes: Phase diagram, partition co-efficient.
4. Study of types of distillation-Simple distillation, Rectification, Steam distillation.
5. Study of yield of crystallization with seeding and without seeding.
6. Study on evaporation with respect to temperature and surface area.
7. Depression and elevation in B.P/M.P. of solids and liquids. Study of boiling point depression.
8. Study of adsorption behavior.
9. Study of humidity parameter using DBT-WBT method and dew point method.
10. Study of characterization of solid particles by screen analysis. Size reduction of solids using crushers and grinders and product analysis by differential analysis by cumulative analysis.
11. Study on efficiency of separation using cyclone.
12. Study on filtration operation.
13. Study on solid liquid mixing and solid-solid mixing.

MJ-9: Fluid Mechanics and Heat Transfer **Credits 04(Full Marks: 75)**

MJ-9T: Fluid Mechanics and Heat Transfer (Theory) **Credits 03 (45 Lectures)**

Course contents:

Unit -1: Utilities - Fuel, Air, Boilers, Steam, Pumps: Fuel: Types of fuels- advantages and disadvantages combustion of fuels composition of fuels. Calorific value, Specifications for fuel oil orate number, cetane number. Air: Specifications for industrial use. Processing of air. Boilers: Specifications for industrial use, various water treatments. Steam : Generation and use. Pumps: Reciprocating pumps, gear pump, centrifugal pumps.

Unit -2 : Fluids & their classification, Viscosity, Newtonian and non Newtonian fluids, Static pressure, Manometer, Mechanism of fluid flow, Types of flow, continuity equation, Bernaulli's theorem, friction factor & friction head. Fluid flow: Basic equation of fluid flow, fans, blowers, compressors, vacuum pumps, ejector.

Unit -3: Fluid moving machineries, Equipments, Pipes and pipe fittings, Pumps Classification and Performance, Reciprocating and Rotary pumps, Centrifugal pumps, Blower, Compressors, Vacuum pump.

Unit- 4: Flow of Heat: Introduction. Heat transfer: Basic Equation of Heat Transfer. Conduction (Fourier law, Thermal conductivity, thermal insulation & problems), Convection (rate of heat transfer and heat transfer coefficients), Radiation (Absorptive, Reflectivity, & Transmissivity, Kirchoff's law concept of black body & examples). Modes of heat transfer, Fourier's law, Thermal conductivity, Thermal insulators, Resistance in series and parallel ,Heat flow through Sphere and Cylinder, Natural and forced convections.

Unit - 5: Natural and forced convections .Heat Transfer equipment . Heat Exchange Equipments: Introduction, Types of Heat Exchanger, Double Pipe Heat Exchanger, Shell& tube Heat Exchanger, Fixed tube, U tube heat exchangers. Extended surface and plate type heat exchanger. Refrigeration cycles.

MJ-9P: Fluid Mechanics and Heat Transfer - lab. **Credits 01 (30 hrs.)**

Practical:

1. Determination of Physical constants: Refractive index, surface tension, Effect of surfactants of surface tension, viscosity-fluids, polymer solutions, effect of additives on viscosity, optical rotation.
1. Study of pipe fittings, pumps and flow meter.
2. Pressure measurement in gas line with manometer.
3. Fluid flow study- Reynolds experiment, Differential pressure meter.
4. Study on working of laboratory centrifuge.
5. Study on heat transfer by conduction and convection

MJ-10: Industrial Instrumentation and Process Control Credits 04(Full Marks: 75)

MJ-10T: Industrial Instrumentation and Process Control (Theory) Credits 03 (45 Lectures)

Course contents:

Unit-1: Temperature: Concept of measurement and accuracy principles, construction and working of temperature measuring instruments- Temperature: Glass thermometers, bimetallic thermometer pressure, spring thermometers, vapor filled thermometers, Expansion thermometer thermoelectric temperature measurement, Resistances thermometers, Pyrometers. Radiation pyrometers.

Unit-2 : Pressure : Pressure Terms, Concept of measurement and accuracy principles , construction and working of Manometers, barometers, Bourdon pressure gauge ,Bellow type and Diaphragm type pressure gauge ,Vacuum measurement, Calibration of pressure gage, Mcleod gauges, Pirani gauges.

Unit-3: Liquid Level Direct: Concept of measurement and accuracy principles, construction and working of Direct and indirect method of liquid level measurement, float type liquid level gauge, ultrasonic level gauges, bubbler system density measurement Sp. Gravity scales, Density and sp. Gravity measurement, Viscosity measurement.

Unit-4: Flow measurement – classification of instruments, Concept of measurement and accuracy principles, construction and working of Differential pressure and differential area meters, Open channel flow measurement.

Unit-5: Control system, Terminology, Manual and automatic control, Open and closed loop control, Process time lags, Modes of control actions, Final Control Element. Indicators, Recorders, Control panels and Control center, instrumentation diagram, Pneumatic and electrical transmission system.

MJ-10P: Industrial Instrumentation and Process Control (Practical) Credits 01 (30 hrs.)

Practical

1. Acquaintance with safely measures in a laboratory, Hazard Chemicals.
2. Ore analysis: Dolomite, Limestone, Calcite, Analysis of alloys such as cupronickel.
3. Industrial Analysis: Analysis of common raw materials as per industrial specifications, such as phenol, aniline, formaldehyde, hydrogen peroxide, acetone, epodixe, olefins, oil. etc.
4. Calibration of thermometers.
5. Process Instrumentation: Transducers for measuring flow control, Determination of Flash point and ignition points of liquids.
6. Water Analysis: Solid content, hardness, COD and other tests as per industrial specifications.

7. Flow Measuring Device: Flow measuring device - Venturimeter & Orifice meter. Floats monographs of representative raw material such as sulphuric acid, toluence, sodium, carbonate, sodium hydroxide, carbon tetrachloride benzoic acid (5-6 compounds), Limit tests for heavy metals Pb, Mg, Fe and ash content.
8. Flow management in pipes of different materials – effect of drag reducers.
9. Instrumental methods of analysis: Use of calorimeter, pH meter, potentiometer, conductometer, refractometer, polarimeter, Material testing: Testing of alloys, identification of plastic/rubber, estimation of yield point, Young's modulus, flaredness, optical, thermal and electrical properties.

MAJOR ELECTIVE (DSE)

Major Elective -1: Concept of heavy Inorganic Chemicals & petrochemicals & Industrial and Environmental pollution **Credits 04(Full Marks: 75)**

MJ DSE-1T: Concept of heavy Inorganic Chemicals & petrochemicals & Industrial and Environmental pollution (Theory) **Credits 04**

Course contents:

Unit-I: Heavy Inorganic chemicals:

i) Manufacture of Sulphuric Acid, Hydrochloric acid, Nitric acid, Phosphoric acid.
ii) Fertilizer Industries: Phosphorus Fertilizers - phosphorus, phosphoric acid, ammonium phosphate, superphosphate, triple superphosphate, Nitrogen Fertilizers - Urea, other fertilizers like ammonium nitrate and ammonium sulphate. Inorganic disinfectant chemicals.
Note: Physico-Chemical Principles, Major equipment's, material of construction to be emphasized in the entire above topic.

Unit-II: Petrochemicals:

Crackers-isolation of different chemicals:

i) C_1 chemicals: Methanol, Formaldehyde, Chlorinated Methanes.
ii) C_2, C_3 and C_4 chemicals: Ethyl Chloride, Vinyl Chloride, Ethylene oxide, Ethylene Glycol, Ethanolamines, Acetaldehyde, Acetic acid, Isopropanol, Oxo-synthesis, Acrylonitrile.
iii) Aromatic compounds- Production and isolation of BTX, monobasic and di-basic acid and its ester, Styrene, Napthalene, Linear Alkyl Benzenes and their sulphonates.

Unit-III: Industrial & Environmental pollution

Industrial & Environmental pollution - An overview: Pollution and pollutants-sources, types and consequences. Air and Water pollution, solid wastes. Imbalance in atmosphere, Hydrosphere and Lithosphere. Industrial Effluents. Industrial Episodes of hazards and pollution: Minamata, Love canal, Flixborough, Bhopal, Chernobyl.
Water as Environmental Resources: Hydrological cycle. Water quality, criteria of pollution suspended solids; physical chemical and biological; dissoloved solids-organics, Bio-degradable and Nonbiodegradable; Inorganic heavy metal and others.
Assessment of water quality- sampling and analysis- Dissoloved oxygen(DO), Bio- chemical oxygen demand (BOD), Chemical oxygen demand(COD), Industrial methods for total organic carbon (TOC), Colorimetric and gas chromatographic methods; Analysis of toxic inorganic pollutants- as fluoride, Hg, Cd, Pb, Sb, Coliform test.

Drinking water standards (India and WHO), Industrial discharge Standards -Minimum National Standards (MINAS)

Waste water treatment methods: Physical, chemical and biological, Primary, secondary and tertiary, Removal of Biodegradable Organics- Activated Sludge Methods, Fixed Film methods- Trickling Filter, Rotating Biological Contractor (RBC), Design criteria of Bio- reactor, Pond Treatment and soil treatment systems. Bioremediation. Concepts of recycling and zero discharge industries.

Air composition and quality: Chemical and photochemical reactions in the atmosphere. Ozone formation and depletion, greenhouse effect.

Unit-IV: Environmental Pollution Law

Some important environmental laws, pollution prevention Act of 1990.

MINOR (MI)

TO BE DECIDED (SELECTED FROM OTHER DECIPLINES)

SEMESTER-VI

MAJOR (MJ)

MJ-11: Advanced Numerical Analysis and Advanced Reaction kinetics

Credits 04 (FM: 75)

MJ-11T: Advanced Numerical Analysis and Advanced Reaction kinetics (Theory)

Credits 03 (45 Lecture)

Course contents:

Unit-I : Advanced Numerical Analysis **(Marks 25)**

Data acquisition and processing:

Interpolation: Finite differences; Newton's forward and backward interpolation formula; Lagrange's formula; Central differences; Formula of Gauss, Bessel and Everett curve fitting: Method of least squares; Cubic splines.

Solution of algebraic and transcendental equations: Iterative methods, Newton-Raphson method, convergence and efficiency of method.

Matrices: Eigen value and Eigen vectors, matrix decomposition, inverse of matrix, norm of matrix.

Solution of System of Linear equations: Direct methods: Gauss elimination method, LU – Decomposition, Cholesky method, iteration methods: Jacobi method, Gauss- Seidel method; Ill conditioned systems. Numerical integration and differentiation.

Numerical solution of ordinary differential equations: Euler method, Modified Euler method and Runge-Kutta method.

Finite difference method for solution of boundary value problems of ordinary and partial differential equations.

Unit – II: Advanced Reaction kinetics **(Marks 25)**

Fundamental aspects of Reaction Kinetics, Collision and Transition state theories of reactions rates. Kinetics of homogeneous and heterogeneous catalytic reactions. Kinetics of electrochemical reactions with special reference to hydrogen evolution reaction and electrodeposition.

Complex reactions; Mechanism of complex reaction, derivation of differential rate equations, steady state and rate limiting approximations as applied for complex reactions, fast reactions, techniques for study of fast reactions. Explosion reactions. Ionic chain reactions; Mechanism of

ionic chain reactions and their kinetics. Kinetic treatment of diffusion in solids, liquids and solutions.

MJ-11P: Advanced Numerical Analysis and Advanced Reaction kinetics (Practical)

Credits 01 (30 hrs.)

Practical

a) Estimation of Lime by Rapid Lime Method, Total Carbonate of Sample, Full analysis (SiO_2, Al_2O_3, Fe_2O_3, CaO and MgO) of Cement & Clinker.

b) Physical testing of Cement: Compressive testing, Specific surface area analysis etc.

Suggested Readings

1. S. S. Sastry: Numerical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi.
2. M. K. Jain; Numerical Methods for Scientists and Engineers et. al., New Age International Publishers, New Delhi.
3. K.J. Laidler: Chemical Kinetics, 3rd Ed. Pearson Education Inc.
4. J. Rajaram, J.C. Kuriacose: Kinetics and Mechanisms of Chemical Transformations, McMillan. India Ltd.
5. S.K. Upadhayay: Chemical Kinetics and Reaction Dynamics, Anamaya Publishers, New Delhi
6. J.O'M. Bockris and A.K.N. Reddy: Modern Electrochemistry Vol II, Plenum Press, and New York.

MJ-12: Petroleum Chemistry **Credits 04 (Full Marks: 75)**

MJ-12T: Petroleum Chemistry (Theory) **Credits 03 (45 Lectures)**

Course contents:

Unit-I : Composition of Petroleum

Introduction to crude oil, exploratory methods, oil reservoirs, Evaluation of oil stocks, Physical properties of a petroleum oil- Specific Heat, Latent Heat, Critical point & other properties, coefficient of Expansion, Detonation Characteristics.

Unit-II : Introduction to processing and Refinery Products

Refinery and Distillation Processes : Boiling Range of Stock, Arrangement of Towers, Flow diagram and operating conditions, Vacuum distillation, Desulphurisation, Refining by adsorption, Preliminary ideas of treating equipments and extraction processes, Dewaxing.

Unit-III: Meaning of the important terms

Meaning of terms such as - Pour point depressants, drag reducers, viscosity reducers, ignition point, flash point, octane number, doctor solution types of hydrocarbon fuels and their characteristics.

Unit-IV: Basic operations in petrochemical industry

Basic idea about the following operations with respect to process, mechanism, catalysts used and applications: Cracking - Catalytic cracking, Hydrocracking, Isomerization, Reforming, Isomerization, Alkylation. Sulphur, hydrogen, petroleum coke and nitrogen compounds from petroleum.

Various catalysts used in petrochemical industry, preparation structure, applications and selectivity.

MJ-12P: Fuels & Furnace Lab (Practical) **Credits 01 (30 hrs.)**

Practical

Determination of Fire Point, cloud point, pour point, Kinetic Viscosity of oil, Proximate analysis of coal, Calorific value of Solid Fuel.

MJ-13: Green Chemistry **Credits 04 (Full Marks: 75)**

MJ-13T: Green Chemistry (Theory) **Credits 04 (60 Lectures)**

Course contents:

Unit-I: Introduction to Green Chemistry:

What is Green Chemistry? Emergence of green chemistry, Need for Green Chemistry. Goals of Green Chemistry, Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Unit-II: Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry and their explanation with examples *Special emphasis on the following:*

- Designing a Green Synthesis using these principles; Prevention of Waste/ by products; maximum incorporation of the materials used in the process into the final products , Environmental impact factor
- Green metrics to assess greenness of a reaction, e.g. Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- Prevention/ minimization of hazardous/ toxic products reducing toxicity
- Risk = (function) hazard x exposure; waste or pollution prevention hierarchy
- Designing safer chemicals with minimum toxicity yet has the ability to perform the desired functions
- Green solvents: super critical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, solvents obtained from renewable resources and how to compare greenness of solvents
- Energy requirements for reactions – alternative sources of energy: use of microwaves, ultrasonic energy and photochemical energy
- Selection of starting materials; should be renewable rather than depleting
- Avoidance of unnecessary derivatization – careful use of blocking/protecting groups
- Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, bio catalysis, asymmetric catalysis and photo catalysis.
- Design for degradation: A product should not persist after the commercial function is over e.g. soaps and detergents and some more
- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.
- Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route o carcarbaryl) and Flixiborough accident (safer route to

cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

Unit-III: Examples of Green Synthesis/ Reactions

- Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
- Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents, Diels-Alder reaction and Decarboxylation reaction
- Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

Unit-IV: Real world case studies based on the Presidential green chemistry awards of EPA

- Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
- A new generation of environmentally advanced wood preservatives: Getting the chromium and Arsenic out of pressure treated wood.
- An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
- Healthier Fats and oils by Green Chemistry: Enzymatic Inter esterification for production of No Trans-Fats and Oils.
- Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting.
- Using a naturally occurring protein to stimulate plant growth, improve crop quality, increase yields, and suppress disease.

Unit-V: Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimcry and green chemistry, biomimetic, multifunctional reagents, combinatorial green chemistry, mechanochemical and solvent free synthesis of inorganic complexes; co crystal controlled solid state synthesis (C^2S^3); Green chemistry in sustainable development.

MAJOR ELECTIVE (DSE)

Major Elective -2: Analytical methods in Chemistry **Credits 04(FM: 75)**

MJ DSE-2T: Analytical methods in Chemistry (Theory) **Credits 03**

Course contents:

Unit I: Qualitative and quantitative aspects of analysis

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression.
Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit II: Optical methods of analysis

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules.
UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Transmittance. Absorbance and Lambert-Beer law.
Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.
Flame Atomic Absorption and Emission Spectrometry:
Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Unit III: Thermal methods of analysis

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Unit IV: Electroanalytical methods

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations.
Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Unit V: Separation techniques

Solvent extraction:
Classification, principle and efficiency of the technique.
Mechanism of extraction: extraction by solvation and chelation, Technique of extraction: batch, continuous and counter current extractions, Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.
Chromatography:
Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition & ion exchange, Development of chromatograms: frontal, elution and displacement methods.

MJ DSE-2P: Analytical methods in Chemistry (Practical) **Credits 01**

List of Practical

I. Separation Techniques
Chromatography:
(a) Separation of mixtures
(i) Paper chromatographic separation of Co^{2+} and Ni^{2+}.
(ii) Separation and identification of the amino acids present in the given mixture by paper chromatography. Reporting the R_f values.

II. Solvent Extractions:
(i) To separate a mixture of Ni2+& Fe2+ by complexation with DMG and extracting the Ni2+ DMG complex in chloroform, and determine its concentration by spectrophotometry.

III. Analysis of soil:
(i) Determination of pH of soil.
(ii) Total soluble salt
(iii) Estimation of calcium, magnesium
(iv) Qualitative detection of nitrate, phosphate

IV. Ion exchange:
(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of amino acids from organic acids by ion exchange chromatography.
Spectrophotometry
Verification of Lambert-Beer's law and determination of concentration of a colored species ($CuSO_4$, $KMnO_4$)

Suggested Readings:

Theory:

- Vogel, Arthur I: A Text book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5 th Ed. The English Language Book Society of Longman .
- Willard, Hobart H. et al.: Instrumental Methods of Analysis, 7 th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6 th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A., Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore, 1998.
- Mikes, O. and Chalmers, R.A. Ed. Laboratory Hand Book of Chromatographic and Allied Methods, Elles Horwood Ltd. London.
- Dilts, R.V. Analytical Chemistry – Methods of separation Van Nostrand 1974

Practical:

- Vogel, Arthur I: *A Text book of Quantitative Inorganic Analysis* (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobart H. et al.: *Instrumental Methods of Analysis, 7th Ed.* Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; *Analytical Chemistry, 6th Ed*. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: *Exploring Chemical Analysis*, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Thomson Asia Pvt. Ltd. Singapore, 1998.
- Mikes, O. & Chalmers, R.A. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Horwood Ltd. London.

MINOR (MI)

TO BE DECIDED (SELECTED FROM OTHER DECIPLINES)