Anekant Education Society's

Tuljaram Chaturchand College, Baramati

413102 (Dist.Pune)(Autonomous)

Revised Syllabus for

M.Sc.(Chemistry) Part I (Semester II)

Choice based Credit System Syllabus to be implemented from Academic year 2022-2023

Title of the course: M.Sc. Chemistry

Structure of the course:

Sr. No.	Subject	Paper Code. (old)	Paper Code. (new)	Credits
1.	Fundamentals of Physical Chemistry- I	CHP-4101	PSCH111	Physical Chemistry I
2.	Molecular Symmetry and Chemistry of P- block elements	CHI-4102	PSCH112	Inorganic Chemistry I
3.	Basic Organic Chemistry	CHO-4103	PSCH113	Organic Chemistry I
4.	Safety in Chemical Laboratory and Good Laboratory Practices	CHA-4104	PSCH114	Safety in Chemical Laboratory and Good Laboratory Practices
5.	Physical Chemistry Practical	CHP-4105	PSCH115	Physical Chemistry Practical
6.	Organic Chemistry Practical	CHO-4106	PSCH116	Organic Chemistry Practical
7.	Human right I	HR 101	HR1	Human right I
8.	Introduction to cyber security 1	CYS 101	CYS1	Introduction to cyber security 1
9.	Fundamentals of Physical Chemistry- II	CHP-4201	PSCH121	Physical Chemistry II
10.	Coordination and Bioinorganic Chemistry	CHI-4202	PSCH122	Inorganic Chemistry II
11.	Synthetic organic chemistry and Spectroscopy	CHO-4203	PSCH123	Organic Chemistry II
12.	General Chemistry	CHA-4204	PSCH124	General Chemistry
13.	Inorganic Chemistry Practical	CHP-4205	PSCH125	Inorganic Chemistry Practical
14.	Analytical Chemistry Practical	CHO-4206	PSCH126	Analytical Chemistry Practical
15.	Human right II	HR 102	HRII	Human right II
16.	Introduction to cyber security II	CYS 102	CYSII	Introduction to cyber security II

PSCH121: Physical Chemistry II, Semester II (4 credits, 48L)

Learning objectives:

The students are expected to learn,

- Basics of atomic spectrum
- Basic concepts of molecular spectroscopy
- Basics of microwave spectroscopy
- Terms related to vibrational spectroscopy
- Principle and applications of various spectroscopy
- Basic concepts of nuclear chemistry
- Basic concepts of radiation chemistry
- Applications of nuclear chemistry
- India's nuclear energy programmes

Learning Outcomes

- Student should understand the spectroscopy concepts in detail
- Student should understand Basic concepts of molecular spectroscopy concepts.
- Student should know P, Q, R, S branches.
- Student should understand the difference between Microwave, Raman, IR spectroscopy.
- Student should know the selection rules of transition in various spectroscopic regions.
- Student should solve the numerical based on all the topics included in this course.
- Student should understand the Types of nuclear reactions in detail
- Student should understand Basic concepts of nuclear chemistry & radiation concepts.
- Student should understand Radiation chemistry
- Student should understand the units of radioactiviy.

SECTION-I

Molecular spectroscopy

1. Recapitulation: Fourier transforms, Regions of spectrum, factors affecting the width and intensity of spectral lines
(2L)

2. Microwave spectroscopy: Rotation spectra of di and polyatomic molecules-rigid and non-rigid rotor, Effect of isotopic substitution, Problems
(3L)

3. Infrared spectroscopy : Harmonic and Anharmonic oscillator, vibrational spectra of di and poly- atomic molecules, coarse and fine structure, Nuclear spin effect, applications **(5L)**

4.Raman Spectroscopy: Introduction, Rotational Raman- spectra, Vibrational Raman Spectra, polarization of light and Raman effect, structure elucidation from

combined Raman and IR spectroscopy, applications, problems **(5L)**

5.Electronic spectroscopy of molecules: Born – Oppenheimer approximation, electronic spectra of diatomic molecules, vibrational coarse structure, rotational fine structure, dissociation energy and dissociation products, electronic structure of diatomic molecules, molecular photoelectron spectroscopy, frank Condon principle, application **(6L)**

6. ESR and Mossbauer spectroscopy: Principle and applications. **(1L)**

7. NMR–Principle, Chemical shift, coupling constant, Chemical applications of ^{1}H-NMR in structure elucidation, problems **(2L)**

References:

1. Fundamentals of molecular spectroscopy: C. N. Banwell and E. Mc. Cash (Fourth edition).
2. Molecular Spectroscopy: P. S. Sindhu, New Age international Publication. (Second edition)
3. Molecular Spectroscopy: Suresh Chandra, Narosa Publication House (2009)

SECTION-II

Nuclear and Radiation Chemistry (2 Credits, 24L, 6 T**)**

1. Radioactivity: Recapitulation–Isotopes, Isobars, Isomers, Isotones, types of radioactive decay, Decay Kinetics, Detection and measurement of nuclear radiation(G.M. & Scintillation counter),Problems (Self study) **(2L)**

2. Nuclear Reactions: Bethe's notation, Types of nuclear reactions, The compound nucleus theory, photonuclear reactions, Thermonuclear reactions, Fusion reactors (**4L)**

3. Nuclear Reactor: - The fission energy, The Natural uranium reactor, the four factor formula- There production factor K, the classification of reactor. Reactor power, Critical size of thermal reactor, excess reactivity & control, the Breeder reactor **(3L)**

4. Isotope separation & Preparation: Enrichment factor, various methods for separation of selected isotope, Typical reaction involved in preparation of radio isotopes: ^{3}H, ^{14}C, ^{22}Na, ^{32}P, ^{35}S and ^{127}I. General Principles of using radioisotopes as tracers. **(4L)**

5. Applications of radioisotopes in agriculture, Healthcare, Industry, Analytical applications: Agricultural applications**;** Studies on soil plant relationship, Food preservation, Healthcare applications: Diagnostic applications: Radioimmunoassay, applications of RIA, Radiotherapy: Teletherapy, Gamma knife, Brachytherapy, Analytical applications: Neutron activation analysis (NAA), Isotope dilution analysis (IDA), radiometric titration (RT) , radiation gauging, friction and wear out, gamma radiography. Problems **(6L)**

6. Elements of radiation chemistry – Radiation chemistry, interaction of radiation with matter, passage of neutrons through matter, interaction of γ-radiation with matter, Units for measuring radiation absorption, Radiation dosimetry, Radiolysis of water, free radicals in water radiolysis, Radiolysis, Fricke dosimetry, Problems **(5L)**

References:

1. Elements of Nuclear chemistry– H.J. Arnikar, fourth edition Wiley Estern Ltd.

2. Source book of atomic energy–S. Glasstone, D.Van Norton Company

3. Chemical applications of radioisotopes– H. J. M. Brown Buffer & Jammer Ltd.

4.Fundamentals of Radiochemistry- D.D. Sood, A. V. R. Reddy, N. Ramamoorthy

PSCH122: Inorganic Chemistry II, Semester II (4 credits, 48L)

Learning objectives:

The students are expected to learn,

- Correlation diagram for Td and Oh ligand field
- d-d transition, charge transfer spectra.
- Basic Concepts, orgel diagram, Tanabe-sugano diagrams.
- Hund's rule, interpretation of electronic spectra

Learning Outcomes:

- Student should understand inter electronic repulsion.
- Hund's rules for arranging the terms according to energy.
- To draw correlations diagram for various configurations in Td and Oh ligand field.
- Student should able to find out the no of microstates and meaningful term symbols, construction of microstate table for various configuration
- Student should know the concept of weak and strong ligand field.
- Student should know basic d-d transition, d-p mixing, charge transfer spectra.
- Interpretation of electronic spectra for spin allowed oh and td complexes using Orgel diagram.
- Student should know basic instrumentation and selection rules and relaxation in rules.

SECTION I

Coordination Chemistry (2 Credits, 24 lectures, 6 T)

A) Concept & Scope of Ligand Fields: **(04L)**

Recapitulation of CFT, Free ion Configuration, Terms and States, Energy level of transition metal ions, free ion terms, microstates, term wave functions, Quantum numbers, spin-orbits coupling.

B) Ligand field theory of coordination complexes: **(07L)**

Effect of ligand field on energy level of transition metal ions, weak cubic ligand field effect on Russell-Saunders terms, strong field effect, Orgel diagram, correlation diagrams, Tanabe-Sugano diagrams, spin pairing energies**.**

C) Electronic spectra of Transition Metal Complexes: **(07L)**

Introduction, Band intensities, band energies, band width and shapes, spectra of 1, 2 and 3rd row ions and rare earth ion complexes, spectrochemical and Nephlauxetic series, charge transfer and luminescence, spectra, calculations of Dq, B, β parameters, percentage of covalent character of metal complexes.

D) Magneto Chemistry **(06L)**

Origin magnetism, types of magnetism, Curie law, Curie-Weiss Law, Magnetic properties of complexes-paramagnetism 1st & 2nd Ordered Zeeman effect, quenching of orbital angular momentum by Ligand fields, Magnetic properties of A, E & T ground terms in complexes, spin free spin paired equilibria**.**

References:

1. Ligand field theory & its applications: B.N. Figgis & M.A. Hitachman (2000) Wiely VCH Publ.
2. Symmetry and spectroscopy of molecules, Second Ed^{n}, by K. Veera Reddy, New Age International Publication, 2009.

3. Elements of magnetochemistry, R. L. Datta and Syamal, Second Ed^{n}, Afiliated East West Press Pvt. Ltd. 2007.

SECTION-II
Bioinorganic Chemistry (2 Credits, 24 Lectures, 6 T)

1. Introductions of Bioinorganic chemistry, role of metals, metalloproteins and metalloenzyme. Principles of coordination chemistry related to bioinorganic chemistry research and protein, Nucleic acid and other metal bonding biomolecules. **(4L)**

2. Thermodynamic aspects - HSAB concept, chelate effect and Irving-William series, pK_a values of coordinated ligands, Tuning of redox potential, Biopolymer effects. Kinetic aspects- Electron transfer reaction, Electronic substitution reaction. Reactions of coordinated ligands and Template effect, concept of spontaneous self-assembly model compounds. **(6L)**

3. Biochemistry of Na, K and Ca with respect to Na/K pumps, Distribution of Cationic and anionic electrolytes in blood plasma and intracellular fluid, Calmodulin, Ionophores natural and synthetic application of Ionophores and Ca in blood Coagulation. **(8L)**

4. Biochemistry of following elements: (**6L)**

a) Iron: Ferritin, Transferrin, Ferredoxin, Rubredoxin, Porphyrin based system

b) Magnesium: Photosystem I

c) Manganese: Photosystem II

References:

1. Principle of Bioinorganic chemistry: S. J. Lippard and J.M. Berg

2. Bioinorganic chemistry: Inorganic elements in chemistry of life W. Kain and B. Schwederski

3. Bioinorganic chemistry: Bertini, Grey, Lippard and Valentine

4. Bioinorganic chemistry: R. J. P, Willams

5. Bioinorganic chemistry: Robert Hay Bioinorganic chemistry: M. N. Hughes

PSCH123: Organic Chemistry II, Semester II (4 credits, 48L)

Learning objectives:

The students are expected to learn,

- Construction of FMO and photochemical and thermal reactions
- Laws of Photochemistry
- Basic principles, photochemistry of carbonyl compounds, alkenes, dienes and aromatic compounds.
- Norrish type I and II reaction, isomerization, Patterno-Buchi reaction
- Chemical shifts and factors affecting chemical shifts
- Complex and simple spin spin coupling.

Learning Outcomes:

- Students will be able to learn construction of FMO and photochemical and thermal reactions
- Students will come to know the laws of Photochemistry
- Student will be aware of basic principles and photochemistry of carbonyl compounds, alkenes, dienes and aromatic compounds.
- Students will gain knowledge of Norrish type I and II reaction, isomerization, Patterno-Buchi reaction
- Students will learn Chemical shifts and factors affecting chemical shifts
- Students will get the knowledge of Complex and simple spin spin coupling

SECTION I

Pericyclic Reactions and Photochemistry (2 Credits 24 Lectures)

A) Pericyclic Reactions (12 L)

Construction of Pi molecular orbitals of ethylene and 1, 3 Butadiene, Symmetry in Pi molecular orbitals, Frontier molecular orbitals, electrocyclic reactions Con and Dis rotatory ring closing and ring opening reactions, Selection rules and stereochemistry of electrocyclic reactions, Theory of cycloaddition reaction. FMO method, [2+2] and [4+2] cycloaddition, Ene reaction

B) Photochemistry: (12 L)

Law of Photochemistry, quantum yield, quenching, photochemistry of carbonyl compounds, alkenes, dienes and aromatic compounds and their application in organic synthesis alpha and beta cleavage Norrish type I and II reaction, isomerization, Patterno-Buchi reaction, Photo Fries Rearrangement.

SECTION-II

Spectroscopy (2 Credits 24 Lectures)

1. UV: (4L)

Factors affecting UV absorption and interpretation of UV spectra of aromatic compounds, Rules and Application of dines, eneons, and aromatic compound

2. IR: **(4 L)**

Principal, Basic Important functional group frequencies, factors affecting IR frequencies, interpretation of IRspectra

3. ^{1}H NMR: **(6 L)**

Fundamentals of $_{1}$H NMR, Coupling constant , factors affecting chemical shift, integration, coupling (1st order analysis), first order spectral analysis , D_2O exchange in H^1 NMR

4. Introduction to CMR: **(4 L)**

Natural abundance, chemical shift values, proton coupled and proton decoupled spectra, DEPT

5. Mass spectrometry: **(6 L)**

Principal, Instrumentation, Terminologies, Rules of fragmentation, McLafferty rearrangement, Rule of 13,fragmentation pattern of some important functional groups.

References:

1. Advanced Organic Chemistry, Part A – F. A. Carey and R. J. Sundberg, 5th Ed.

Springer (2007)

2. Excited states in Organic Chemistry- J.A. Barltrop and J.D.Coyle, John Wiley & sons

3. Photochemistry and Pericyclic reactions-Jagdamba Singh, Jaya Singh 3rd Ed.

4. Organic photochemistry: A visual approach-Jan Kopecky, VCH publishers (1992).

5. Conservation of orbital symmetry – R. B. Woodward and R. Hoffmann;

VerlagChemie, Academic press (1971).

6. Introduction to spectroscopy – D.l. Pavia, G.M. Lampman, G.S. Kriz, 3rd Edition

7. Spectroscopic methods in organic melecules – D.H. William & I Flemming Mc Graw Hill

8. Mechanism and Structure in Organic Chemistry - E.S. Gould

PSCH124: General Chemistry II, Semester II (4 credits, 48L)

Learning objectives:

The students are expected to learn,

- Acquire knowledge about the widely used analytical instruments
- Select instrument for a particular analysis with come idea of it's merits ,demerits and limitations
- Able to design various types of electrodes, analyser and Spectrometer
- Student should know about principal and applications of GC, HPLC and Mass Spectrometry
- Basic concepts of Biochemistry
- To study the substance found in living organism and chemical reaction underlying life process
- To learn and understand the fundamentals of cellular metabolism of carbohydrates, lipids, amino acid and nucleic acid
- To learn and understand the various metabolic processes

Learning Outcomes:

- Students will be able to know various basic fundamentals of chromatography and its classification.
- Students will be able to know the various Hyphenated techniques like GCMS, LCMS etc.
- Student will be able to know the utilization of various instrumental techniques for separation and chemical analysis
- Students will gain knowledge of different types of gas analyzers
- Student should understand the Biochemical Morphology
- Students will be able to demonstrate accurate quantitative analysis
- Students will be able to understand and effectively apply scientific ethics.
- To perform analysis that provide an information about biochemical questions and helps to solve biochemical problems

SECTION I

Part A –Modern Separation Methods and Hyphenated Techniques (2 Credits 24 Lectures)

A) Mass Spectrometry: (08 L)

Principle, Instrumentation, Ionization methods-Electron bombardment ionization, Arc and spark ionization, Photo-ionization, Thermal ionization, Chemical ionization, Mass Analyzer-Magnetic, Double focusing, Time of flight, Quadrupolar, Ion cyclotron resonance analyzer ,Correlation of mass spectra with molecular structure and molecular weight ,Isotopic Abundances ,Fragmentation patterns, Quantitative analysis, Applications and Problems, Fourier transform mass spectrometry ,Tandem mass spectrometry, Inductively coupled plasma-mass spectrometry

B) Gas Chromatography (06L)

Introduction, Basic principle of GC, Instrumentation of GC, Sample injection–Split and splitless injection, Column types, Solid/Liquid Stationary phases ,Column switching techniques, Basic and specialized detectors ,elemental detection, Chiral separations, Gas chromatographs and chemical analysis, Application of GLC, Gas solid chromatography and Problems

C) High Performance Liquid Chromatography (06L)

Theory and instrumentation of HPLC, Optimization of column performance, Gradient elution and related procedure, Derivatization, Mobile phase Delivery System, Sample injection, Separation column, Detector, Interfacing HPLC With Mass spectrometry, Structure types of column packing, Adsorption Chromatography, Bonded phase chromatography, Reversed phase chromatography, Ion Pair Chromatography, Ion exchange Chromatography, Size Exclusion Chromatography and problem.

D) Hyphenated Techniques **(04L)**

Introduction, GC-MS, LC-MS theory working and applications

References:

1.Introduction to Instrumental Analysis,R.D.Braun,McGraw-Hill.Inc.1987

2.Instrumental Methods of chemical Analysis ,H. H.Willard, L.L.Merrite Jr.,J.A.Dean &F.A.SettleJr.,6th Edition, Wadsworth Publishing Company,USA,1986

3. Hand book of Instrumental Techniques for Analytical Chemistry, F.A.Settle editor,Prentice Hall Inc. A Simon and Schuster Company,New Jersey,1997

4. Fundamentals of Analytical Chemistry ,D.A. Skoog, D.M.west, F.J.Holler,S.R.Crouch,7th Edition, Thomson Asia Pte.Ltd,Singapore,2004

SECTION-II

Part-B: Basic Biochemistry (2 Credits 24 Lectures) (02L)

1. Introduction to Biochemistry: **(2L)**

Scope of the subject in pharmaceutical sciences, Biochemical reactions.

2. Biochemical Morphology: **(4L)**

Prokaryotes and Eukaryotes, Cell structure, sub-cellular components: Nucleus, plasma membranes, endoplasmic reticulum, Lysosome, Peroxisomes, Golgi apparatus and Mitochondria.

3. Biomembrane: **(4L)**

Structure, functions and composition, Model proposed, Function and properties of membrane, Transport hypothesis, Active and passive facilitated transport, drug transport.

4. Biomolecules: **(7L)**

Proteins*:* Introduction ,functional, classification of amino acids, classification ,physicochemical properties, Optical activity, Reaction with ninhydrin, Formaldehyde, Amino acids, Essential and nonessential amino acids, efficacy, structure, peptide bond, end group analysis, globular protein, fibrous protein, amino acid therapy, Protein engineering Carbohydrates: complex carbohydrate, structure of Chitin, Starch, Glycogen + Metabolism

Lipids: definition, classification, functions, types of fatty acids, and its biological role and metabolism.

5. Enzymes: **(7L)**

Introduction, classification according to the reaction catalysis and source structure of enzyme, co factures, active sites, Binding sites, Km, Vmax, Enzyme kinetics, Double reciprocal plot, effect of substrate, pH ionic strength, Concentration, Temperature on the rate of enzyme reactions, Enzyme inhibition (competitive, uncompetitive, non competitive and irreversible).

References:

1. Principals of biochemistry, Albert Lehninger (CBS Publisher and Distributers Pvt. Delhi.
2. Biochemistry Lubert Stryer,W.H.(Freeman and company New York)
3. Harper's Biochemistry by R.K.Murray, D.I.Granner, P.A.Mayes, (Prentice Hall International Inc.)
4. Practical Clinical Biochemistry, Harold Varley, (CBS Publisher and Distributers Pvt. Delhi.
5. Molecular Biology, J.D. Watson (The Ben jamin/Cumming Company, Inc.)

PSCH125 - INORGANIC CHEMISTRY PRACTICALS (4 Credits, 48 L)

Learning Objectives:

- To develop effective laboratory practices.
- Aware about use of flammable and hazardous chemicals.
- Aware about use of personnel protective and other safety equipment's.

Learning outcomes:

At the end of course student will understand

- Introduction to Good Laboratory Practices and its applications
- Managing chemical waste
- Precautions of hazardous chemicals

1. **Alloy Analysis: - (Any 2)**
   a) Determination of Tin & lead from Solder alloy
   b) Determination of Iron & Chromium or carbon from Stainless steel alloy.
   c) Determination of Copper & Nickel from Cupronickel alloy.
   d) Determination of Bismuth, Lead, Tin, Cadmium from Wood's metal. (any 2)
   e) Determination of Aluminium, Nickel, Cobalt from Alnico alloy.

2. **Inorganic synthesis & purity: (Any 6)**
   a) Chloro penta- amine cobalt (III) chloride.
   b) Nitro penta -ammine cobalt (III) chloride.
   c) Cis Potassium diaquo dioxalato Chromate (III).
   d) Trans Potassium diaquo dioxalato Chromate (III) .
   e) Potassium tri-oxalato Aluminate .
   f) Tris (acetylacetanato) Mangnese (III).
   g) Bis (acetylacetanato) Copper (II)
   h) Tris (Ethylenediamine) Nickel (II) thiosulphate.

3. **Inorganic Chracterization Techniques: (Any 1)**
   a) Solution state preparation of $[Ni(en)_3]S_2O_3$, $[Ni(H_2O)_6]Cl_2$, $[Ni(NH_3)_6]Cl_2$. Record absorption spectra in solution of three complexes and calculate 10 Dq. Arrange three ligands according to their increasing strength depending on observation.
   b) Determination of Magnetic Susceptibility of Mercury tetracynato Cobalt or $[Fe(acac)_3]$ orFerrous ammonium sulphate by Faraday or Gouy's method .
   c) Determination of equilibrium constant of M-L system Fe(III) Sulphosalicylic acid by Job's continuous variation method.
   d) Estimation of Cu using iodometric method Potentiometrically.

4. **Synthesis of Nanomaterials: (Any 2)**
   a) Synthesis of nanosized ZnO, its characterization by UV-Visible Spectroscopy & Removal of dye bye ZnO – Photo catalysis and determine the band gap by absorption spectroscopy.
   b) Synthesis of nanosized alpha -Fe_2O_3 & Study of adsorption of Phosphate on it.
   c) Synthesis of CdS nanoparticles.
   d) ZnO, TiO_2, Fe_2O_3 nanoparticles powder XRD, SEM, TEM or any another Technique.(At least one spectral analysis/study should be done)

5. **Synthesis & Chracterization: (Any 1)**
   a) Synthesis & Photochemistry of K $[Fe(C_2O_4)_3]3H_2O$
   b) Kinetics of substitution reaction of $[Fe(Phen)_3]^{2+}$

6. Solvent Extraction and Colorimetric: (Any 1)

a) Determination of Cu(II) Solvent extraction as Dithiocarbamate complex.

b) Determination of Iron by solvent extraction techniques in a mixture of Fe (III)+Al(III) orFe (III)+Ni(III) using 8-hydroxyquinoline reagent.

7. Report on Industrial visit.

References:

1) Text book of Quantitative Analysis, A.I. Vogel 4^{th} edn (1992)
2) Electronic Spectroscopy by A.B. P. Lever.
3) Inorganic Synthesis (Vol. Series).
4) Practical Manual made by Department of Chemistry, University of Pune.
5) Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in chemical Science.
6) Experiments in chemistry, D. V. Jahagirdar, Himalaya Publishing House.
7) General Chemistry Experiments, Anil. J Elias, University Press.

PSCH-126: -Analytical Chemistry Practical, Sem-II,(4 Credits,)

Learning Objectives:

- To develop effective laboratory practices.
- Aware about use of Chemicals.
- To establish an appreciation of the role of chemistry in various fields
- To develop an understanding of the range and uses of analytical methods in chemistry
- Aware about use of personnel protective and other safety equipment's.

Learning outcomes:

At the end of course student will understand

- Introduction to different analytical techniques.
- Explain the fundamentals of analytical chemistry and steps of a characteristic analysis
- Handling of advanced analytical instruments
- Precautions of hazardous chemicals

1. **Table work: (Any Three)**
   a. Statistical treatment of experimental data.
   b. Analysis of crystal structure from single crystal X-ray pattern.
   c. Data analysis, error analysis, least square method.
   d. Analysis of given spectra.
2. **Use of Chemistry Software: (Any Two)**
   a. .Chem Office: Draw the Structures of simple organic compounds and find out IUPAC name,
   Convert structure to name and predict ^{1}H-NMR and ^{13}CMR.
   b. ACD/NMR processor: Convert FID file in spectrum, how to integrate, how to find J value.
   c. Endnote: How to add references to word file.
3. **Volumetric Analysis: (Any Two)**
   a. Determination of ibuprofen using acid-base titration.
   b. Determination of percentage purity of indomethacin by acid–base titration.
   c. Analysis of Vitamin C in juices and squashes.
4. **Conductometry: (Any Four)**
   a. Determination of concentrations of strong acid and weak acid present in the mixture by titration with strong base.
   Determination of critical micelle concentration (CMC) and ΔG of micellzation of sodium dodecyl sulphate (SDS).
   b. Verification of Debye Huckel theory of ionic conductance for strong electrolytes KCl, $BaCl_2$, K_2SO_4, $K_3[Fe(CN)_6]$
   c. Structural determination of metal complexes by conductometric measurements.
   d. To study complex formation between Fe (III) with sulphosalicylic acid by conductometry.
   e. Determination of the strength of commercial phosphoric acid/ vinegar by conductometric titration.
5. **Potentiometry: (Any Two)**
   a. Determination of concentrations of strong acid and weak acid present in the mixture by titrating with strong base.
   b. Determination of concentrations of reductant or oxidant by redox titration.
   c. Complexometric determination using disodium EDTA of Co^{2+}, Al^{3+} and Cu^{2+}

6. Colorimetry/ Spectrophotometry:(Any Four)

a. Estimation of phosphate from waste water by calibration curve method.

b. Determination of equilibrium constant of M-L system such as Fe (III)–Sulphosalicylic acid by Job´s continuous variation method.

c. Determination of equilibrium constant of M-L system such as Fe (III) – resorcilic acid by Mole ratio method.

d. Determination of iron by solvent extraction technique in a mixture of Fe(III)+Al(III) or Fe(III)+Ni(III)using8-hydroxyquinoline reagent.

e. Determination of Cu (II) by solvent extraction as Dithiocarbamate/ 8-hydroxyquinoline complex.

f. Study of kinetics of iodination of acetone spectrophotometrically.

7. **Ion Exchange Chromatography: (Any two)**

   a. Separation of mixture of Zn (II) and Cd (II) using Amberlite IRA 400 anion exchanger and quantitative estimation of separated ions Zn (II) and Cd (II).

   b. Separation of mixture of Zn(II)and Mg (II) using Amberlite IRA-400 anion exchanger and quantitative estimation of separated ions Zn (II) and Mg (II).
   c. Separation and estimation of Fe and Al on cation exchanger.

8. **Flame photometry: (Any One)**

   a. Estimation of Ca in milk powder sample by flame photometry.

   b. Determination of concentration of Na^+ and K^+ in oral rehydration sachet by flame photometry

9. **Report on Industrial visit**

References:

1. Lab Manual: Selected experiments of Pharmaceutical Analysis, Aness A Siddiqui.

2. Experimental physical chemistry, Athawale, Mathur, Newage Int. Publishers.

3. Textbook of quantitative analysis A. I. Vogel 4^{th} Edition.
4. Experiments in Chemistry, D. V. Jahagirdar.

5. General Chemistry Experiments, Anil J .Elias University Press.

6. Ligand Field Theory, B. N. Figgis

7. Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.)

8. Senior Practical Physical Chemistry, B. D. Khosla and V.S. Garg (R.Chand and Co.,Delhi.)
9. Practical physical chemistry, B. Vishwanathan and P.S.Raghavan,2^{nd} edition, (2012)