Punyashlok Ahilyadevi Holkar Solapur University, Solapur

NAAC Accredited-2015

'B' Grade (CGPA 2.62)

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Syllabus: Industrial Chemistry

Name of the Course: M.Sc. II (Sem.– III & IV)

(Syllabus to be implemented from w.e.f. 2021)

PUNYAHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

M. Sc. II, INDUSTRIAL CHEMISTRY COURSE SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS) (w.e.f. June 2021)

A two-year duration **M. Sc. Industrial Chemistry** course syllabus has been prepared as per the CBCS semester system. M. Sc. II, SEM-III & SEM-IV Industrial Chemistry syllabus will be implemented from June 2021. The syllabus has been prepared taking into consideration the syllabi of other Universities, SET, NET, UGC guidelines, and the specific inputs of the Expert Committee Members.

General Structure of the Course:

The course will be of four semesters spread over two academic years. Each semester will have four theory papers of 80 marks for university external examination and 20 marks for internal examination for each semester and two practical of 80 marks, 20 marks for internal practical. The distribution of marks is mention below

Theory Paper (Semester exam), 16 X 80+20 marks	1600 marks
Practical's (semester end exam.), 8 X 80+20 marks	800 marks
Tutorials for each semester, 4 X 25	100 marks
	Total: 2500 marks

Ratio of marks (Theory: Practical): (73:27)

Semester	Code	Title of the Paper	Semester exam			L	T	P	Credits
I		**Hard core**	**Theory**	**IA**	**Total**				
	HCT-101	Inorganic Chemistry -I	80	20	100	4		-	4
	HCT-102	Organic Chemistry -I	80	20	100	4		-	4
	HCT-103	Physical Chemistry -I	80	20	100	4		-	4
		Soft Core (Any one)	80						
	SCT-104	Analytical Chemistry -I	80	20	100	4		0	4
	SCT-105	Chemistry in Life Sciences	80	20	100	4		0	
		Practical							
	HCT- 106	Inorganic	40	10	50	-	-	2	6
	HCP- 107	Organic	40	10	50	-	-	2	
40	HCP-108	Physical	40	10	50	-	-	2	
		Soft core (Any one)							
	SCP-109	Analytical	40	10	50	-	-	2	2
	SCP-110	Analytical	40	10	50	-	-	2	
	T-I	Tutorial			25				1
		Total for first semester	**480**	**120**	**625**				**25**
II		**Hard core**							
	HCT-201	Inorganic Chemistry -II	80	20	100	4		-	4
	HCT-202	Organic Chemistry -II	80	20	100	4		-	4
		Soft core (Any one)	80						
	SCT-203	Physical Chemistry -II	80	20	100	4		-	4
	SCT-204	Green Chemistry	80	20	100	4		-	
		Open elective (Any one)	80						
	OET-205	Analytical Chemistry-II	80	20	100	4		-	4
	OET-206	Medicinal Chemistry	80	20	100	4		-	
	T-2	Tutorial			25		1		1
		Practical							
	HCP- 207	Practical HCP 2.1	40	10	50	-	-	2	4

	HCP-208	Practical HCP 2.2	40	10	50	-	-	2	
		Soft core (Any one)							
	SCP-209	Practical SCP2.1	40	10	50	-	-	2	
	SCP-210	Practical SCP2.2	40	10	50	-	-	2	2
		Open elective (Any one)							
	OEP-211	Practical OEP2.1	40	10	50	-	-	2	
	OEP-212	Practical OEP2.2	40	10	50	-	-	2	2
		Total for second semester	**480**	**120**	**625**				**25**
III		**Hard core**							
	HCT-301	Unit operations of chemical Engineering	80	20	100	4		-	4
	HCT-302	Unit processes in Chemical Technology	80	20	100	4		-	4
		Soft core (Any one)	80						
	SCT-303	Instrumental Analysis-I	80	20	100	4	1	-	
	SCT-304	Instrumental Analysis -II	80	20	100	4		-	4
		Open elective (Any one)	80						
	OET-305	Advanced Topics in Industrial Chemistry-I	80	20	100	4		-	
								-	4
	T-3	Tutorial			25		1		1
		Practical							
	HCP- 306	Inorganic Chemistry	40	10	50	-	-	2	2
	HCP-307	Organic Chemistry	40	10	50	-	-	2	2
	HCP-308	Physical Chemistry	40	10	50	-	-	2	2
		Open elective (Any one)							
	OEP-309	Analytical Chemistry-I	40	10	50	-	-	2	
	OEP-310	Analytical Chemistry-II	40	10	50	-	-	2	2
		Total for third semester	**480**	**120**	**625**				**25**
IV		**Hard core**							
	HCT-401	Chemical Industries	80	20	100	4		-	4
	HCT-402	Pollution Monitoring and Control	80	20	100	4		-	4
	HCT-403	Nanomaterial and its Characterization	80	20	100	4		-	4
		Soft core (Any one)							

	SCT-404	Industrial Management and Material Balance	80	20	100	4		-	4
	SCT-405	Advanced Topics in Industrial Chemistry-II	80	20	100	4		-	4
	T-4	Tutorial			25		1		1
		Practical							
	HCP - 406	Inorganic Chemistry	40	10	50	-	-	2	2
	HCP-407	Organic Chemistry	40	10	50	-	-	2	2
	SCP-408	Physical +Analytical Chemistry	40	10	50	-	-	2	2
	HCMP-409	Major Project	40	10	50	-	-	2	2
		Total for four semester	**480**	**120**	**620**				**25**
	Total								**100**

L = Lecture T = Tutorials P = Practical
4 Credits of Theory = 4 Hours of teaching per week
2 Credit of Practical = 4 hours per week
HCT = Hard core theory
SCT = Soft core theory
HCP = Hard core practical
SCP = Soft core practical
OET = Open elective theory
OEP = Open elective practical
HCMP = Hard core main project

HCT – 301 Unit operations of Chemical Engineering

Credits-04 **60 hr**

Course Objective

To introduce mass and heat transfer processes, their practical application in industries and basic equipment extensively demanded in industries.

Course Outcomes

At the completion of this course, students should be able to:

1. Apply basic principles of Heat & mass transfer to basic engineering systems
2. Understand the construction & working of various equipments used in distillation, extraction, leaching, drying, and filtration.
3. Analyze and design plate & packed columns for distillation, mixer-settlers and RDC for extraction, packed column batch & continuous driers, Constant rate & constant pressure filters.

Unit I:

A) Heat Exchangers

Introduction; Shell and Tube Heat Exchanger, Shell side and tube side passes ;Classification of Shell and Tube Heat Exchangers-Fixed tube sheet heat exchanger, Fixed tube sheet 1-2 heat exchanger, Internal floating head heat exchanger, U-tube heat Exchanger, Kettle Reboiler.

B) Evaporation

Introduction; Types of evaporators-Jacketed, Horizontal and Vertical tube evaporators, forced Circulation evaporation; Effect of various parameters on Evaporation; Multiple effect evaporators and its Economy.

Unit II:

A) Distillation

Introduction; Boiling and Distillation; Vapor liquid equilibria; Azeotropic mixture; Flash/Equilibrium distillation; Steam distillation; Vacuum distillation; Extractive distillation; Batch and Continuous distillation; Equipment and working of Rectifier/Fractionating column-Bubble cap plate, Sieve-plate, Valve plate, Downcomers.

B) Extraction

Introduction; Selection of solvent for Extraction; Extraction with agitation and its Equipments-Mixer Settler, Spray column ,packed column, Sieve column , Rotating disc Contactor, pulse column; Extraction with reflux.

C) Leaching

Introduction; solid liquid leaching- Batch plant for extraction of oil from seed, Bollman extractor, Rotocel extractor; continuous leaching Equipments-Dorr Agitator, Dorr thickener, Continuous counter- current extraction.

Unit III:

A) Filtration

Introduction; Principles of cake filtration ; Types of filtration-Constant rate, Constant pressure filtration; Filter aids; washing filter cake; Filtration Equipment – centrifugal filtration, Rotary drum filter.

B) Crystallization

Introduction; Supersaturation, Methods of supersaturation, Nucleation, Homogeneous Nucleation; crystal growth; Caking of crystal; Crystal hydrates and Solvates; Deliquescence and Hygroscopicity; Efflorescence; crystallization equipment-Agitated tank crystallizer, Swenson - walker crystallizer, vacuum crystallizer, Oslo cooling crystallizer.

Unit IV: 15hr

A) Crushing, Grinding, Drying and Mixing

Equipment for crushing-Blake Jaw crusher, Gyratory crusher; Equipment for grinding –Hammer mill, Revolving mill, Ball mill ; Equipment for drying processes-Tray, Tunnels, Drum, Rotary ,and Spray driers, Equipment for mixing processes-propeller, turbines.

B) Mechanical Separation and Beneficiation

Introduction; Screening sieves- equipment and use, Removal of solid from gases- Cyclone, Hydrocyclone, Dust filters- electrostatic dust precipitators, colloidal particles and their removal-scrubbers.

C) Mechanical properties; **Material of Construction for Designing Equipment**

Reference Book:

1. F.A. Henglein: Chemical Technology (Pergamon)

2. J.M. Coulson, J.F. Richardson,: Chemical Engineering Vol I, II,III (Pergamon)

3. R.N. Shreve: The Chemical Process industry (MGH)

4. W.L. Badger and J.T. Bandchero: Introduction to Chemical Engineering (MGH).

5. O.A. Hougen, K.M. Watson and R.A. Ragetz: Chemical Process Principle Vol I II (JW).

6. Prakash G. More, Comprehensive Industrial Chemistry, Pragati prakashan, Meerut

(Uttar Pradesh)

HCT – 302 Unit Processes in Chemical Technology

Credits-04 **60hr**

Course Objective

To impart knowledge to the students with regards to unit processes available commercially and blend of unit operation with unit processes that covers various unit processers like halogenations, oxidation, nitration, sulfonation, esterification, Polymerization.

Course Outcomes

At the completion of this course, students should be able to:

1. Gain knowledge about raw materials, reagents, their stoichiometry, and reaction conditions required to carry out the specific unit process.
2. Understand reaction mechanism, kinetics and thermodynamics of unit processes carried out in large scale.
3. Knowledge of material of construction for designing different types of equipment for different unit processes.
4. Understand the safety and hazard criteria related to each type of unit processes.

Unit I: Nitration **15hr**

A) Introduction; Nitrating agents, Aromatic nitration, Thermodynamics of Nitrations; Heat of Nitration ; Process equipment for technical nitration; Mixed acid for nitration- Acid processing, Mixed acid composition, D.V.S. Calculation, Relation between D.V.S. and Stablity of Nitrator Charge ; Typical industrial Nitration process (Nitrobenzene, and α-Nitronaphthalene)

B) Chemical reactors

Classification of chemical reactors

Unit II:

A) Sulphonation **15hr**

Introduction; Sulphonating agents and their applications; The Desulphlonation Reaction – General consideration, Separation of isomers, Raw material and waste Recovery ; working -up procedures; Industrial equipments and Techniques-Material of construction, Commercial Sulfonation Methods; Technical preparation of Sulfonates - Aromatic Sulfonates (The mono sulfonation of Benzene, Anthraquinome -1- Sulfonates).

B) Reagents in Organic Synthesis : Use of following reagents in organic synthesis and functional group transformations- Gilman's reagent, dicyclohexylcarbodimide, Woodward and Prevost hydroxylation, osmium tetraoxide, DDQ, selenium dioxide,

Unit III: A) Halogenation **15hr**

Introduction; Design and construction of Equipment for Halogenation ; Technical Halogenations - Manufacturing Processes for Monochlorobenzene, and Vinyl chloride (Ethylene and Acetylene).

Unit III: B) Esterification

Introduction; Esterification by organic acid; Esterification of carboxylic acid Derivative; Ester by addition to unsaturated system; Manufacture of Vinyl acetate, Cellulose acetate.

Unit III: C) Selective Organic Name Reactions: Favorskii reaction,, Michael addition, Barton reaction, Hofmann Loffler-Freytag reaction, Shapiro reaction, Baeyer-Villiger reaction, Chichibabin reaction

Unit IV: A) Polymerization **15hr**

Introduction; Chemistry of polymerization reactions; Methods of polymerization, Polymerization kinetics; industrially importance polymerization and polymers: Phenolic, Urea and melamine and alkyl resins, Polyamides, Polyesters, Epoxy resins, Polyethylene, Polypropylene, Vinyl polymers, Polystyrene, Acrylonitrile polymers.

Unit IV: B) Oxidation

Introduction; Types of oxidative reactions; Liquid phase oxidation with oxygen-Acetaldehyde to Acetic acid, Vapour phase oxidation aliphatic compound- oxidation of Methanol.

Reference Books

1. P.H.Groggins: Unit processes in organic synthesis (MGH)
2. F.A.Henglein: Chemical Technology (Perga mon)
3. M.G.Rao & M. Sitting: Outlines of Chemical Technology (EWP)
4. Clausen,Mattson: Principle of Industrial Chemistry
5. F.A. Lowenheim & M.K. Moran: Industrial Chemicals
6. Kirks & others: Encyclopedia of Chemical Technology
7. Kent: Riegels Industrial Chemistry (N-R)
8. Prakash G. More, Comprehensive Industrial Chemistry, Pragati Prakashan, Meerut (Uttar Pradesh)
9. S.D.Shukla & G.N.Pandey: A text book of Chemical Technology Vol. II
10. J.K.Stille: Industrial Organic Chemistry (PH)
11. Billmayer: A text book of Polymer Science

SCT-303 Instrumental Analysis -I

Credits-04 **60 hr**

Course Objective

To provide basic information regarding application of various spectroscopic tools like, IR, NMR, mass, and electro-analytical technique to analyze and authenticate unknown compound synthesized in chemical laboratory.

Course Outcomes

At the completion of this course, students should be able to:

1. Understand the basic of spectroscopy
2. Understand theory, principle and application of various analytical techniques like IR, NMR, Mass Spectroscopy and electro-analytical technique that help to examine the authenticity and also chemical nature of unknown compound.
3. Analysis of sample with the best utilization of technique that provide structure information.
4. Identification of impurities and purities in sample and also method development for specific compound nature.

Unit I: **15hr**

Combine simpler structure elucidation with IR, ^{1}H NMR, ^{1}C NMR, Mass spectrometry and two dimensional spectroscopy (2D)

Unit II:

A) Electro Analytical Techniques/Sensor **15hr**

Sensors; Electro analytical sensors, Sensors electrode- Metal electrode sensors , Membrane electrode- pH Sensor, Liquid membrane ,Crystalline membrane, Gas sensing, Biomembrane/Enzyme electode; Ionic conductors- Zircona, Tin oxide, Zinc oxide, Titania

B) Nephlometry and Turbidometry

Introduction; Principle; Turbidimetry and Nepelometry- Instrumentation and Applications.

Unit III:

A) Introduction to three electrode system: **15hr**

Modern polarography and voltammetry necessity and development of new voltammetry techniques and their comparison with classical DC polarography,

B) Voltammetry methods:

Sampled DC polarography (TAST), linear sweep voltammetry (LSV), cyclic voltammetry (CV), diagnostic criteria of cyclic voltammetry

Unit IV: Chromatography **15hr**

Principles of gas chromatography, plate theory of gas chromatography, Instrumentation for gas chromatography, working gas chromatography, application of gas chromatography, programmed

temperature chromatography, flow programming chromatography, gas-solid chromatography, and hyphenated techniques in chromatography- GC-MS, LC-MS

Books Recommended:

1. Introduction to Spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 3rd Ed. (Harcourt college publishers).
2. Spectrometric identification of organic compounds R. M. Silverstein, F. X. Webster, 6th Ed. John Wiley and Sons.
3. Spectroscopic methods in organic chemistry – D. H. Williams and I. Flemming Mc Graw Hill.
4. Absorption spectroscopy of organic molecules – V. M. Parikh
5. Nuclear Magnetic Resonance – Basic Principles- Atta-Ur-Rehman, Springer- Verlag (1986).
6. One and Two dimensional NMR Spectroscopy- - Atta-Ur-Rehman, Elsevier (1989).
7. Organic structure Analysis- Phillip Crews, Rodriguez, Jaspars, Oxford University Press (1998).
8. Organic structural spectroscopy- Joseph B. Lambert, Shurvell, Lightner, Cooks, Prentice-Hall (1998).
9. Organic structures from spectra- Field L. D., Kalman J.R. and Sternhell S. 4th Ed. John Wiley and sons Ltd.
10. NMR spectroscopy of Organic compounds. Jackmann and Sternhell S.
11. Spectroscopy: Donald L. Pavia, Gary M. Lampman.
12. A.J.BardandL.R.Faulkner,Electrochemical Methods,2ndEd,John Wiley and sons, Asia Pvt. Ltd,(2004)
13. J.J.Lingane , Electro-analytical Chemistry, 2 ndEd, Inter science Publishers, Inc., New York (1958)
14. A.M.Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., New York,(1980)
15. A.J.Bard(Ed), Electro-analytical Chemistry, Marcel DekkreInc., New York (A series of volumes)..

16. Donald T.Sawyer ,A.Sobkowiak and J.L.Roberts,Jr., Electro chemistry for Chemists, 2 ndEd., John Wiley and Sons, Inc., New York.,(1995).

17. D.A.Skoog, F.J.Holler, J.A.Nieman, Principles of Instrumental analysis, 6thEd.

18. R.D.Braun.introduction to Instrumental Analysis, MacGrawhill, 1987.

19. H.A. Willard, L.L.Merritt, J.A.Dean&F.A.Settle, Instrumnetal methods of analysis, 5thEd.CBS, 1986.

20. M.noel,K.J.Vasu,Cyclic Voltammetry and Frontiers of electro chemistry,IBH, NewDelhi,1990.

21.D.A. Skoog & D.M. West, Fundamentals of Analytical Chemistry - Holy Rinchart.

22. G.W. Ewing, Instrumentation Methods of Chemical Analysis, McGraw Hills.

23. S.M. Khopkar, Basic Concepts of Analytical Chemistry.

24. D. Ambrose and B.A. Amborse, As chromatography.

SCT-304 Instrumental Analysis -II

Credits-04 **60 hr**

Course Objective

To provide basic information regarding application of various spectroscopic tools like, IR, NMR, mass, and electro-analytical technique to analyze and authenticate unknown compound synthesized in chemical laboratory.

Course Outcomes

At the completion of this course, students should be able to:

1. Understand the basic of spectroscopy
2. Understand theory, principle and application of various analytical techniques like IR, NMR, Mass Spectroscopy and electro-analytical technique that help to examine the authenticity and also chemical nature of unknown compound.
3. Analysis of sample with the best utilization of technique that provide structure information.
4. Identification of impurities and purities in sample and also method development for specific compound nature.

UNIT-I Group Theory **15hr**

Molecular symmetry, elements of symmetry and symmetry operations, Products of operation, point group, classification of Molecules into point group, reducible and irreducible representation, the great Orthogonality theorem, character table, symmetry aspects of Molecular orbitals.

Unit-II Electronic absorption Spectroscopy **15hr**

Term symbols, energies of atomic and Molecular transitions, Selection rule, Morse potential energy diagram, electronic transitions, polarized absorption spectra. Nature of absorption spectra, nature of absorption spectra of transition metal complexes, Orgel diagram, Tanabe Sugano diagram, and charge transfer spectra.

UNIT-III Mossbauer Spectroscopy **15hr**

Introduction to Mossabaur effect, recoilless emission & absorption of x-rays, Instrumentation, isomer shift, Quadrapole splitting and hyperfine interactions, application of Mossbaur effect to the investigations of compounds of iron and tin .

UNIT-IV Electron spin Resonance [ESR] 15hr

A) Principles of ESR, hyperfine splitting in simple systems, Instrumentation, factors affecting G values, applications to inorganic complexes.

B) Nuclear Quadra pole Resonance Spectroscopy [NQR]

Introduction, effects of magnetic field on the spectra, relation between electric field gradient and structure, application of NQR.

Reference Books

1. Fundamentals of Molecular Spectroscopy. By C N Banwell.
2. Electron Spin Resonance. By Assculiein.
3. Molecular Spectroscopy. By G M Barrow
4. Molecular Spectroscopy. By I N Levine. Wiley Interscience.
5. Basic Concept in Analytical chemistry, by S.M. Khopkar.
6. Spectroscopy (Atomic and Molecular) by G R Chatwal and S K Anand
7. Instrumental methods of chemical analysis by H. Kaur
8. F. J. Welcher: Standard methods of Chemical analysis, 6th Ed. Vol. I and II(D. Van Nostard Comp.)
9. I. M. Kolthoff: Treatise on Analytical Chemistry Vol. I & II
10. F. D. Snell: Encyclopedia of industrial Chemical Analysis Vol. 1 to 20 (John Wiley)
11. Riech: Outline of Industrial Chemistry.
12. K. H. Buchel: Chemistry of Pesticides (John Wiley)
13. K. Burger, Coordination Chemistry-experimental methods, Butterworth's
14. R. Drago: Physical method in Inorganic Chemistry, DUSAP.
15. Hill & Day advanced methods in Inorganic Chemistry, J.Weily
16. F.A. Cotton, chemical application of group theory, Weily eastern

17. Figgis, Introduction to ligand field theory field

18. Schaefer & Gilman: Basic principles of ligand field Theory, J. Wiely

19. P.R. Backer: Molecular symmetry and Spectroscopy A.P.

20. Ferraro Ziomeek, Introduction to Group theory, plenum Soctland Molecular symmetry DVN

21. Dorian: symmetry in Chemistry EWAP

22. Hall: Group theory and symmetry in Chemistry MGLt

23. Nakamoto Infrared R Raman Spectra of Inorganic & Coordination compounds J.Weily

24. Nakanisha: Spectroscopy and structure J. Weily

OEP 305 – Advanced Topics in Industrial Chemistry-I

Credits-04 60 hr

Course Objective

To gain knowledge on types of fuels and their characteristics, combustion systems with emphasis on engineering applications and to provide fundamental information concerning pharmaceutical dosage forms, their merits and demerits along with analysis of fertilizer constituent in view of green chemistry.

Course Outcomes

At the completion of this course, students should be able to:

1. Understand various types of formulation of pharmaceutical dosage forms viz. solid, semi-solid, syrup and intravenous.
2. Understand thoroughly tablet and capsule production at commercial scale.
3. Meticulously understand analysis procedure of constituents in fertilizer.
4. Recognize and carry out methods to purify fuels on the basis of phase.
5. Understand how to implement and work as per green chemistry guidelines

Unit I: 15hr

A) Analysis of Fertilizers - Sampling, sample preparation. Analysis of nitrogen, phosphrous and potassium. Nitrogen- urea nitrogen, Kjeldahl nitrogen method, Ammonia nitrogen; phosphrous- Total phosphrous. Alkalimetric ammonium molybdophosphate method, potassium - potassium by sodium tetraphenyl borate method.

B)Fuel analysis: Introduction to Solid, liquid and Gaseous fuel ; Analysis of coal - Ultimate and Proximate analysis ; Analysis of Liquid fuel-Aniline point, Flash point and Fire point; Octane number of Liquid; Determination of Calorific valve of Fuel by bomb Calorimeter; Orsat apparatus and its use in exhaust gas analysis. Lubricant analysis-cloud point and pour point, carbon residue, viscosity by Redwood method

Unit II:

A) Drug 15hr

Introduction;Pharmacokinetics-absorption,distribution,metabolism,excretion,Toxicity: Pharmacodynamics-receptor, protein receptor, DNA as receptor; Concept of prodrug; Pharmacophore; LD_{50}, ED_{50} , $IC_{50,}$ MIC,; Structure activity relationship in drug- elucidation with sulpha drug; Synthesis of drug- chloroquine, Salbutamol, Ibuprofen ,methyldopa, Alprazolam, ciprofoxacin.

Unit III:

Formulation of Drug 15hr

Introduction; Need for the conversation of drug into medicine; Additives and their role; Classification of drug –Route-wise dosage forms, Solid dosage forms; solid dosage forms- Tablets, Capsule; liquid dosage forms-parenterals; liquid oral dosage forms- Syrups, suspension; Semi –solid dosage forms – ointments, creams.

Unit-IV: **15hr**

A) Pharmacopoeial analysis of drugs

Introduction, Assay of drug-Analgesic drug; Analysis of pharmaceuticals using IP/B.P./U.S.P procedures.

B) Green Chemistry

Introduction, Alternative energy sources for initiation and execution of chemical reaction: Microwave and sonochemistry.

Books Recommended:

1.P.T. Aastae and J.C. Werner: Green Chemistry Theory and practical (Oxford Press 1998).

2. F.J. Welder: Standard Methods of chemicals analysis Vol III part A and B.

3. I.P./B.P and U.S.P. books latest edition

4. Burger: Medicinal chemistry (I.W.)

5. W.O. Foye: Principles of medicinal chemistry (L.E.)

6. Zechmeister: Progress in chemotherapy (C.H.)

7. Lendicer and Mitscher: The Organic Chemistry of drug synthesis

HCT - 401 Chemical Industries

Credits-04 60 hr

Course Objective

To make students understand process technologies of various organic and inorganic process industries.

Course Outcome:

1. Realize a manufacturing of various inorganic and organic chemicals.
2. Comprehend the process flow diagram and various process parameters.
3. Understand and identify to solve problems arising during production.

Unit I: A)

A) Metallurgy Industry **15hr**

Extraction and applications of metal alloys

a) Iron and steel: Iron, steel alloy, tool steel, stainless steel.

b) Aluminum

B) Cement Industry

Introduction; Classification and Manufacturing processes of Cement and Lime; Setting and Hardening process.

C) Glass Industry

Introduction; Physical and Chemical properties; Characteristics of glass; Raw material Manufacturing process of glass; Ceramic- Raw material, Manufacturing process of White ware, Glazing.

Unit II:

A) Paints and Pigments Industries **15hr**

Paints- Introduction; Classification of paints; Constituents of paints; Formulation of paints; Mixing of paints; Manufacturing processes of paints ; Failure of paints; Varnishes, Enamals, Emulsion paints- Constituents.

Pigment- Manufacturing processes of zinc oxide and titanium dioxide, properties and application

B) Dyes

Classification of dyes according to the mode of applications and according to the chemical constitution; Methods of preparation of commercial dyes of different classes with suitable examples; Typical manufacturing processes of dyes; Fluorescent brightening agents

Unit III:

Agrochemicals: **15hr**

a) Organo chlorine pesticides: BHC, Aldrin, Dialdrin, Endosulphan,

b) Organo phosphorus pesticides: Malathion, monocrotophos, Dimethoate, chloropyriphos.

c) Carbamates: Carbaryl, Bygon, Ziram, Zineb, Maneb.

d) Insect pheromones and Repellants: Pheromone, general introduction and application in integrated pest management (no synthesis), Repellant: Survey and synthesis of following repellants: N,N Diethyl-3-methyl benzamide, N,N, Diethylenebenzamide, 2-ethyl-1,3, hexanediol, Butopytranexyl, Dimethylcarbamate, Dimethylpthalate

Unit IV:

Petrochemicals **15hr**

Crude oil, Natural gas, Petroleum hydrocarbons- Types and source of crude oil; Refining various petroleum fractions- Thermal cracking, Recycle cracking, Thermal cracking of fuel ; outline of chemicals derived from natural gases/ paraffin hydrocarbon-Ethylene, Propylene Butylenes, Benzene, Toluene.

Reference Books

1. F.A. Henglein: Chemical Technology (Pergamon)
2. R.W. Thomas & P.Farago: Industrial Chemistry (HEB)
3. R.N. Shreve: Chemicals Process Industrial (MGH)
4. Riegel's: Industrial Chemistry (Reinhold)
5. D.S.T: Perspectives in science and technology Vol I & II (Vilas)
6. W.H. Dennis: Foundation of iron and steel metallurgy (Elsevier)
7. Prakash G. More, Comprehensive Industrial Chemistry, Pragati Prakashan, Meerut (Uttar Pradesh)
8. Kirk R Smith: Biofuels: Air pollution and Health: A Global Review (Kluwer Academic/Plenum publisher
9. Plant oil as fuels- Present state of science and future developments Edited by N. Martini and J.S. Sebeli Springer Verlag 1998.

HCT – 402: Pollution Monitoring and Control

Credits-04 60 hr

Course Objective:

The aim is to learn the essential principles used in industrial pollution abatement and understand important issues in industrial pollution abatement and relevant environmental legislations.

Course Outcomes

1. Become aware of environmental regulatory legislations and standards.
2. Comprehension about the quantification and analysis of wastewater and their treatment before discharge.
3. Understand the atmospheric dispersion of air pollutants, and operating principles.
4. Understand analysis and quantification of inorganic and organic hazardous chemical waste treatment before discharge.
5. Capable to understand the methods to recycle polymeric waste.

Unit I: 15hr

A) Regulatory aspects

Environmental legislation -Water (prevention and control of pollution) Act 1974, Air (Prevention and control of pollution) Act 1981, its implication application and effectiveness in industrial pollution control, water quality management in India; Indian standards- IS – 2490, IS – 3360, IS – 3307 and IS – 2296; MINAS for- Sugar industries, Distilleries, Synthetic fiber industries, Oil refineries.

B) Removal of phenolic residues

Sources of phenolic residues; Analytical treatment/Removal methods- Stream gas Stripping, Ion exchange, Solvent extraction, Oxidation method, Biological treatment.

Unit I: 15hr

A) Waste Water Treatment

Treatment of waste water:

b) Primary treatment-Sedimentation, Flocculation.

c) Secondary treatment- Tricking filters, Activated sludge process, oxidation pond .

d) Tertiary treatment- Ion-exchange, Electrodialysis, and Reverse osmosis.

e) Advanced waste water treatment-Nitrogen and Phosphorus removal.

B) Air Pollution and its measurements

Nature of Industrial effluents- Gaseous and liquid effluents; Methods of gas analysis-Analysis of CO, SO_2, NO_x, H_2S, in the gaseous effluents. Methods of removal of pollutants from gaseous effluents- Particulate matter, Particle size analysis;

Unit III: 15hr

A) Removal of Heavy toxic metals

Chromium-control method; Removal method- Reduction Precipitation ,ion Exchange, Reverse osmosis, Lime coagulation and absoption; Mercury- Measurement of mercury,Removal of mercury from Gaseous streams,Removal of mercury from liquid streams, Ion exchange method

B) Polymer Recycling

Polymer recycling technologies- Melt processing, Chemical Conversation.

Unit IV: 15hr

A) Soil Pollution and analysis

Concept of Soil pollution; Sources, types of pollutants and pollution;

Analysis of soil: Moister, pH, total nitrogen, phosphorous, silica, lime, Magnesia, Manganese, sulfur & alkali salts.

B)Water Pollution and Analysis

Analysis of process waste water - free acids and bases, dissolved oxygen, inorganic compounds – chloride, fluoride,cyanide, SO_x, PO_x, NO_x , suspended solids.

Reference Books

1. S P Mahajan: Pollution control in process industry (J W).
2. J R Holmes: Refuse Recycling and recovery(JW)
3. M Sitting: Resources recovery recycling handbook and industrial waste (N D S).
4. J O Niagh: Sulphur in the environment Vol I & II (J W)
5. P S Milor: The industry EPA contribution (MGH)
6. R B Pojasele: Toxic and hazardous waste disposal Vol. I and II(AAS)
7. A K Dey: Environmental chemistry
8. W Handley: Industrial safety handbook.
9. J E Huheey: Inorganic Chemistry (1993)
10. A.C. Stern: Air pollution : Engineering control Vol (IV) A.P.
11. P.N. Cheremsioff and R.A. Young: Air pollution control and design handbook Vol I and II Dekkar.
12. Liptak: Air pollution
13. Wark & Warner: Air pollution origin and control
14. A.K. De: Environmental chemistry
15. S.M. Khopkar: Environmental pollution analysis
16. R.S. Ramalho: Introduction to waste water treatment process (A.P.0
17. M.J. Hammar: Water and waste water technology (J.W)

HCT-403 Nanomaterial and its Characterization

Credits-04 60 hr

Course Objective

To endow with basic information regarding synthesis of Nanomaterial and application of various instrumental techniques like, XRD, SEM, TEM, TGA and DSC to analyze and authenticate Nanomaterial synthesized in chemical laboratory.

Course Outcomes

At the completion of this course, students should be able to:

1. Acquires the basic knowledge of synthesis of Nanomaterial
2. Understand theory, principle and application of various techniques like XRD, SEM, TEM, TGA and DSC.
3. Identification of impurities and purities in sample and also method development for specific compound nature.
4. Educate in structure identification, topology, morphology, composition and crystallographic information by using XRD and TEM, SEM.

Unit I:

A) Nanoscience and Nanotechnology 15hr

Introduction, Possible application of nanotechnology for Nano device-Nano sensor (only introductory).

B) Synthesis and growth technique of Materials/Nanomaterial

Synthesis of solid state materials conventional methods- Electrodeposition, Spray Pyrolysis, Sol-gel, Hydrothermal synthesis, Chemical bath deposition, Chemical Vapor deposition CVD, Photo assisted CVD, plasma assisted CVD, Magnetron Sputtering; Crystal growth from vapors, melt and solutions; Preparation of ultra pure elements of Gallium, Indium and Germanium for semiconductors- Czochralski method. Zone refining; Preparation and purification of silicon,; Amorphous and Crystalline silicon.

Unit II:

Optical and electron microscopy: 15hr

SEM, TEM, AFM, and XPS Instrumentation and application.

Unit III:

Thermal Methods 15hr

Introduction to TGA; Instrumentation ;Chemical change versus weight loss plots, TGA analysis, Use in characterization of raw materials, minerals, polymers, hydrate analysis.

Introduction to DTA; Instrumentation; Exothermic and Endothermic chemical and physical changes; DTA profile; Applications,

Introduction to DSC; Instrumentation; Applications.

Unit IV:

X-Ray Diffraction **15hr**

Methods of production of x-rays; Properties of x-rays; Diffraction of x-rays; Bragg's Law; lattice and powder diffraction methods; Analysis of molecular structure by XRD

Problems

Reference Books

1. Z.Wite, R. Speight: Ultra purity (MDI)
2. F. A. Kroger: Chemistry of Imperfect Crystals
3. H. Gopanov: Optical and Electronic Properties of Nanocrystalline Materials
4. F.J. Welder: Standard Methods of chemicals analysis Vol III part A and B.
5. H.A. Strobel: Chemical Instrumentation (AW).
6. Willard, Meritt & Dean: Instrumental Methods of analysis (FWAP)
7. F.D. Snell, Encyclopedia of Industrial: Chemical Inorganic analysis Vol. 1 to 20 (J.W.)
8. Hillebrand, Llundell and Hoffman: Applied inorganic analysis (Interscience)
9. D.K. Chakrabarry: Solid state chemistry.

SCT – 404 Industrial Management and Material Balance

Credits-04 60 hr

Course Objective:

To understand and apply the basics of calculations related to material and energy flow in the processes, to study various types of conventional (coal, petroleum and natural gas) and non-conventional energy resources (solar, wind, nuclear, geothermal, tidal and biomass) and necessity to explore alternate energy resources. To make students realize personal safety, industrial safety, and various elements of process safety management. To make students aware of small scale industries, management practices in industry so as to motivate to become a future entrepreneur.

Course Outcome:

1. Ability to make material balances on unit operations and processes
2. Understand the energy demand of world, nation and available resources to fulfill the demand
3. Comprehension about the conventional energy resources and their effective utilization
4. Capable to identify available nonconventional (renewable) energy resources and techniques to utilize them effectively.
5. Understand personal safety and design safe systems for unit operations & unit processes.
6. Conscious to become entrepreneur.

Unit I

A) Environmental Management of Toxic and Hazardous Chemicals 15hr

Classification and segregation of Industrial chemicals Potentially explosive chemicals; Incompatible chemical; Pyrophoric chemical; Transportation of hazardous chemicals; Incineration of hazardous chemicals; Safety concept in Industry.

B) Small Scale Industries

Need and scope of Small Scale Industries, SSI registration, license, Incentives-Financial and Non- Finacial; Indian factory act-1948; FDA; Export –Import regulations.

Unit II:

A) R & D and Technology Transfer 15hr

Role of R & D; University-Industry interface; Introduction to Intellectual Property: Patents, Copywrite; Technology transfer,

B) Pilot Plant Operation and Scale up

Pilot Plant- Introduction, Typical Research program undertaken to avoid risk.

C) Quality Control

Concept of quality control ;Role of Quality Control ;Government Standards - ISI, MINAS, Agmark, I.P., B.P., U.S.P; Control charts-Types of control chart, Preparation of Control charts - X-Bar Chart, R-Chart, p-Chart, C-chart; Application of Control chart, Sampling ,Inspection.

Unit III:

A) Material Balance **15hr**

Material Balance – Process classification; Integral Balances on Batch Processes; Material Balance Calculations- Flow Chart, Flow Chart Scaling and Basis of Calculation;
Balances on multiple unit processes; Recycle and Bypass.

B) Energy Balance

Forms of energy; Kinetic and Potential energy; Energy Balances on closed systems; Energy Balances on open systems at steady state- Flow Work and Shaft Work.

Unit IV: APPICATIONS

A) Fuel cells and batteries –

primary and secondary power cells, fuel cells, Li ion battery, evaluation of performance of electrochemical systems, energy density, shelf life, and Faradic efficiency.;.

B) Energy Resources

Introduction to Conventional and Nonconventional energy resources; Tide, wind sources, Energy from fission and fusion reaction. Solar Cells: photovoltaic and photogalvanic cells; photoelectron chemistry; prospects of solar energy conversion and storage, organic solar cells: Fuel Cell-Hydrogen-oxygen fuel cell, Construction and Working.

D) Biofuels

Introduction; Types of Biofuels -Bioethanol, Biodiesel, Raw materials for the Synthesis of Biofuels; Manufacturing process of Bioethanol from molasses; Manufacturing process of Biodiesel ; Biofuels and economy.

Reference Books:

1. R.R. Mukharjee: Element of Quality Control (Vanled books)
2. Industrial Organization & Engineering Economics-T.R.Banga
3. R.H. Lonter, N.C. Enrlok and H.E. Mottley: Quality for profit (IP)
4. W.N. Smith, E.G. Mayer and A.R. Hirsig: Industry R D Management ch 1, 3, 5, 10, 11, 13, 14, 15, 18 (Marcel Dekker)
5. A.Gerstenfield: Effective management of R & D (AW)
6. N.N Singh: Scientific management of SSI (Lalwani)
7. Kirk R Smith: Biofuels: Air pollution and Health: A Global Review (Kluwer Academic/Plenum publisher
8. K.K.Rohatgi-Mukherjee. Fundamentals of Photochemistry.Reprint 2002. New AgeInternationalPublisher,1978.-

SCT – 405 Advanced Topics in Industrial Chemistry-II

Credits-04 **60 hr**

Course Objective

To make students understand process technologies of various organic and inorganic process industries.

Course Outcome:

1. Realize a manufacturing of various inorganic and organic chemicals.
2. Comprehend the process flow diagram and various process parameters.
3. Understand and identify to solve problems arising during production

Unit I: **15hr**

Phosphorus industries: Calcium phosphate, manufacture of phosphoric acid, single and triple super phosphate, baking powder and DAP.

Sulphur and Sulphuric acid: Mining and manufacture of sulphur and manufacture of sulphuric acid by contact process.

Nitrogen Industries: Manufacture of Urea, calcium cyanamide, ammonium nitrate, nitric acid.

Unit II: **15hr**

Dairy Chemistry: Milk and milk products, composition and structure of milk, milk proteins, enzymes, vitamins, minerals, density and viscosity of milk, effect of heat on milk, milk processing, basic milk categories, butter, ghee and clarified butter.

Leather Chemistry: Introduction, constituents of animal skin, manufacture and preparation of hides, cleaning, soaking, limiting and degreasing, finishing and sharing, tanning; leather, vegetable, chrome, tanning effluents; pollution and control.

Unit – III **15 Hrs**

Food Chemistry;Classification, chemical composition and nutritional value of common food stuffs,properties of foods, food preservation and processing, food deterioration, methods of preservation and processing by heat, cold, chill storage, deep freezing, drying, concentration, fermentation, and radiation. Food quality; senory evaluation, objective methods, non-nutritional constituents and food safety.

Unit – IV **15 Hrs**

Metal finish technology: Electro refining of metals, electroplating of nickel, chromium, copper, cadmium, silver and Gold, surface treatment technology, surface coats.

Introduction, Electrodeposition, electroplating(Factors affecting, requirements and applications), hot dipping, metal cladding, immersion plating, metal spraying, vapour deposition and chemical and organic coating.

Chloralkali Industries: Soda Ash, Caustic Soda, Chlorine

Recommended Books

1. Lowenheim F A (1974) Modern Electroplating III Ed Chapman & Hall, Landon.
2. Gable, D: Principal of metal Treatment and protection. Pergamon, Press Oxford (1978)
3. G.A. Keneth: Electroplating for Engineering's A Hand Book IIIrd Edn Van Nastrad Reinbold Co London
4. F A Lowinbein: Modern Electroplating, Electroplating Publication New Jersey
6. R.R.Iash: afromulary of paints and other coating Vol. I
7. J.D. Gilchrist: Extraction Metallurgy (Pergamon)
8. S.D. Shukla & G N Pandey: A text book of chemical technology Vol. 1
9. F A. Henglein: Chemical Technology (Pergamon)
10. L. W. Aurand, A. E. Woods, Food Chemistry, AVI Publishing Inc.
11. L. H. Mayer, Food Chemistry, Affiliated East-West Press Ltd., New Delhi.
12. N. Shakuntala Manay, M. Shadakhsara Swamy, Foods-Facts and Principles.
13. John M. deMan, Principles of Food Chemistry.

Practical Course Semester III

HCP- 306, HCP-307, HCP -308 (OEP-309 or OEP-310)

Course Objective:
To learn practical application in the area of organic, inorganic and analytical chemistry. To learn analytical experimental methods using sophisticated instruments and interpretation of experimental data.

Course Outcome:
1. Capable to plan experiments and present the experimental data meaningfully
2. Ability to apply theoretical concepts for data analysis and interpretation
3. Skilled to explain and select instrumental techniques for analysis
4. Aptitude to plan experiments and operate several specific instruments
5. Ability to analyze and interpret the experimental data

INDUSTRIAL INORGANIC CHEMISTRY

1. To determine of capacity of cation exchange resin.
2. To determine of capacity of anion exchange resin.
3. Analysis of commercial caustic soda.
4. Prepare aluminum as 8 – hydroxy quinolate.
5. Preparation of nickel oxide.
6. Estimate the amount of chlorine from bleaching powder.
7. Preparation of potash alum from aluminum metal.
8. To determine the influence of surface on rate of corrosion – Kinetics of corrosion I
9. To determine the influence of surface on rate of corrosion – Kinetics of corrosion II
10. Preparation and Analysis of copper ferrite.
11 To estimate phosphoric acid in cola drink by molybdenum blue method.
12. Estimation of Na, K and Li individually by Flame Photometry.
13. Determination of amount of Zinc from the given sample solution by Nephelometric/Turbidimetric titration using standard solution of Ba $(NO_3)_2$ or Pb $(NO_3)_2$.
14, Estimation of purity of a given azo dye by colorometry.
15. To estimate the amount of D-Glucose in given solution polarimetrically.

Note: Any other relevant experiments may be added

Reference Books:

Vogel's textbook of Quantitative Inorganic analysis

A.J.E. Welch, Inorganic Preparations, George Allen and Unwin Ltd.

W.G. Palmer, Experimental Inorganic Chemistry, Cambridge Press, 1965.

M.A. Malati Experimental Inorganic /Physical Chemistry, Harvard Publishing Chichester.

INDUSTRIAL ORGANIC CHEMISTRY

1. Preparation of p-nitroso N N dimethyl aniline.
2. Preparation of benzyl acetate.
3. Preparation of benzanilide from benzophenone. (Beckman Rearrangement)
4. Estimation of sulphur, nitrogen.
5. Preparation of Nitrophenol from Phenol
6. Preparation of Benzyl alchol and benzoic acid from Benzaldehyde.(Cannizaro Reaction)
7. Preparation of β-hydroxynaphthaldehyde from β-naphthol (Reimer-Tiemann Reaction).
8. Interpretation of IR spectrum with reference to stretching vibration 0-2 C=N, C=O, N-, M-O
9. Interpretation of NMR spectrum with reference to calculation of chemical shifts and general comments.
10. Preparation of p- Idonitrobenzene by Sandmeyer reaction.
11. Preparation of p- chloro nitrobenzene by Sandmeyer reaction

Note: Any other relevant experiments may be added

Reference Books

1. A text book of Practical Organic Chemistry – A. I. Vogel
2. Practical Chemistry – Mann and Saunders.
3. A Handbook of quantitative and qualitative analysis – H. T. Clarke.

Organic Synthesis collective volumes – Gillman and Batt.

4. Laboratory experiments in Organic chemistry-Arun Sethi
5. Practical Organic Chemistry.

Industrial Physical Chemistry

1. To determine the heat of solution of benzoic acid.
2. To determine heat of solution of NaCl, KCl, $BaCl_2$.
3. Study of effect of ionic strength on the reaction between persulphate and iodide by visual method.
4. Determine the formula of the complex formed between cupric ion and ammonia by distribution method
5. Determine the pKa values of weak dibasic acid pH metrically.
6. To determine the critical micelle concentration of sodium lauryl sulphate in aqueous solution conductometry
7. To determine the equivalent conductance at infinite dilution of strong electrolyte and weak acid by Kohlrausch law and dissociation constant of weak acid Conductometry.
8. Determine the E_0 value of Ag/AgI electrode and the solubility product of PbI_2 potentiometrically.
9. To determine pK value of methyl red indicator at room temperature spectrophotometrically.
10. To determine half wave potential of a given ion using half height method, differential method and wave equation method. (Polarography)

Note: Any other relevant experiments may be added

Reference Books:

1. Findlay's Practical Physical Chemistry – Revised by J.A. Kitchner (V Edition)
2. Experimental Physical Chemistry – F. Daniels and J. Williams
3. Experimental Physical Chemistry – R.C. Das and B. Behera

Practical Course Semester IV

HCP –406, HCP- 407, SCP-408, HCMP-409 (Major Project)

Course Objective:
To learn practical application in the area of organic, inorganic and analytical chemistry. To learn analytical experimental methods using sophisticated instruments and interpretation of experimental data.

Course Outcome:
1. Capable to plan experiments and present the experimental data meaningfully
2. Ability to apply theoretical concepts for data analysis and interpretation
4. Skilled to explain and select instrumental techniques for analysis
4. Aptitude to plan experiments and operate several specific instruments
5. Ability to analyze and interpret the experimental data

Industrial Inorganic Chemistry

1. Estimate the amount of calcium from plaster of paris.
2. Determine the amount of Cobalt in given unknown sample by colorimetric method
3. Determine the amount of Chromium and Nickel from given stainless-steel alloy.
4. Estimate the amount of Iron in given unknown sample by colorimetric method.
5. Preparation of chrome alum.
6. Preparation and Analysis of Zinc ferrite.
7. Analysis of Cement
8. Analysis of Fertilizer
9. X-ray powder diffraction analysis of cubic compound
10. Determination of moisture content in food/drug sample by Karl Fisher reagents.
11. Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode
12. Analysis of iodized table salt.

Note: Any other relevant experiments may be added

Reference Books:

1. Vogel's textbook of Quantitative Inorganic analysis
2. A.J.E. Welch, Inorganic Preparations, George Allen and Unwin Ltd.
3. W.G. Palmer, Experimental Inorganic Chemistry, Cambridge Press, 1965.

4. M.A. Malati Experimental Inorganic /Physical Chemistry, Harvard Publishing Chichester.

Industrial Organic Chemistry

1. Preparation of sulphanilic acid.
2. Preparation of p-amino benzoic acid.
3. Preparation of p- nitroaniline from acetanilide.
4. Preparation of phenyl benzoate.
5. Preparation of paracetamol.
6. Pinacole-Pinacolone Rearrangement.
7. Preparation of phthaliamide from phthallic anhydride.
8. Preparation, purification and assay of aspirin.
9. Estimation of sodium benzoate/sodium metabisulphite. boric acid and salicylic acid in food.
10. Isolation of casein from milk.

Note: Any other relevant experiments may be added

Reference Books

1. A text book of Practical Organic Chemistry – A. I. Vogel
2. Practical Chemistry – Mann and Saunders.
3. A Handbook of quantitative and qualitative analysis – H. T. Clarke.
4. Organic Synthesis collective volumes – Gillman and Batt.
5. Laboratory experiments in Organic chemistry-Arun Sethi

Industrial Physical Chemistry

1. Determine the acidic and basic dissociation constant of an amino acid and hence determine the isoelectric point of acid pH metrically.
2. To determine the specific refraction of given mixture of liquid and hence find out unknown concentration of mixture.
3. Investigate the autocatalytic reaction between potassium permangnate and oxalic acid.
4. To determine the latent heat of fusion a given solid naphthalene in toluene
5. To determine the molecular weight and state of benzoic acid in benzene by cryoscopic method.

6. to determine the molecular weight and state of acetic acid in benzene Cryoscopy.

7. Demonstration of major sophisticated instruments (uv-visible, IR, TG-DSC, Brookefield viscometer, VPO etc)

8. To determine stoichiometry & stability constant of ferric Sulphosalicylic acid/ salicylic acid complex by Job's Method and mole ratio method spectrophotometrically.

9.To determine equilibrium constant of reaction $KI + I_2 \longrightarrow KI_3$ Spectrophotometrically.

10.Determination of unknown concentration of Cd^{+2} / Zn^{+2} ion in the given solution. by standard addition method.(Polarography)

11. Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode

12.Analysis of malathion by colorometry.

Note: Any other relevant experiments may be added

Reference Books:

1. Findlay's Practical Physical Chemistry – Revised by J.A. Kitchner (V Edition)

2. Experimental Physical Chemistry – F. Daniels and J. Williams

3. Experimental Physical Chemistry – R.C. Das and B. Behera