Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous),

Shivajinagar, Pune -05

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus

For

M.Sc. (Analytical Chemistry)

(Based on NEP 2020 framework)

(To be implemented from the Academic Year 2023-24)

Semester 1 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP111	Major Paper 1 (Theory)	Fundamentals of Physical Chemistry I	4	4	50	50	100
	23ScCheP112	Major Paper 2 (Theory)	Molecular Symmetry and Main group Chemistry	4	4	50	50	100
	23ScCheP113	Major Paper 3 (Practical)	Lab Course on 23ScCheP111 & 23SCheP112	4	4	50	50	100
	23ScCheP114	Major Paper 4 (Theory)	Basic Organic Chemistry	2	2	25	25	50
Major Electives (4)	23ScCheP121	Major Elective (T+P)	Organic Reactions (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP122	Major Elective (T+P)	Analytical Methods (T + P)	6	4	50	50	100
RM (4)	23ScCheP131	RM Paper 1	RM Core Paper	2	4	50	50	100
	23ScCheP131	RM Paper 2	Department Specific Paper	2				
OJT(4)		–	–	–	–	–	–	–
Total				26	22	275	275	550

Semester 2 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP211	Major Paper 1 (Theory)	Molecular Spectroscopy and Nuclear Chemistry	4	4	50	50	100
	23ScCheP212	Major Paper 2 (Theory)	Coordination and Bioinorganic Chemistry	4	4	50	50	100
	23ScCheP213	Major Paper 3 (Practical)	Lab Course on 23ScCheP211 & 23ScCheP212	4	4	50	50	100
	23ScCheP214	Major Paper 4 (Theory)	Organic Spectroscopy	2	2	25	25	50
Major Electives (4)	23ScCheP221	Major Elective (T+P)	Synthetic Organic Chemistry (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP222	Major Elective (T+P)	Analytical Chemistry (T + P)	6	4	50	50	100
RM (4)	-	–	–	–	–	–	–	–
	-	–	–	–				
OJT(4)	23ScCheP241	OJT	On Job Training	8	4	50	50	100
Total				30	22	275	275	550

Semester 3 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP311	Major Paper 1 (Theory)	Advanced Analytical Electrochemical Methods	4	4	50	50	100
	23ScCheP312	Major Paper 2 (Theory)	Introduction to Advanced Sophisticated Analytical Techniques	4	4	50	50	100
	23ScCheP313	Major Paper 3 (Practical)	Lab Course on Analytical Chemistry I	4	4	50	50	100
	23ScCheP314	Major Paper 4 (Theory)	Photochemistry, Free radicals and Pericyclic Reactions	2	2	25	25	50
Major Electives (4)	23ScCheP321	Major Elective (T+P)	Pharmaceutical Analysis (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP322	Major Elective (T+P)	Geochemical & Alloy analysis (T + P)	6	4	50	50	100
RP (4)	23ScCheP351	RP	Research Project	8	4	50	50	100
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

Semester 4 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP411	Major Paper 1 (Theory)	Analytical Spectroscopy	4	4	50	50	100
	23ScCheP412	Major Paper 2 (Theory)	Industrial Chemicals, Characterization of Functional Polymers and Solid Catalyst	4	4	50	50	100
	23ScCheP413	Major Paper 3 (Practical)	Lab Course on Analytical Chemistry II	4	4	50	50	100
Major Electives (4)	23ScCheP421	Major Elective (T+P)	Analytical Toxicology & Food Analysis (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP422	Major Elective (T+P)	Safety in Chemical Laboratory (T + P)	6	4	50	50	100
RP (4)	23ScCheP451	RP	Research Project	12	6	75	75	150
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

OE : Open Elective
AEC: Ability Enhancement Course
VEC: value Education Courses
CC : Co-Curricular Courses
IKS : Indian Knowledge System
OJT : On Job Training
FP : Field Project
VSC : Vocational Skill Courses
CEP : Community Engagement Project

Semester 1

23ScCheP111: Fundamentals of Physical Chemistry I (4 Credits, 60 L)

Chapter No.	Section I: Thermodynamics (2 Credits, 30 L)	
1	**Recapitulation** Basic concepts of Chemical Mathematics, Heat, work & Conservation of energy – The basic concepts, the First law, infinitesimal changes, mechanical work, work of compression &expansion, free expansion, expansion against constant pressure, reversible expansion. Heat: - Heat Capacity, Enthalpy. State functions & differentials – State functions, exact & inexact differential, changes in internal energy, temperature dependence of the internal energy, temperature dependence of the enthalpy. Work of adiabatic expansion – Irreversible adiabatic expansion, reversible adiabatic expansion	**3 L**
2	**The Second law of Thermodynamics** The second law of Thermodynamics, definition of entropy, the entropy changes in the system, natural events. Entropy changes in the universe: The enthalpy change when a system is heated. Entropy changes in surroundings. The entropy of phase transition. The entropy of irreversible changes. Concentrating on the system: The Helmholtz & Gibbs function, some remarks on the Helmholtz function. Maximum work, some remarks on Gibbs function. Evaluating the entropy & Gibbs function. The third law of Thermodynamics, Third law entropies standard molar Gibbs function	**6 L**
3	**Combining First & Second law of Thermodynamics** Fundamental equations and properties of Gibbs function. The temperature dependence of the Gibbs functions. The pressure dependence of the Gibbs functions. The chemical potential of a Perfect gas. The open system & changes of composition	**5 L**
4	**Changes of State** Physical Transformation of pure materials. The stabilities of phases, Phase equilibrium & phase diagrams. The solid – liquid boundary. The liquid - vapor	**4 L**

	boundary. The solid-liquid-vapor boundary	
5	**Quantum Chemistry** Historical development of quantum theory, failure of classical mechanics, black body radiation, photo electric effect, specific heats of solids, Atomic spectra, wave particle duality, uncertainty principles, Wave particle and its interpretation, Operators, Eigen value equation, exception, value, degeneracy, Schrödinger equation, free particle, particle in one dimensional box, two dimensional box and three dimensional box, hydrogen like atoms (No derivation), atomic orbitals, Application of quantum theory-Variation and perturbation theory	**12 L**
	Section II: Chemical Kinetics and Reaction Dynamics (2 Credits, 30 L)	
1	**Recapitulation** Rate of reaction, rate constants, rate law, Order of reaction, molecularity of reaction, zero order, first order and second order reactions, higher order reactions, half life periods, fractional order reactions and their half life periods, Arrhenius equation, energy of activation, steady state approximations	**3 L**
2	**The kinetics of complex reactions** Kinetics of reversible reactions, parallel reactions, consecutive reactions, chain reaction- explosion, photochemical reactions, quantum efficiency, fast reactions-flash photolysis, flow techniques, relaxation methods	**6 L**
3	**Molecular reaction dynamics** Theories of reaction rates - collision theory, the steric requirements, Diffusion control reactions- classes of reactions, diffusion and reactions, the details of diffusion, Activated complex theory- the reaction coordinate and the transition state, the formation and decay of the activated complex, Eyring equation, thermodynamics aspects, reactions between ions	**7 L**
4	**Catalysts** Definition of catalysis, Types of catalysis, Enzyme catalysis, Michaelis-Menten mechanism, limiting rate, Lineweaver Burk and Eadie plots, Enzyme inhibition: competitive and non-competitive inhibition	**4 L**

5	**Molecular Thermodynamics** Molecular energy levels, Boltzmann distribution law, partition functions and ensembles, translational, rotational and vibrational partition functions of diatomic molecules, Obtaining energy, heat capacity, entropy free energy, equilibrium constants from partition functions, equipartition of energy, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics	**10 L**

References

1) Physical Chemistry- P.W. Atkin and De Paule 8th edition (2010)
2) Physical Chemistry-T. Engel and P. Reid, Pearson Education (2006)
3) Physical Chemistry and molecular approach- D. Mcquarie and J. Simon (University Science) (2000)
4) Physical Chemistry for Biological Sciences by Raymond Change (Universal books) (2000)
5) Physical Chemistry – Marron and Prouton
6) Physical Chemistry- G.M. Barrow, Tata Mc Grow Hill 1988
7) Quantum Chemistry- Ira Levine 5th edition, Prentice Hall, 1999.
8) Text book of Physical Chemistry by Samuel Glasstone

23ScCheP112: Molecular Symmetry and Main Group Chemistry (4 Credits, 60L)

Chapter No.	Section I: Molecular Symmetry (2 Credits, 30 L)	
1	**Molecular Symmetry and Groups theory** Introduction, Importance of molecular symmetry, Symmetry operations, Symmetry elements, The inversion centre or center of symmetry(i), Proper rotation axis(C_n)/ Rotational axis of symmetry, Classification of rotational axes: a) Principal axis b) Simple or secondary rotational axes (C_2) Symmetry planes or mirror plane(σ): a)Vertical Plane(σ_v) b)Horizontal Plane(σ_h) c) Dihedral Plane(σ_d), Improper rotation axis(S_n), Identity element (E), Products of symmetry operations, Equivalent symmetry elements and equivalent atoms, General relations between symmetry elements and symmetry operations, Symmetry elements and optical isomerism	**8 L**
2	**Concept of point group** Assignment of point groups, C-type point groups, D-type point groups, Higher symmetry point groups: $C_{\infty v}$ point groups, $D_{\infty h}$ point groups, C_{2v} point groups, C_{3v} point groups, C_{2h} point groups, D_{3h} point groups, Dn_d point groups, S_n point groups, Exercise on point groups (example of each point group)	**3 L**
3	**Group, Subgroups, Classes** Group multiplication tables, Group generating elements	**3 L**
4	**Representations of Groups** Matrix representation of symmetry elements, Matrix representation of point groups, Transformation matrices, The Great Orthogonality Theorem and its consequences, Character tables (No mathematical part)	**4 L**
5	**Group theory and quantum mechanics** Reducible and irreducible representation, Wave function as basis for irreducible representations, Theoretical treatment of rotational, vibrational and electronic spectroscopy of point groups	**3 L**
6	**Symmetry Adapted Linear Combinations** Projection operators and their use in construction of Interhalogens SALC (Construction of SALC for sigma bonding for molecules belonging point	**5 L**

	groups: D_{2h}, D_{3h}, D_{4h}, C_{4v}, T_d, O_h, normalization of SALC.	
7	**Molecular Orbital Theory** Transformation properties of atomic orbital, MOs for Sigma bonding AB_n molecules, tetrahedral AB_4 and Oh AB_6 cases.	**4 L**
	Section II: Main group chemistry (2 Credits, 30 L)	
1	**S-Block elements** Types of hydrides: metallic hydrides, Alkali and alkaline earth metals:Solutions in non-aqueous medium, Application of crown ethers in extraction of alkali and alkaline earth metals	**4 L**
2	**Boron group** Simple hydrides of boron, Higher boranes and borohydrides, Synthesis and interconversion of lower and higher boranes, Bonding in boranes, Wade's rules and structures of boranes, Characteristic reactions of boranes, Metalloboranes and carboranes, Silicates: Zeolites and their applications	**7 L**
3	**Carbon group** Allotropy of carbon, Graphite intercalation compounds, Fullerenes: Structure, properties and application, Carbon nanotubes: Single-Walled & Multi-Walled CNTs, their synthesis, and application (Electronic, thermal, biomedical, catalytic, etc.), Graphene: Synthesis, properties and application and Graphene oxide, Carbon dots	**4 L**
4	**Nitrogen Group** Oxidation states of Nitrogen and their interconversion, Oxides of Oxoanions of Nitrogen, Phosphazenes, SN and BN compounds	**3 L**
5	**Oxygen Group** Oxyacids and Oxoanions of Sulphur, Metal Sulphides, Selenides and Tellurides	**2 L**
6	**Halogen Group** Pseudohalogens, Interhalogens, Chemical properties, Cationic interhalogens, Polyhalides, Oxoacids & oxoanions: Structure & properties, Fluorocarbons	**2 L**
7	**Important compounds of Noble gases** Xenon fluoride: Synthesis, structure and reactions, Xenon oxygen compounds	**2 L**
8	**Organometallic chemistry**	**6 L**

	Synthesis, properties, structures and uses of organometallic compounds of following elements: Al & Bi, 18-electron Rule, Ligand substitution in square planar complexes	

References:

1) Chemical Applications of Group Theory, 3rd Edn., Author - F. A. Cotton (Wiley, New York)
2) Symmetry and spectroscopy of molecules, 2nd Ed. 2009; K. Veera Reddy, (New Age International Publication)
3) Group Theory and its Chemical Applications, P.K. Bhattarchrya
4) Inorganic Chemistry: Shriver & Atkins (4th edition 2003, Oxford)
5) Concise Inorganic Chemistry, J. D. Lee, Fourth Edn.(Chapman and Hall)
6) Inorganic chemistry: principle of structures and reactivity, Huheey, Keiter, Keiter, Medhi, Pearson Education, 4th Edn. (2007).
7) Inorganic Chemistry: Catherine Housecroft
8) Inorganic Chemistry: Messler & Tarr, Pearson Publishers 3rd Edition
9) Organometallic Chemistry-A Unified Approach: R. C. Mehrotra & A. Singh

23ScCheP113: Lab Course on 23ScCheP111 & 23SCheP112 (4 Credits)

Experiment No.	Name of the Experiment
	PHYSICAL CHEMISTRY
1	**Colorimetry & spectrophotometry**
	Determination of amount of copper present in the given solution by colorimetric titration method using standard EDTA
	To determine the concentration of dichromate and peramagnet ions by simultaneously determination method from their mixture Spectrophotometrically
	Simultaneous determination of Ni and Co by spectrophotometry
2	**Chemical kinetics**
	Determine the individual orders of iodide and persulphate ions and overall order of oxidation reaction of iodide ion by persulphate ion.
	Investigation of influence of ionic strength on rate constant of rate constant of reaction between potassium persulphate and potassium iodide (Bronsted Primary Salt effect).
	Determine the temperature coefficient and energy of activation of acid catalyzed hydrolysis reaction of ester.
	Study of the kinetic decomposition of diacetone alcohol by dilatometric method.
	Study of the kinetic of oxidation of ethanol by potassium dichromate.
3	**Non-instrumental experiments**
	Analysis of crystal structure from X-ray diffraction pattern.
	To determine the molecular weight of a given organic liquid by steam distillation method
	Study of three-component system: Water-Acetic acid-Chloroform.
4	**Electrical conductance**
	Study the Hydrolysis of ammonium chloride or sodium acetate or aniline hydrochloride conductometrically.
	Determination of concentrations of strong acid and weak acid present in the mixture by titration with using strong base.

5	**Potentiometry**
	Determine the concentrations of strong acid and weak acid present in the mixture by titrating with strong base.
	Determine of stability constant of silver-ammonia complex by potentiometric method.
	Estimation of Fe by ceric sulphate and potassium dichromate titration potentiometrically
	Simultaneous estimation of Cl and I by potentiometric method
6	**pH metry**
	Determine the acid and base dissociation constant of an amino acid and hence the isoelectric point of the acid.
7	Estimation of vitamin B2 in the medicinal tablets fluorimetrically.
	INORGANIC CHEMISTRY
1	**Alloy Analysis**
	Determination of tin & lead from solder alloy.
	Determination of iron & chromium from stainless steel alloy.
2	**Inorganic synthesis & purity determination**
	a) Synthesis of chloropentaamminocobalt (III) chloride. b) To determine the purity of chloropentaamminecobalt (III)chloride.
	a) Synthesis of nitropentaamminocobalt (III) chloride. b) To determine the purity of nitropentaamminocobalt (III) chloride.
3	**Spectrophotometry**
	Estimation of phosphate from waste water sample by calibration curve method.
	Determination of composition of complex formed between Fe (III) & salicylic acid by Job's continuous variation method & thereafter to fond the stability constant of the complex.
	Determination of composition of complex formed between Fe (III) & sulphosalicylic acid by Job's continuous variation method & thereafter to fond the

	stability constant of the complex.
	Determination of Cu (II) by solvent extraction as 8- hydroxyquinoline
4	**Gravimetric Analysis**
	Determination of H_2O of crystallization in hydrated salts.(At least 4 compounds)
5	**UV visible spectral studies**
	Recording UV visible spectrum of 4 - 5 coordination complexes & interpretation of the spectra.(demonstration only)

References

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

2) Experiments in Physical Chemistry, J. M. Wilson, K. J. Newcombe, A. R. Denko. R. M. W. Richett (Pergamon Press)

3) Senior Practical Physical Chemistry, B. D. Khosla and V. S. Garg (R. Chand and Co., Delhi).

23ScCheP114: Basic Organic Chemistry (2 Credits, 30 L)

Chapter No.	Basic Organic Chemistry	
1	**Structure and reactivity** Chemical bonding and basis of reactivity- Chemical bond, delocalization, conjugation, resonance, hyperconjugation, tautomerism, inductive effects, Acidity and basicity: various structural effects, HSAB concept, Aromaticity: Benzenoid and non-benzenoid compounds, Huckels rule, antiaromaticity, Application to carbocyclic and heterocyclic systems, annulenes, azulenes, current concepts of aromaticity, Structure and stability of reactive intermediates, carbenes, nitrenes, carbocations, carbanions and free radicals	**10 L**
2	**Stereochemistry** Sterochemical principles, enantiomeric relationship, distereomeric relationship, R and S, E and Z nomenclature in C, N, S, P containing compounds, Prochiral relationship, stereospecific and stereoselective reactions, optical activity in biphenyls, spiranes, allenes, examples of chiral metal complexes. Conformational analysis of cyclic (4, 5, 6 membered) and acyclic compounds, Structural effect on reactivity of cyclohexane, Cram's rule and Felkinahn Model	**20 L**

References

1) Organic Chemistry–by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)

2) Advanced Organic Chemistry –by J. March 6th Edition

3) Advanced Organic Chemistry (part A) –by A. Carey and R.J. Sundberg

4) Stereochemistry of carbon compound-by E.L. Eliel

5) Stereochemistry of organic compound-by Nasipuri

6) Guide book to Reaction Mechanism–Peter Sykes

23ScCheP121: Organic Reactions (Theory) (2 Credits, 30 L)

	Organic reactions (2 Credits, 30 L)	
1	**Substitution reaction of saturated carbon** Aliphatic nucleophilic substitution - SN^1, SN^2 mechanism, NGP by pi and sigma bonds, classical and non-classical carbocations, phenonium ions, norbornyl system, carbocation rearrangement in NGP, SN^i mechanism, nucleophilic substitution in allylic, trigonal and vinylic carbon. Effect of structure, nucleophile, leaving group and solvent on rate of SN^1 and SN^2 reactions, ambident nucleophile and regioselectivity	**8 L**
2	**Aromatic Electrophilic substitution** Arenium ion mechanism, orientation and reactivity, energy profile diagram, ortho, para, ipso attack, orientation in other ring systems, six and five membered heterocycles with one hetero atom Important reactions like Friedel crafts alkylation and acylation, Nitration, halogenation, formylation, chloromethylation, sulphonation, diazonium coupling	**7 L**
3	**Aromatic nucleophilic substitution** SNAr, SN^1, Benzyne and SNR^1 reactions, reactivity: effect of substrate structure, leaving group and attacking nucleophile	**3 L**
4	**Addition reactions** Addition to C-C multiple bonds - mechanism and stereochemical aspects of addition reaction involving electrophile, nucleophile and free radicals, Regio and chemo selectivity, orientation and reactivity, conjugate addition	**4 L**
5	**Elimination reactions** E^1, E^2, E1cB mechanisms, orientation and stereochemistry in elimination reaction, reactivity effect of structure, attacking and leaving group, competition between elimination and substitution, syn eliminations	**4 L**
6	**Heterocyclic Chemistry:** Recapitulation of Synthesis and reactivity of Pyrrole, Furan and Thiophene, Synthesis and reactivity of Benzofuran, Benzopyran, Benzothiophene, Quinoline, Isoquinoline, Indole, etc.	**4 L**

References

1) Organic Chemistry–by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)

2) Advanced Organic Chemistry –by J. March 6th Edition

3) Advanced Organic Chemistry –by A. Carey and R.J. Sundberg

23ScCheP121: Organic Reactions (Practical) (2 Credits)

	ORGANIC CHEMISTRY
1	**Techniques of Purification**
	Recrystallization 3 samples (Yield, TLC, and M.P.)
	Recrystallization 3 samples (Yield, TLC, and M.P.)
	Distillation (Steam distillation, vertical distillation, Fractional distillation, etc.) (Yield, TLC, and M.P.)
	Column chromatography separations (Yield, TLC, and M.P.)
2	**Single Stage Preparations**
	Coupling of β- Naphthol
	Diels alder reaction
	Multicomponent synthesis
	Riemann – Tiemann reaction
	Nitration reaction
	Henry reaction
	Reduction using $NaBH_4$
	Chalcone from acetophenone
	Benzoylation of Glycine
	Oxidation of Cyclohexanone
	Acetylation of Resorcinol (Resaceto Phenol)

References

1) Textbook of practical organic chemistry – A. I. Vogel

23ScCheP122: Analytical Methods (Theory) (2 Credits, 30 L)

Chapter No	Section I: Analytical Method Developments and validation (2.0 Credits, 30L)	
1	**Assay Validation and Inter Laboratory Transfer** Introduction, fundamental definitions, Essential principles of method transfer, method validation report, the inter-laboratory qualification (ILQ) process	**6 L**
2	**Statistical Analysis and analytical Figure of Merit** Introduction, Errors (gross errors, systematic errors, random errors), accuracy, validation parameters: Accuracy, precision, mean and standard deviation, calibration, (linear response functions (linear regression-errors in slope and the intercept, error in the estimate of concentration, standard additions), non-linear response functions and weighted regression analysis, internal standards), selectivity and specificity (chromatographic methods), limits of detections (spectrophotometric methods, chromatographic methods and related techniques, receptor binding assay), limit of quantification, sensitivity, ruggedness and robustness, analyte stability in the sample matrix, how to reduce systematic errors, mean and standard deviation, reliability of results, confidence interval, comparison of results, comparison of two means of two samples, experimental design	**15 L**
3	**Overview of World Wide Regulations**	**3 L**
4	**Specific methods and Applications: Dissolution Studies** Introduction, **Dissolution** test, Apparatus – USP type –I and II, Sampling and analytical instrumentation, Single point test vs Dissolution profile, Calibration, regulatory guidelines, analytical validation, linearity, accuracy, precision, specificity	**6 L**

References

1) Development and validation of Analytical Methods, Progress Pharmaceutical and Biomedical Analysis, Vol-3, Edited by Chitofer M. Riley and Tomas W. Rosanske (Elsvier)
2) Vogel's Textbook of quantitative Chemical Analysis, sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.
3) Handbook of modern pharmaceutical analysis, edited by Satinder Ahuja and Stephen Scypinski, Academic Press, Separation science Series, Vol-3

4) HPLC method Development for pharmaceuticals, Edited by Satinder Ahuja and Henrik Rasmussen, Academic Press, Separation science Series, Vol-8
5) Practical HPLC method Development, Snyder, Kirkiand, Glajch, Wiley India Pvt. Ltd.

23ScCheP122: Analytical Methods (Practical) (2 Credits)

Experiment No.	Name of the Experiment
	PHYSICAL CHEMISTRY
1	**Conductometric Titration**
	Detrmination of Thermodynamic dissociation constant of weak acid
2	**pH metry**
	Determination of pH of a buffer solution by colour matching of indicator
	Potentiometry
3	Potentiometric titration of Anthranilic acid and Glycine with NaOH
4	**Noninstrumental**
	Determination of surface area of activated charcoal by Langmuir adsorption isotherm
	Determination of partition coefficient of iodine between water and an organic solvent
	INORGANIC CHEMISTRY
1	Determination of copper and nickel from cupranickel alloy
2	Estimation of Copper and iron in mixed solution of a both by gravimetric method
3	Determination of influence of ligand field strength upon the spectra of copper (II) complexes
	Inorganic Preparations
4	Preparation of Copper Tetramine Sulphate $[Cu(NH)_4]SO_4.H_2O]$
5	Prepation of Prussian Blue $KFe[Fe(CN)_6]$
	ORGANIC CHEMISTRY
1	To prepare benzanilide (N-benzoyl aniline) from aniline
2	To prepare 2,4-dinitrochlorobenzene from chlorobenzene

3	To prepare 3,5-dinitrobenzoic acid from benzoic acid
4	To prepare phenyl azo-β-naphthol from aniline
5	To prepare methyl orange from sulphanilic acid

References

1) Textbook on practical chemistry by K. S. Mukherjee
2) Advanced practical chemistry by Jagdamba Singh, R. K. P. Singh, Jaya Singh, L. D. S. Yadav, I. R. Siddiqui and Jaya Srivastava
3) Experiments in chemistry by D. V. Jahagirdar
4) Vogel's Textbook of Practical Organic Chemistry
5) Advanced Practical Organic Chemistry by O. P. Agarwal

23ScCheP131: Research Methodology Core Paper

Chapter No.	Research Methodology Core Paper	
1	**Research Problem and Design** Introduction to research: meaning and definition of research, objective of research, importance of research characteristics of good research, purpose and role of research classification of research **Research problem**: defining of research problem Criteria for selecting the research problem, importance of literature survey in defining research problem. **Hypothesis**: Defining Hypothesis, types of hypothesis, characteristics of good hypothesis, formulation of hypothesis **Research Design**: Definition and features of research design, Concept of research design, types of research design, preparation of research design, Sampling techniques, characteristics of good sampling designs	**15 L**
2	**Data analysis, report writing and publication ethics** Definition of Data, methods of data collection, analysis of data, types of data analysis, Questionnaire, Design of Questionnaire. Testing hypothesis parametric and non-parametric tests T-test, Z-test, Chi-square test. ANOVA **Report writing:** Importance of interpretation of results, meaning, definition and significance of report /thesis writing. Principals of research report drafting. Types of reports, layout of research report, important parts of reports, precautions of preparation of report/ thesis **Publication ethics:** Definition, introduction and importance, best practices/ standard settings initiative and guidelines COPE, WAME, etc, conflict of interest. Publication misconduct definition, concept problems that lead to unethical behavior violation of publication ethics, predatory publishers and journals, software tools to identify predatory publications developed by SPPU	**15 L**

References

1) C. R. Kothari (2004) Research Methodology Methods and Techniques 2" Edition New age International (p) Ltd Publications, New Delhi, India

2) J W Creswell and J D. Creswell (2017) Research Design Qualitative, Quantitative, and

Mixed Methods Approaches, 5th Edition. SAGE Publications, USA

3) CG Thomas (2021) Research Methodology and Scientific Writing, 24 Edition, Springer Nature, New York.

4) M. Kheider lectures from University of Biskra (2017) https://univ-biskra.dz/sites/f/images/houadili%20Ahmed%20Chaouki.pdf

23ScCheP131: Department Specific Paper

Chapter No.	**Nanomaterials**	
1	The Big world of nanomaterials History and scope-Can small things make big difference? – Classification of nanomaterials – Fascinating Nanostructures – Applications of nanomaterials- The nature: The Bets Nanotechnologist – Challenges and future prospects	**4 L**
2	Unique Properties of Nanomaterials Microstructure and defects in monocrystalline Materials - Effect of Nano dimensions on material behaviour Optical Properties, Electrical Properties, Mechanical Properties, Magnetic Properties	**5 L**
3	Synthesis Routes Bottom-Up approaches – Top-Down approaches - Consolidation of Nano powders Mechanical Grinding, Wet Chemical Synthesis of Nanomaterials –Sol Gel Process, Gas Phase Synthesis, Flame assisted ultrasonic spray pyrolysis, Gas Condensation Processing, Chemical Vapour Condensation (CVC) etc.	**7 L**
4	Application of Nanomaterials Nano electronics –Micro and Nano-Electromechanical Systems (MEMS/NEMS) – Nanosensors –Nanocatalysts- Food and Agriculture Industries – Cosmetic and Consumer goods – Structure and Engineering – Automotive Industry-Water treatment and environment – Nanomedical applications – Textile-Paints –Energy-Defence and space applications – Structural applications , etc.	**7 L**
5	Tools to Characterize Nanomaterials X-Ray Diffraction (XRD) – Small Angle X Ray Scattering (SAXS)-Scanning Electron microscopy (SEM) – Transmission Electron Microscope (TEM)-Atomic Force Microscope (AFM) –Scanning Tunnelling Microscope (STM) - Field Ion Microscope (FIM) –Three Dimensional Atom Probe (3DAP) –Nano indentation	**7 L**

References

1) Text Book of Nanoscience and Nanotechnology by B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday – Springer and University Press (2013)

2) Chapter - Introduction to Nanomaterial - Alagarasi, A, -2016-Research Gate

Semester 2

23ScCheP211: Molecular Spectroscopy & Nuclear Chemistry II (4 Credits, 60 L)

Chapter No.	Section I: Molecular Spectroscopy (2 Credits, 30 L)	
1	**Introduction to spectroscopy** Basic Elements of practical spectroscopy Signal to noise: resolving power, Width and intensity of spectral transitions, Fourier Transform Spectroscopy, Enhancement of spectra: computer Averaging	**3 L**
2	**Microwave Spectroscopy** The Rotation of Molecules, Rotational Spectra, Diatomic molecules, Polyatomic molecules, Techniques and Instrumentation, Chemical Analysis by Microwave Spectroscopy, The Microwave Oven, Problems	**5 L**
3	**Infrared spectroscopy** Harmonic and anharmonic oscillator, vibrational spectra of di –and poly- atomic molecules, coarse and fine structure, Nuclear spin effect, application, Problems	**5 L**
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 in structure elucidation, Problems	**6 L**
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 and applications	**6 L**
6	**ESR and Mossbauer spectroscopy applications.** **ESR**-Introduction, g factor, The Hyperfine Structure of ESR, Double Resonance, Electron-Electron Coupling, Techniques of ESR, Problems. **Mossbauer Spectroscopy** - Introduction, Principle, Applications of Mossbauer Spectroscopy, Problems	**5 L**

	Section II: Nuclear and Radiation Chemistry (2Credits, 30 L)	
1	**Radiation Chemistry** Recapitulation – Types of radioactive decay, Decay Kinetics, Detection& measurement of radiation (G.M. & Scintillation counter), Radiation chemistry, interaction of radiation with matter, passage of nucleus through matter, Units for measuring radiation absorption, Radiation dosimetry, Radiolysis of water, free radiation in water Radiolysis, Radiolysis of some aqueous solution	**9 L**
2	**Nuclear Reactor** The Natural uranium reactor, the four factor formula- The reproduction factor K, the classification of reactor, Reactor power, Critical size of thermal reactor, excess reactivity & control, the Breeder reactor, Reprocessing of spent fuel, Recovery of Uranium &Plutonium, Nuclear waste management, Natural nuclear reactor	**7 L**
3	**Isotopes for nuclear reactors** Isotope separation, separation of selected isotopes, Plutonium	**4 L**
5	**Applications of radioactivity** 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. Physical constants – Diffusion coefficients, surface area, solubility. Analytical applications neutron activation analysis, dilution analysis, radiometric titration. Industrial applications– radiation guaging, friction and wear out, gamma radiography	**10 L**

References

1) Fundamentals of molecular spectroscopy: C.N. Banewell and E.Mc. Cash (Fourth edition)

2) Elements of Nuclear chemistry – H. J. Arnikar, fourth edition wiley Estern Ltd.

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

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

23ScCheP212: Coordination and Bioinorganic Chemistry (4 Credits, 60 L)

Chapter No.	Section I: Coordination Chemistry (2 Credits, 30 L)	
1	**Concept & Scope of Ligand Fields** Free ion configuration, Spin – Spin coupling, Orbital coupling, Spin –Orbital coupling, The Energy terms coupling schemes, Russell- Saunders's coupling scheme, J-J Coupling scheme, Effect of V_{Oh} & V_{Td} on terms	**6 L**
2	**Basic concepts of electron absorption spectroscopy** Selection rules - Spin selection rule, Laporte selection rule	**2 L**
3	**Ligand Field Theory of Coordination Complexes** Effect of ligand field on energy levels of transition metal ions, Weak cubic ligand field effect on Russell- Saunders terms, Strong field effect on Russell- Saunders terms, Widths of absorption bands, Relative variation of energy levels under the influence of Crystal field, Orgel diagrams, Application of Orgel diagrams, Use of Orgel diagrams, Correlation diagrams, Tanabe-Sugano diagrams, Spin-Pairing energies	**7 L**
4	**Electronic spectra of Transition Metal Complexes** Introduction, Band intensities, Band energies, Band width & shapes, Spectra of 1^{st}, 2^{nd} & 3^{rd} row ions and rare earth ion complexes, Spectrochemical & nephlauxetic series, Charge transfer spectra & luminescence, Calculations of Dq, B, β parameters	**7 L**
5	**Magnetic Properties of Coordination Complexes** Origin and types of magnetism, Curie and Curie-Weiss Law, Magnetic properties of complexes-Paramagnetism, 1^{st} & 2^{nd} 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	**8 L**
	Section II: Bioinorganic Chemistry (2 Credits, 30 L)	
1	**Overview of bioinorganic chemistry** Biological functions of metal ions, Metalloenzyme functions, Recapitulation of thermodynamic and kinetic aspects related to bioinorganic chemistry, Summary of biomolecules, proteins, Nucleic acids, Other metal binding biomolecules	**6 L**

2	**Bioinorganic chemistry of Cu, Zn** Biochemistry of copper, Copper centers in enzymes: Type-1, Type-2 and Type - 3, Copper proteins as oxidases/reductases, Cu-Zn Superoxide Dismutase, Hemocyanin, Biochemistry of Zinc, Carbonic Anhydrase (CA) Carboxypeptidase A (CPA), Alcohol Dehydrogenase (ADH), Zinc Finger protein	**8 L**
3	**Bioinorganic chemistry of Iron** Porphyrin based systems: Hemoglobin and myoglobin, Ferritin, Transferrin (Receptor mediated endocytosis), Iron-Sulfur clusters, Cytochrome P-450, Alternative Oxygen Transport in Some Lower Animals: Hemerythrin	**9 L**
4	**Bioinorganic chemistry of Ca, Mn** Calcium: Calmodulin & Role of Ca in blood coagulation Manganese: Photosynthesis	**4 L**
5	**Electrolyte balance in human body** Generation of ionic gradients (Na^+-K^+-ATPase), Acetylcholine receptor	**3 L**

References:

1) Ligand field theory & its applications: B. N. Figgis & M. A. Hitachman (2000) Wiely VCH Publication
2) Symmetry and spectroscopy of molecules, Second Edn, by K. Veera Reddy, New Age International Publication 2009.
3) Elements of magnetochemistry, R. L. Datta and Syamal, Second Edn , Afiliated East West Press Pvt. Ltd. 2007.
4) Principle of Bioinorganic Chemistry: S. J. Lippard and J. M. Berg
5) Bioinorganic Chemistry: Inroganic Elements in Chemistry of Life: W. Kaim and B. Schwederski
6) Bioinorganic Chemistry: Bertini, Gray, Lippard and Valentine
7) Bioinorganic Chemistry: R. J. P. Willams
8) Bioinorganic Chemistry: Robert Hay
9) Bioinorganic Chemistry: M.N. Hughes

23ScCheP213: Lab Course on 23ScCheP211 & 23ScCheP212 (4 Credits)

Experiment No.	Name of the Experiment
	PHYSICAL CHEMISTRY
1	**Colorimetry & spectrophotometry**
	Simultaneous determination of Cations from their mixture Spectrometrically
	The reaction between potassium persulphate and potassium iodide by colorimetry
2	**Radioactivity**
	a) Determine the half-life of a given radioactive nuclide and counting error b) Find the percentage error in the given experimental data by the method of least squares
	Determine E_{max} of β-radiation and absorption coefficient in Aluminium
3	**Non-instrumental experiments**
	Determine the radius of glycerol molecule from viscosity measurements
	Determine the densities of a series of solutions and calculate the partial molar volume of the components
	Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method)
4	**Electrical conductance**
	Determine equivalent conductivity at infinite dilution and dissociation constant of acetic acid conductometrically.
	Study the second order velocity constant of the hydrolysis of ethyl acetate by sodium hydroxide using conductivity measurement
	To determine concentration of Boric acid titrating with NaOH by Conductometry
5	**Potentiometry**
	Determination of Solubility and Solubility product of the given sparingly soluble salts.
	Determine the amount of chloride, bromide and iodide present in their mixture by potentiometric titration.
6	**pH metry**
	Determine dissociation constants of tribasic acid.

	To determine dissociation constant of carbonic acid
	To determine the ionization constant of methyl red/ bromophenol blue.
7	**Interpretation of spectra/data-I**
	Interpretation of ESR spectra. Interpretation of Mössbauer spectra
	INORGANIC CHEMISTRY
1	**Ion exchange chromatography**
	Separation & estimation of a mixture of Zn (II) & Mg (II) using ion exchange chromatography
	Separate the binary mixture of Zinc and Cadmium using ion exchange chromatography
2	**Ore analysis**
	Determination of Silica (SiO_2) & Manganese (Mn) in pyrolusite
	Determination of silica & iron from haematite
3	**Inorganic synthesis & purity determination**
	a) Synthesis of tris-ethylene diaminenickel (II) thiosulphate b) To determine the purity of tris-ethylene diaminenickel (II)thiosulphate
	a) Synthesis of tris (thiourea) copper (I) chloride. b) To determine the purity of tris (thiourea) copper (I) chloride
	a) Synthesis of potassium trioxalatoaluminate (III) trihydrate b) To determine the purity of potassium trioxalatoaluminate (III)
	a) Preparation of Copper Tetramine Sulphate
	b) To determine the purity of Copper Tetramine Sulphate
	a) Preparation of hexamine Ni (II) chloride
4	**Conductometry**
	To verify Debye- Hukel theory of ionic conductance for strong electrolytes using KCl, $BaCl_2$, K_2SO_4, $K_3[Fe(CN)_6]$
5	**Photochemistry**
	Synthesis & photochemistry of potassiumtrioxalatoferrate (III) trihydrate
6	**Synthesis of Nano Materials**
	Synthesis of nano size ZnO, its characterization by UV- visible spectroscopy and

	removal of dye by ZnO photocatalysis
7	**Interpretation of spectra/data-I**
	Interpretation of DTA, TG, and DTG curves.
8	**Table work**
	Analysis of Electronic Spectra of transition metal complexes at least for one system [dn (Oh) or (Td)] and calculation of Crystal Field parameters, interelectronic repulsion parameter and bonding parameter.

References:

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

2) Experiments in Physical Chemistry, J. M. Wilson, K. J. Newcombe, A.R. Denko. R. M. W. Richett (Pergamon Press)

3) Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.).

4) Text book of Quantitative Analysis, A. I. Vogel 4th Edn. (1992).

5) Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003. .

6) Physical chemistry by Wien (2001)

7) Practical physical chemistry, B. Vishwanathan and P.S. Raghavan, 2nd edition, (2012)

8) Experimental Physical chemistry, V.D. Athawale, Parul Mathur, New age International publishers.

9) Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.

10) Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House

11) General Chemistry Experiments, Anil. J Elias, University press (2002)

12) Electronic Spectroscopy by A.B. P. Lever.

23ScCheP214: Organic Spectroscopy (2 Credits, 30 L)

Chapter No.	Organic Spectroscopy	
1	UV: Factors affecting UV absorption and interpretation of UV spectra	**3 L**
2	IR: Basic ideas about IR frequencies, interpretation of IR spectra	**5 L**
3	NMR: Fundamentals of ^{1}H-NMR,^{13}C-NMR factors affecting chemical shift, integration coupling (1st order analysis) , 2D- NMR COSY, HOMO, HETCOR, NOE, DEPT	**15 L**
4	Introduction to Mass spectrometry	**3 L**
5	Problems on UV, IR, PMR and Mass	**4 L**

References

1. Introduction to spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 3rd Edition
2. Spectroscopic methods in organic molecules – D.H. William & I Flemming Mc Graw Hill
3. Spectrometric Identification of Organic Compounds Robert M. Silverstein, Francis X. Webster, David Kiemle
4. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)

23ScCheP221: Synthetic Organic Chemistry (Theory) (2 Credits, 30 L)

Chapter No.	Synthetic Organic Chemistry	
1	**Oxidizing agents and their reactions** CrO_3, PDC, PCC, $KMnO_4$, MnO_2, Swern, SeO_2, $Pb(OAc)_4$, Pd-C, OsO_4, m-CPBA, O_3, $NaIO_4$, DDQ, HIO_4, Woodward and prevost hydroxylation, etc.	**6 L**
2	**Reducing agents and their reactions** Boranes and hydroboration reactions, MPV reduction and reduction with H_2/Pd-C, Willkinson's catalyst, DIBAL and Wolff Kishner reduction, Birch reduction, LAH, Catalytic Hydrogenation. Suzuki coupling, etc.	**6 L**
3	**Rearrangements** Beckmann, Hofmann, Curtius, Smith, Wolff, Lossen, Bayer-villiger, Sommelet, Favorskii, Pinacol-pinacolone, Benzil-benzilic acid, Fries, Claisen rearrangement, cope rearrangement, Wagner Meervin rearrangement, etc.	**8 L**
4	**Ylides** Phosphorus, Nitrogen and Sulphur ylides	**3 L**
5	**C-C bond formation reactions:** Grignard, organozinc, organocopper, organolithium, reagents to carbonyl and unsaturated carbonyl compounds, Palladium catalyst, suzuki, Heck reaction	**4 L**
6	**Heterocyclic Chemistry :** Synthesis and Reactivity of Pyrazole, Oxazole, Diazole, Triazole, Flavone, Isoflavones, Coumarin, etc.	**3 L**

References:

1. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
2. Modern Synthetic reactions- H.O. House
3. Organic Synthesis – M.B. Smith
4. Advanced Organic Chemistry (part A & B) – A. Carey and R. J. Sundberg
5. Stereochemistry conformations and mechanism by P. S. Kalsi
6. Organic chemistry by Cram, Hammond, Pine and Handrickson
7. Mechanism and Structure in Organic Chemistry - E.S. Gould

23ScCheP221: Synthetic Organic Chemistry (Practical) (2Credits)

	ORGANIC CHEMISTRY
1	**Ternary Mixture Separation (Any 8)**
	Using ether separation method including TLC, M. P., Yield (5 Ether Soluble & 3 Ether Insoluble one compound)
2	**Double stage Preparations**
	Nitrobenzene to *m*- dinitrobenzene to *m*- nitroaniline
	β- Naphthol to 2- methoxy naphthalene to 1- formyl-2- methoxy naphtahalene
	Benzaldehyde to Benzalacetophenone to Epoxide
	Resorcinol to 4-methyl-7-hydroxy to coumarin 4-Methyl-7-acetoxy coumarin
	Hydroquinone to Hydroquinone diacetate to 1,2,4 – Triacetoxy
	Hippuric acid to Azalactone to 4-Benzylidene 2-phenyloxazol-5-one
	p-Cresol to p-Cresyl benzoate to 2-Hydroxy-5-methyl benzophenone
	Phthalimide to N-Benzylphthalimide to Benzylamine
	Benzyl cyanide to p-Nitrobenzyl cyanide to *p*-Nitro phenyl acetic acid
	Chlorobenzene to 2, 4 dinitrochlorobenzene to 2, 4 dinitro phenyl Hydrazine

References:

1) Textbook of practical organic chemistry – A. I. Vogel

23ScCheP222: Analytical Chemistry (Theory) (2 Credits, 30 L)

Chapter No	Analytical Chemistry	
1	**Data Handing and Spreadsheets in Analytical Chemistry** Accuracy and Precision, classification of errors, Significant figures, rounding off, ways of expressing accuracy, Mean Deviation, Average Deviation, RMD, Standard Deviation Propagation of errors, Confidence limits, Tests of Significance, Rejection of results and Problems.	**12 L**
2	**Sampling, Standardization and Calibration** Analytical Samples and Methods of Sampling, Sample Handling, Gross sample, Preparation of Laboratory samples, Automated Sample Handling, Comparisons with standard and Numerical Problems.	**10 L**
3	**Introduction to analytical separations** Separation by precipitation, separation of species by distillation, separation by extraction, separation by ion exchange chromatography and problems.	**8 L**

References

1) Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, 5th Edition, Thomson Asia Pvt. Ltd, Singapore, 2004.
2) Analytical Chemistry, G.D. Christian, 6 th Edition.
3) Vogel's Text book of Quantitative Analysis.
4) Analytical Chemistry, G.D. Christian, 6 th Edition.
5) Instrumental Methods of Chemical analysis, H. H. Willard, L. L. Merritt Jr., J. A. Dean & F. A. Settle Jr., 6th Edition, Wadsworth Publishing Company, USA,1986

23ScCheP222: Analytical Chemistry (Practical) (2 Credits)

Experiment No.	Name of the Experiment
	PHYSICAL CHEMISTRY
	Potentiometry
1	Potentiometric Titration of a standard solution of KCl against $AgNO_3$ solution
	Potentiometric titration of ferrous iron in Mohr's salt against a standard solution of $K_2Cr_2O_7$ or $KMnO_4$
2	**Kinetics**
	Determination of rate constant of reaction between H_2O_2 and HI
	Determination of order of hydrolysis of ethyl acetate by NaOH
	Determination of heat of neutralization of HCl by NaOH
	INORGANIC CHEMISTRY
1	Estimation of Iron and Nickel in a mixed solution of both by gravimetric method
2	**Inorganic Preparations**
	Preparation of Ferrous Ammonium Sulphate (Mohr's salt) $[FeSO_4 (NH_4)_2SO_4]6H_2O$
	Prepartion of Manganese pthalocyanin $[Mn(C_6H_4CN)_4]$
	Preaparation of Sodium cobaltinitrite $Na_3[Co(NO_2)_6]$
3	**Chromatography**
	Paper chromatographic separation of Ni (II), Co (II) and Zn (II)
	ORGANIC CHEMISTRY
	Preparations: Double stage
1	Phthallic anhydride – Phthallimide – Anthranillic acid
2	Acetophenone – Oxime – Acetanillide
3	Phthalic anhydride – o – benzoyl benzoic acid anthraquinone
4	Chlorobenzene – 2, 4 – dinitrochlorobenzene – 2,4-dinitrophenol
5	Benzoin – Benzil – Benzilic Acid

References

1) Textbook on practical chemistry by K. S. Mukherjee
2) Advanced practical chemistry by Jagdamba Singh, R. K. P. Singh, Jaya Singh, L. D. S. Yadav, I. R. Siddiqui and Jaya Srivastava
3) Experiments in chemistry by D. V. Jahagirdar
4) Vogel's Textbook of Practical Organic Chemistry
5) Advanced Practical Organic Chemistry by O. P. Agarwal

M. Sc. II (Analytical Chemistry)

Syllabus

(As per NEP 2020 Recommendations)

20th March, 2024

P. E. Society's

Modern College of Arts, Science and Commerce (*Autonomous*), Shivajinagar, Pune - 05

M.Sc. II (Analytical Chemistry) Syllabus

Semester III

23ScCheP311: Advanced Analytical Electrochemical Methods (4 Credits, 60 L)

Chapter No.	Section I: Electrochemical Methods of Analysis (2 Credits, 30L)	
1	**Voltammetry and Polarographic methods** **A) Polarography principles** Instrumentation, Types of microelectrode such as Dropping mercury electrode, Static drop mercury electrode, rotating disc and ring disc electrode, Cell for polarography, Reference and counter electrode and circuit diagram, Polarogram and polarographic currents charging or capacitive current, Role of supporting electrolyte, Factors affecting on polarographic wave, Ilkovic Equation, Advantages and disadvantages of DME, polarographic maxima and Maxima suppressors, Interference due to dissolved oxygen, Applications such as qualitative and quantitative analysis by calibration curve and standard addition methods, Numerical problems. **B) Hydrodynamic voltammetry** Principle, Applications, Volatametric detectors in chromatography, Flow injection analysis, Voltametric oxygen sensors. **C) Pulse Polarography** Different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, Stripping method, Voltametry with ultra-microelectrode, Applications of differential pulse polarography and Square wave polarography. **D) Cyclic voltametry** Principle of cyclic Voltammetry, Cyclic voltamogram of $K_3[Fe(CN)_6]$, parathion, riboflavin etc.Criteria of reversibility of electrochemical reactions, Quasi reversible and irreversible processes.	**16 L**
2	**Amperometry**	**05 L**

	Principle, Instrumentation, Applications, amperometric titrations, chronoamperometry, Chrono-potentiometry	
3	**Coulometry** Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, Electrolysis at constant working electrode potential, Coulometric methods of analysis Faradays laws of electrolysis, Instrumentations-Constant current and constant voltage instruments, Potentiostaticcoulometry-Instrumentation and applications, Coulometric titrations (Amperostatic coulometry - Apparatus and applications, advantages and limitations) Numerical problems	**09 L**
	Section II: Current Analytical Methods of Analysis in Industries **(2 Credits, 30 L)**	
4	**Radiochemical Methods of Analysis** **A)Activation analysis:** Neutron activation analysis, principle, technique, steps involved in neutron activation analysis, Radiochemical and instrumental methods of analysis, important applications of NAA. **B)Isotope dilution analysis:** Principle, types of isotope dilution analysis, typical applications of isotope dilution analysis. **C) Radiometric titration:** Principle, techniques based on complex formation and precipitation, radiometric titration curves for estimation of ions from their mixture.	**14 L**
6	**Thermal methods of analysis** Principle, different methods of thermal analysis, **A) Thermogravimetric method of analysis** Instrumentation, Thermogravimetric analysis, Factors affecting thermogram, Applications TGA for quantitative analysis (TG analysis of CaC_2O_4 H_2O,$CuSO_4.5H_2O$, dolomite ore, $AgNO_3$, nylon 6, nylon 6,6etc.) and problems based TGA), Brief introduction of TGA-IR.	**14 L**

	B) Differential Thermal Analysis (DTA) Instrumentation, General Principles, Differential thermogram, DT and TG curve together, Applications (DT analysis of mixture of polymers, DT analysis of $CaC_2O_4H_2O$, DT analysis of sulphur, DT analysis of $CuSO_4.5H_2O$, TG and DT curve for $Mn(PH_2O_2)_2H_2O$. **C) Differential Scanning Calorimetry (DSC)** Principle, Instrumentation, and Applications,(DSC curve of polyethylene terephthalate),DSC curve for isothermal crystallization of polyethylene, DSC of phenacetein), Evolved gas analysis.	
7	**Thermometric titrations**	**02 L**

Reference:

1) Introduction to instrumental analysis by R. D. Broun, Mc Graw Hill (1987)
2) Instrumental methods of chemical analysis by H. Willard, L. Merrit, J.A. Dean and F.A. settle. Sixth edition CBS (1986)
3) Fundamentals of analytical chemistry by D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992) and Principles of Instrumental Analysis Skoog, West, Niemann.
4) Vogel Text Book of quantitative analysis 6th Ed.
5) J. chemical education, 60,302 to 308 (1983)
6) Thermal analysis by W.W. Wendlandt, John Wiley, (1986)
7) Cyclic Voltammetry and frontiers of electrochemistry by N. Noel and K. I. Vasu IBH, New Delhi (1990)
8) Source book of Atomic energy by Glasstone.
9) Principle of Activation Analysis- P. Kruger, John Wiley and sons, (1971).
10) Instrumental methods of chemical analysis by H. Kaur

23ScCheP312: Introduction to Advance Sophisticated Analytical Techniques

(4 Credits, 60L)

Chapter No.	Section I: Advance Analytical Techniques (2 Credits, 30 L)	
1	**Polarimetry** Introduction, Principle, Types of Polarimetry, Instrumentation, Plane polarised light, Theory of optical activity, Applications, Numerical Problems.	**05 L**
2	**Circular Dichroism (CD)** Introduction, Principle, Plane and circularly polarized light, Circular Dichroism Spectroscopy, Instrumentation, Examples, Applications, Advantages , Limitation.	**05 L**
3	**Optical Rotatory Dispersion (ORD)** Introduction, Fundamental principle of ORD, Theory, Instrumentation, Hyphenated techniques, Cotton effect and curves, Types of cotton curve, Specific applications of ORD, Octant rule, Difference between ORD and CD, Conclusion.	**05 L**
4	**Advanced Chromatographic Techniques** High Performance Thin Layer Chromatography (HPTLC), Gas Chromatography (GC), High Performance Liquid Chromatography, Ultra Performance Liquid Chromatography (UPLC), Inductively Coupled Plasma (ICP), Fourier Transform Infrared (FTIR)	**08 L**
5	**Hyphenated Techniques** Principles, Instrumentation, Applications, ICP-AES, ICP-MS, GC-MS, GC-IR, HRMS/MS, LCMS, with case study	**07 L**
	Section II : Atomic Spectroscopy Techniques (2 Credits, 30 L)	
6	**X- ray Methods of Analysis & Electronic Spectroscopy technique** Principle, Theory- X-ray spectral lines, X-ray tube, X-ray Emission- instrumentation and chemical analysis , X-ray absorption - instrumentation and chemical analysis, X-ray fluorescence -	**11 L**

	instrumentation and chemical analysis ,X-ray diffraction - instrumentation and chemical analysis , X-ray photo electron spectroscopy- instrumentation and chemical analysis , Auger electron microscopy, Ultraviolet photoelectron spectroscopy, Numerical problems	
7	**An Introduction to Microscopy (surface and microscopic characterization techniques)** Limitations of the Human Eye, The X-ray Microscope, The Transmission Electron Microscope, The Scanning Electron Microscope, Scanning Transmission Electron Microscope, Analytical Electron Microscopy, Scanning-Probe Microscopes, SEM and TEM Analysis, SEM and TEM applications, SAED (Selected Area Electron Diffraction) pattern, EDX (Energy Dispersive X-Ray) Analysis – Elemental mapping, Colour mapping.	**14 L**
8	**Photo acoustic spectroscopy** Introduction, Principle, Theory, Instrumentation, Applications.	**05 L**

References

1) Introduction to Instrumental Analysis by R. D. Broun, Mc Graw Hill (1987)
2) Instrumental methods of chemical analysis by H. willard, L.Merrit, J.A. Dean and F.A. settle. Sixth edition CBS (1986)
3) Fundamentals of Analytical Chemistry, 6th edition, D.A. Skoog, D.M. West and F.J. Holler, Saunders college publishing.
4) Principles of Instrumental Analysis, Skkog, Holler, Nieman, (Sixth Ed.)
5) Vogel's Textbook of Quantitative analysis 6th Ed.
6) Modern analytical techniques in the pharmaceutical and bio analysis By Dr. Istvan Bak (Book Available Online).
7) Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott (free e book available on internet).
8) Extraction technique in analytical science, John R. Dean, Wiley (2009).

9) Organic Spectroscopy by William kemp 3rd edition.
10) Application of Circular Dichroihm, International journal of molecular science ISSN 1422-0067.
11) Instrumental methods of chemical analysis by B.K.Sharma.
12) Encyclopedia of Materials Characterization by Richard Brundle, Charles K Evans, Jr., and Shaun Wilson.
13) Principles and techniques of biochemistry and molecular biology, 7th edition, by Keith Wilson and John Walker.

23ScCheP313: Lab Course on Analytical Chemistry I (4 Credits)

Chapter No.	Name of the Experiment
	PHYSICAL PRACTICALS
1	**Conductometry-** 1. Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their Ka value by conductivity measurement method. 2. Determination of commercial vinegar by conductometry titration. 3 Determination of Critical Miceller Concentration (C.M.C) of a surface active agent by Conductometrically. 4. Determination of concentration of sulfuric acid,acetic acid and copper sulphate by conductometric titration with sodium hydroxide. 5. Determination of Boric acid by conductometry.
2	**Potentiometry-** 1. Determination of strength of phosphoric acid by Potentiometric titration.
3	**Flame Photometry-** 1. Determination of Na from water sample by flame photometry. Calibration curve method or by standard addition method. 2. Determination of Na and K from water sample by flame photometry binary method/internal standard method.
4	**Turbidimetry-** 1. Determination of Cl^- by turbidimetric method using turbidimetric titration 2. Determination of Cl^- by turbidimetric method using calibration curve method.
5	**Spectrophotometer-** 1. Spectrophotometric determination of pK value of an indicator. 2. Determination of phosphorous in given unknown solution by Spectrophotometry.

6	**Polarimetry-** 1. Determination of purity of Sugar sample by optical rotation by polarimetry. 2. Determination of purity of Glucose sample by optical rotation by polarimetry
7	**Radioactivity-** 1. To determine the characteristics of Geiger-muller counter. 2. To determine Absorption coefficient and half thickness of aluminium (Al) Absorber for gamma radiation source using G.M. counter.
8	**Polarography-** 1. Determination of Cu and Zn 2. Amperometric titration of Pb(II) with potassium dichromate solution. 3. Identification and Determination of Cd^{2+}
9	**Data Analysis-** 1. Statistical Evaluation of given experimental Data.
	INORGANIC PRCTICALS
1	Analysis of Bronze with respect to Copper and tin
2	Estimation of Copper by Spectrophotometrically from alloy sample (Brass / Bronze)
3	Analysis of Bauxite Ore for Aluminium, Iron and Silica
4	Analysis of Dolomite Ore for Calcium, Magnesium and Silica
5	Analysis of Zinc-Chrome pigment for Chromium and Zinc
6	Determination of alcohol from given sample by Spectrophotometrically
7	Estimation of Iron from syndent Spectrophotometric method
8	Determine amount of magnesium from given Talcum Powder
9	**Thermogravimetric Analysis (TGA)** 1) $CaCO_3$ 2) $CaC_2O_4.H_2O$

	3) $AgNO_3$ 4) $Mn(PH_2O_2)_2H_2O$ 5) Polymer 6) Dolomite ore for $CaCO_3$ and $MgCO_3$ content
10	Determination of Chemical Oxygen Demand from waste water.
11	Determination of Ni(II) or Co(II) by using alpha nitroso beta naphthol from steel sample or from given sample by spectrophotometry
11	Estimation of any two metal ions by Atomic Absorption spectroscopy from soil or any given sample
12	Determination of Zn (II) by Photofluorimetry
13	Analysis of Commercial Hypochlorite or peroxide solution by iodometric titration
14	Lanthanide separation by column chromatography.

23ScCheP314: Photochemistry, Free radical and Pericyclic Reactions (2 Credits, 30L)

Chapter No.	Photochemistry, Free radical and Pericyclic reactions (2 Credits, 30 L)	
1	**Pericyclic Reactions** Recapitulation of molecular orbitals, their symmetry properties, Woodward- Hoffmann's conservation of orbital symmetry property rule and its application to the ground state and excited state electrocyclic reactions, Cylcoaddition, Chelotropic, Sigmatropic reactions etc. Fukui's HOMO and LUMO orbitals and its application to the ground state and excited state electrocyclic reactions. Synthesis of Endiandric acid and Citral (through pericyclic reactions and BASF synthesis).	**15 L**
2	**Photochemistry** Principles of photochemistry, Orbital symmetry considerations, Excited states and their properties, experimental setup of photochemical reactions; Photochemical reactions of olefins, carbonyl, aromatic substrates and their application in organic synthesis. Reaction viz Isomerisation, Paterno-Buchi, Barton, Norrish type I and II etc. Photochemical aromatic substitution reaction, Reactions with singlet oxygen.	**10 L**
3	**Free radicals in organic synthesis** Formation, stability and detection of long and short lived radicals, homolysis and free radical displacement, addition and rearrangement of free radicals, Baldwin's rule of ring closure, radical cyclizations and their applications in synthesis	**5 L**

References

1) Advanced Organic Chemistry, Part A- F.A Carey and R.J Sundberg 5th edition.
2) Excited states in Organic Chemistry- J.A Barltrop and J.D Coyle, John Wiley & Sons
3) Radical in Organic Synthesis B. Giese, Pergamon press (1986)
4) Organic Photochemistry : A Visual approach, Jan Kopecky, VCH publishers
5) Organic Photochemistry, O Kaan
6) Norman R.O.C Organic Chemistry.

7) Conservation of orbital symmetry, R. B. Woodward and R Hoffmann; Verlag Chemie, weinheim (1970)
8) Orbital Symmetry : A problem solving approach- R. E. Lehr and A.P. Marchand;Academic (1972)
9) Organic reactions and orbital symmetry, 2nd Ed. T. L. Gilchrist and R. C. Storr; Cambridge, University Press.
10) Modern Heterocyclic Chemistry, L. A. Paquette (Benjamin).

23ScCheP321: Pharmaceutical analysis (Theory) (2 Credits, 30 L)

Chapter No.	Pharmaceutical Analysis (2 Credits, 30 L)	
1	**Development of new drug** Definitions of Drug and Generic Drugs, Development of New Drugs, **Preclinical pharmacology (Animal Studies),** Acute, Subacute and Chronic Toxicity Studies (Toxicity Profile), Therapeutic Index (Safety and Efficacy Evaluation), Absorption Distribution and Assimilation Studies (Pharmacokinetics), **Clinical Pharmacology (Human Studies),** Clinical Trials Phase I, Phase II, Phase III, Phase IV Trials, Stability Studies and Self Life Fixation.	**06 L**
2	**Biological Tests & Assay** Introduction to biological assay**,** Biological assay of Heparin sodium, Determination of Amylase activity**,** Determination of Proteolytic Activity, Test for Insulin in solution, Test for Undue Toxicity	**05 L**
3	**Microbiological Tests and Assays** Microbiological test for Antibiotics, Standard preparation and units of Activity, Test organisms and Inoculums, apparatus – Cylinder plate assay and Turbidimetric Assay receptacles, Methods a) Cylinder plate or Cup-plate method – a) Two level factorial Assay b) Turbidimetric or Tube Assay Method, Test for Sterility	**07 L**
4	**Physical Test, Determinations, Limit tests and Sterilization** Disintegration Test for Tablets and Capsules, Dissolution Test for Tablets and capsules, Moisture / water content by Karl-Fischer titration, Limit tests for Arsenic, Heavy metals, Iron, Lead, Sulphate, Chloride, methods for sterilization, steam sterilization, dry heat sterilization, sterilization by filtration, gas sterilization, sterilization by ionizing radiation, sterilization by heating with Bactericides.	**07 L**
5	**Dosage forms and Chemical Analysis** Brief introduction to different dosage forms, Tablets – Different types of tablets, Additives used in tablet Manufacture, Capsules - Types of	**05 L**

	capsules, Assays as per IP - Aspirin, Adrenaline, Paracetamol, Isoniazid, Niacinamide.	

Reference

1) Indian Pharmacopeia Volume I and II.
2) Practical Pharmaceutical chemistry A. H. Beckett & J. B. Stenlake third edition volume 1.
3) Remington‘s Pharmaceutical sciences.
4) Ansel’s Pharmaceutical Analysis.

23ScCheP321: Pharmaceutical analysis (Practical) (2 Credits, 60 L)

Chapter No.	Name of the Experiment
1	Assay of local anaesthetic (Lignocaine) by non aqueous titration method.
2	Determination of iron from pharmaceutical preparation by titration with ceric ammonium sulphate.
3	Estimation of glucose from Glucon-D by titration with Fehling solution.
4	Estimation of Vitamin-C by using 2, 6- Dichlorophenol Indophenol method.
5	Preparation, purification and assay of aspirin.
6	Analysis of paracetamol as per IP with respect to identification and assay by titrimetry.
7	Estimation of reducing sugar by dinitrosalicylic acid (DNSA) method by spectrophotometry
8	Estimation of 'Fe' from given syrup sample by spectrophotometric thiocyanate method.
9	Analysis of ibuprofen as per IP with respect to identification and estimation of percent purity.
10	Estimation of creatinine and cholesterol from given sample by kit method.
11	Estimation of glucose from given sample by glucose oxidase method and Estimation of urea by kit method by spectrophotometry
12	Estimation of tryptophan by spectrophotometry
13	Estimation of ethanol content of sample by pyknometer.
14	Estimation of Sulfur by Messenger's method.
15	Estimation of protein by Lowry's method.
16	Preparation of Methyl Salicylate (Wintergreen Oil) and assay its purity.
17	Synthesis of nanoparticles and its characterization.
18	Determination of Iron from pharmaceutical preparation by titration with ceric ammonium sulphate.
19	Estimation of Phenolic compounds (Salicylic acid, Salbutamol Sulphate, Phenol) by Folin Ciocalteau reagent

20	Limit test of heavy metals and iron to pharmaceutical preparation

23ScCheP322: Geochemical and Alloy analysis (Theory) (2 Credits, 30L)

Chapter No.	Geochemical & alloy Analysis (2 Credits, 30 L)	
1	**Methods for alloy and geochemical analysis** Dolomite (For Silicate, Mg and Ca content), Ilmenite (for Silicate, Ti and Fe content), Monazite (for rare earth metals), Hematite and Magnetite (silicate and Fe content), Pyrolusite (for silicate and Mn content) and Bauxite (for Al and Silicate content). (Analytical methods as per Indian Standards)	**10 L**
2	**Analysis of Alloys** Stainless Steel (for Fe, Cr, Ni, Co, Cu, Mn, W, Si, V, Mo, Ti, Pb and Zr) Bronze and Gun metal (Cu, Sn), Brass (Cu, Zn, Sn, Pb), Solder (Pb and Sn), Nichrome (Fe, Ni, Cr), analysis of nickel Silver (Sn, Pb, Cu, Fe, Ni and Zn) and Aluminium based alloys (Al, Mg, etc.). (Analytical methods as per Indian Standards)	**10 L**
3	**Analysis of Soil** i) Sampling, ii) Carbonate, Organic carbon, and organic matter, iii) Total nitrogen, ammonia and nitrates, iv) Total determination of major soil constituents by fusion analysis, v) silica and total combined oxides of Iron, Aluminium, and Titanium, vi) Determination Ca, Mg, Na, K, phosphate, boron, Co, Cu, Zn, vii) Exchangeable cations viii) Cation exchange capacity, ix) chemical analysis as a measure of soil fertility. (Analytical methods as per Indian Standards)	**10 L**

References

1) Standard Methods of Chemical Analysis by F. J. Welcher Part A and Part B Sixth Edition

2) Quantitative Inorganic Analysis including Elementary Instrumnetal analysis, By A. I. Vogel

23ScCheP322: Geochemical and Alloy analysis (Practical) (2 Credits)

Chapter No	Geochemical & alloy Analysis (Practical) (2 Credits)
1	Alloy analysis 1) Magnalium 2) Nichrome
2	Analysis of industrial material 1. Plaster of Paris 2. Talcum powder 3. Pigment (Ti) 4. End group analysis of polymer (acid number /hydroxyl values/ Iodine value)
3	Spectrophotometer 1.Determination of p-nitrophenol from the given mixture 2. Estimation of Cu and Fe 3. Removal of toxic dyes /metals.
4	Analysis of silica and iron from Ilmenite ore.
5	Analysis of cupronickel alloy.
6	Synthesis and characterization of Tris (ethylene diammine) Ni(II) thiosulphate.
7	Synthesis and characterization of CuO nanoparticles
8	Photocatalytic activity of CuO nanoparticles

References

1) Standard Methods of Chemical Analysis by F. J. Welcher Part A and Part B Sixth Edition

2) Quantitative Inorganic Analysis including Elementary Instrumnetal analysis, By A. I. Vogel

Semester IV

23ScChep411: Analytical Spectroscopy (4 Credits, 60L)

Chapter No.	Section I: Atomic spectroscopic analysis (2 Credits, 30 L)	
1	**Atomic Spectroscopy** Introduction, Elementary Theory, Sources, Burners, Atomic emission spectra, Atomic absorption spectra, Effect of temperature on emission, absorption and fluorescence, Electro thermal atomizers, Instrumentation for AFS, Radiation sources atomic absorption methods, Instrumentation for AAS, Interferences, Background correction methods: Deuterium arc background correction, Zeeman background correction, The Smith-Hieftje system, Standard addition and internal standard method of analysis, Comparison of atomic absorption and emission methods, Inductively coupled plasma and direct current plasma emission spectroscopy, Cold vapour technique, Determination of these micronutrients from soils, plants and fruits, Applications of AAS, AES an ICPAES, analysis of micronutrients like Mo, B, Cu, Zn essential towards the healthy growth of crops and fruits, Determination of these micronutrients from soils, plants and fruits.	**12 L**
2	**Atomic Mass Spectroscopy** Principle, Instrumentation, Ionization methods- Electron bombardment ionization, Arc and spark ionization, Photo-ionization, Thermal ionization, Chemical ionization, Field ionization and field desorption, Laser-induced ionization, Photoelectric ionization, Mass analyzers- Magnetic, Double focusing, Time of flight, Quadrupolar, Ion cyclotron resonance analyzer, Correlation of mass spectra with molecular structure and molecular weight, Using library, Isotopic Abundances, Fragmentation patterns, Quantitative analysis, Applications and Problems. Fourier transform mass spectrometry	**09 L**
3	**Laser Based techniques** Atomic Fluorescence Spectroscopy (AFS), Introduction, Apparatus for AFS, EMR source for AFS, LASERS, Cells for AFS, Plasmas, Wavelength selection for AFS, Detectors for AFS, Theory of AFS, Analysis with AFS, Interference	**09L**

	with AFS, Resonanant Ionization Spectroscopy, Laser-enhanced ionization spectroscopy, Principle, Types of transition tunable laser, Classification of medium pumping and controlling mechanism, Instrumentation, Detecting of various gases, liquid and solids.	
	Section II: Molecular Spectroscopic Techniques (2Credits, 30L)	
4	**Chemiluminiscence** Introduction, Principle, Types, Measurement of chemiluminescence, Instrumentation, Quantitative chemiluminescences, Gas phase chemiluminescence's analysis, Chemiluminescences titrations, Electro-chemiluminescence.	**09 L**
5	**Fluorescence and phosphorescence** Introduction, Fluorescence, Photo luminescent theory, Electron transitions during photoluminescence, Factors affecting photoluminescence, Luminescent apparatus, Optical extractive sources, Wavelength selectors, Detectors ad readout devices, Photo luminescent spectra ,Photo luminescent analysis, Analysis of non-photoluminating compounds, Determinations of mixtures ,Specific examples of analysis using photoluminescence ,Numerical Problems	**09 L**
6	**Ultraviolet-Visible Spectroscopy of Polyatomic Species** Introduction,ElectronTransitions,Chromophores,Instrumentation,Qualitative analysis, Quantitative analysis, Wavelength choice, Solvents, Determination of Non-absorbing substances, Mixture of absorbing species, Derivative Spectrophotometry,Expanded-Scale,Spectrophotometry,DifferenceSpectrophotometry,Titrations,Ligand-Metal Ratio, Equilibrium Constants, Kinetic Measurements, Numerical problems.	**12 L**

References

1) Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.
2) Analytical spectroscopy by Kamalesh Bansal- First edition.
3) Instrumental methods of chemical analysis by Willard, Dean and Merittee- Sixth edition.
4) Analytical chemistry principles by John H. Kenedey- Second edition, Saunders college

publishing.

5) Spectroscopic identification of organic compounds Fifth Ed., Silvestrine, Bassler, Morrill, John Wiley and sons.
6) Analytical Chemistry, Ed. by Kellner, Mermet, otto, Valcarcel, Widmer, Second Ed. Wiley – VCH.
7) Vogel's Textbook of quantitative Chemical Analysis, sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.
8) Electron microscopy in the study of material, P. J Grundy and G. A Jones, Edward Arnold.

23ScCheP412: Industrial Chemicals, Characterization of Functional Polymers and Solid Catalyst (4 Credits, 60L)

Chapter No.	Section I: Fertilizer, Paint, Pigment and Functional Polymers (2Credits, 30L)	
1	**Analysis of fertilizers:** Sampling and sample preparation, Nitrogen: Total nitrogen by kjeldahl, method for nitrate - Total nitrogen by reduced iron medhod, Phosphorous: Total phosphorous available and non available, Total phosphorous by alkalimetric ammonium molybdophosphate method, Water soluble phosphorous citrate insoluble phosphorous. Potassium : Potassium by titrimetric tetraphenyl borate method, Flame photometric method, Numericals based on % of N,P and K.	**07 L**
2	**Analysis of Paint and Pigment:** Introduction, test on the total coating, Separation of pigment binder and thinner of solvent type coating. Separation of pigment binder and Thinner of latex paints. Identification of the binder. Identification of polymer resins and oils. Identification of plasticizer, Identification and Analysis of pigments. Identification of inorganic pigments. Analysis of white and tinted pigments, outline of general procedure, HCL insoluble, Titanium dioxide, total lead, Acid soluble calcium, antimony oxide, total sulfate, total carbonate.	**07 L**
3	**Introduction to polymers**: Brief history to polymers. How polymers are made. Classification of polymers. Types of polymerization reactions.	**02 L**
4	**Analysis and testing of polymers**: Chemicals analysis of polymers, X-ray	**08 L**

	diffraction analysis, Thermal analysis : TGA, DTA, Physical testing of polymers Mechanical Properties: Fatigue testing; Impact testing, Tear resistance, Hardness, Abrasion resistance, Thermal Properties: Softening temperature, Flammability. Optical Properties: Transmittance, Color, Gloss, Haze and transparency. Electrical Properties: Dielectric constant and loss factor, Resistivity, Dielectric strength. Determination of functional group of polymer. Solubility test	
5	Measurement of molecular weight and size: End group analysis, colligative properties measurements, solution viscosity, Derivations for number average molecular weight (Mn), Weight average molecular weight (Mw), Molecular weights and degree of polymerisation, molecular size, Numericals based on number.average molecular weight, weightt average molecular weight, functionality, polydispersity index (PDI) etc.	**06 L**
	Section II: Solid Characterization Techniques (2Credits, 30L)	
6	**Solid State UV-VIS Spectroscopy** Introduction, DRS- UV Spectroscopy	**04 L**
7	**Solid State IR Spectroscopy** Introduction, DRS- IR Spectroscopy, Py-IR spectral studies, Qualitative acidity measurement Lewis and Brønsted acidity calculations, Applications	**06 L**
8	**Solid State NMR Spectroscopy** Basic principles, Structural and chemical information from solid state NMR line shapes, ^{29}Si NMR examples, ^{31}P NMR examples	**04 L**
9	**BET Analysis** Adsorption of gases: Chemisorption, Physisorption, Behavior of physisorption isotherms, BET equation and theory, Instrumentation (Schematic), Applications in the measurement of Pore volume, Pore size analysis, Total surface area	**06 L**
10	**Temperature Programmed studies** Temperature Programmed Desorption, Temperature Programmed Reduction, Temperature Programmed Oxidation	**05 L**
11	**Powder XRD Studies** Basic principles, SAXRD (Small Angle X-Ray diffraction pattern) and	**05 L**

	WAXRD (Wide Angle X-Ray diffraction pattern), XPS, Study of XPS	

References

1) Solid State Chemistry and its Applications by Anthony West, 2nd edition, John Wiley & Sons, Ltd, 2014
2) Solid State Chemistry by Lesley Smart and Elaine Moore, 3rd edition, Taylor and Francis Group, 2005
3) Encyclopedia of Materials Characterization by Richard Brundle, Charles K Evans, Jr., and Shaun Wilson, Butterworth-Heinemann of Reed Publishing (USA), 1992.

23ScCheP413: Lab Course on Analytical Chemistry II (4 Credits)

Experiment No.	Name of the Experiment
	PHYSICAL PRACTICALS
1	**Potentiometry-** 1. Differential Potentiometric titration. 2. Determination of pK values of maleic acid/ malonic acid by Potentiometric titration with sodium hydroxide using glass electrode 3. Determination of commercial vinegar by Potentiometric titration
2	**Flame photometry-** 1. Determination of K from water sample by flame photometry. Calibration curve method or by standard addition method. 2. Determination of calcium from dairy whitener by Flame photometry.
3	**Turbidimetry-** 1. Determination of SO_4^{2-} by turbidimetric method using turbidimetric titration. 2. Determination of SO_4^{2-} by turbidimetric method using calibration curve method.
4	**Spectrophotometer-** 1. Determination of amount of each copper and bismuth or copper and Iron (III) from the given mixture by spectrophotometric titration using standard EDTA solution.

	2. To determine constant of ferric thiocyanate complex by Ostwald method spectrophotometrically. 3. Spectrophotometric determination of pH of buffer solution.
5	**Spectroflurometry-** 1. To determine concentration of Riboflavin in given unknown solution fluorimetrically by calibration curve method. 2. To determine concentration of Riboflavin in given unknown solution fluorimetrically by standard addition method.
6	**Atomic Absorption Spectroscopy-** 1. Analysis of metals ions.
7	**Polymer -** 1. To determine the Molecular weight of a polymer by end group analysis. 2. To determine the chain linkage in polyvinyl alcohol from viscosity measurement.
8	**XRD** - Interpretation of given XRD spectrum.
9	Pyridine-IR graph plotting and interpretation by origin software
10	Solid-UV data interpretation.
	INORGANIC PRCTICALS
1	Analysis of Cement with respect to Calcium, Magnesium, Aluminium, Iron and Silica
2	Analysis of copper ferrite ($CuFe_2O_4$) and determine amount of copper and iron volumetrically.
3	To determine phosphoric acid in cold drink by molybdenum blue method
4	Estimation of Cu and Fe(III) by spectrophotometric titration. (Standardization of EDTA is expected)
5	Determination of anion or Cation exchange capacity of anion or Cation Exchange Resin.
6	Determination of Titanium from Pigment/raw material by spectrophotometry
7	Determination of Calcium from given sample of plaster of Paris
8	To determine unit cell constant or lattice constant (parameter) of crystalline solid by

	powdered X-ray Diffraction method.
9	To find the g Value from given Spectra (EPR Spectroscopy)
10	Determination of Phosphorous from fertilizer sample by volumetric method
11	Estimation of organic nitrogen by kjeldahl's method or semimicro kjeldahl's method from given sample (Milk powder, Soil sample, fertilizer)
12	Estimation of Borate with curcumin reagent by using spectrophotometrically from talcum powder or given sample
13	Estimation of Cobalt by Spectrophotometrically from given sample
14	SO_4^{2-} by spectrophotometry
15	Estimation of Mn (II) by spectrophotometrically
16	Estimation of NH_4^+ or NH_3 by spectrophotometry (Alkaline Phenol Perchlorate reagent)
17	Estimation of NO_3^- or NO_2^- by spectrophotometry
18	Interpretation of XRD small/Wide angle analysis by origin software
19	TEM Analysis for particle size distribution
20	XPS analysis
21	Visit to waste water treatment plant/ Pharmaceutical Industry/ Forensic Laboratory/ Instrumentation Laboratory and writing a detailed visit report.

References:

1) Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)
2) Standard methods of chemical analysis by F. J. Welcher
3) Environmental Chemistry by A. K. De
4) Biochemical Methods, Sadashivam and Manickem, Narosa publicatinon
5) Indian Pharmacoepia volume –I and II
6) Experiments in chemistry by D. V. Jahagirdar, Himalaya publication
7) Practical Pharmaceutical Chemistry, 4th Ed. part-2, Beckette, Stenlake
8) Standard Instrumental methods of Chemical Analysis, F. J. Welcher

23ScCheP421: Analytical Toxicology and Food analysis (Theory) (2 Credits, 30 L)

Chapter No.	Toxicology and Food Analysis (2 Credits, 30 L)	
1	**Narcotics and Psychotropic substances Act.** Definitions –addict, cannabis (hemp), Coca derivative, Coca leaf, Manufacture medicinal Cannabis, Narcotic drug, Opium, Opium derivative, Opium poppy, poppy straw, psychotropic substance, Illicit Traffic, Prohibition Control Regulation, Offence and Penalties, Government resolutions related to Narcotic Substances	**04 L**
2	**Toxicology** Isolation, identification and determination of following Narcotics - heroin and cocaine Stimulants- caffeine, amphetamines, Mephedrone Depressants - Barbiturates, Benzodiazepines Hallucinogen – Lysergic acid diethylamide (LSD)	**10 L**
3	**Carbohydrates** Definition, classification, and Functions, Analysis of Carbohydrates by Nelson Somogi Method, Total Carbohydrate by Anthrone Method, Estimation of Starch by Anthrone Method, Determination of Amylose	**05 L**
4	**Proteins and Lipids** **Proteins -** Definitions and functions, Analysis of proteins by Kjedahl's method, Analysis of protein by Lowry method, Estimation of amino acids by colorimetric method **Lipids** - Estimation of oil in oilseeds, Estimation of free fatty acids, Determination of Saponification value, Iodine value, Acid value and Peroxide value of oil	**05 L**
5	**Vitamins** Classification of vitamins with Example, Each of the following vitamins with respect to functions, Deficiency diseases, daily requirement, and analytical method, Retinol (determination of retinol), Vitamin B_1 (thiamine	**04 L**

	determination by fluorometry), Vitamin C (Ascorbic acid) Volumetric method using 2,6 dichlorophenol method.	
6	**Determination of food preservatives** Definition of food preservatives, Determination of SO_2 by Tanners Method	**02 L**

References:

1) Practical Biochemistry in clinical Medicine by R. L Nath, 2nd Edition 1990
2) Texbook of Forenisc pharmacy by B. M. Mithal 9th Edition 1993
3) Pearson's chemical analysis of food
4) Practical Clinical Biochemistry, Gowenlock, 6th Edition, CBS published
5) Practical Pharmceutical Chemistry by Becket
6) Basic Analytical Toxicology By R. J. Flanagan R. A. Braithwaite, S. S.
7) Brown, Published by WHO, Available Online
8) Biochemical Methods, By S .Sadashivan, A. Manickam Sixth Edition.
9) Critical Reviews in food Science and Nutrition 2017, Vol. 57, No. 6, 1174-1189

23ScCheP421: Toxicology and Food analysis (Practical) (2 Credits)

Experiment No.	Toxicology and Food analysis (Practical) (2 Credits)
1	Estimation of caffeine from given tea or coffee sample.
2	Estimation of HMF from honey.
3	Determination of total casein or lactose in milk sample (Ref 1)
4	Determination of Saponification value of given oil sample (Ref 2)
5	Determination of iodine value of given oil sample (Ref 2)
6	Isolation of lycopene from tomato.
7	Estimation of Tannin from tea sample by Folin -Denis method.
8	Isolation of piperine from black pepper.
9	Estimation of Vitamin A from given sample.
10	Estimation of thiamine from given sample by Spectrophotometry.
11	Determination of Amylose from given sample.
12	To determine quinine sulphate from given sample by flurometry

13	Estimation of Amino acids using ninhydrin method.
14	Estimation of Amino acids using ninhydrin method.
15	Isolation of eugenol from cloves.
16	Estimation of proline
17	Isoation and Analysis of plant materials: Resin (Ginger sample)
18	Estimation of chlorophylls in leaf pigments

References

1) Manual of methods of analysis of foods food safety and standards authority of India Ministry of Health and family Welfare Gvt of India New Delhi 2015 Milk and Milk Products: https://old.fassai.gov.in/portals/0/pdf/Draft_manuals/MILK_AND_MILK_PRODUCTS.pdf

2) Biochemical Methods, third Edition, By S. Sadasivan, A. Manickam, New Age International Publisher

23ScCheP422: Safety in Chemical Laboratory (Theory) (2 Credits, 30L)

Chapter No	Safety in Chemical Laboratory (2.0 Credit, 30 L)	
1	**History and importance of safety and health in Laboratory** Importance of Safety and security, responsibility and accounting for safety, types of hazards and risk in chemical laboratory, Moral legal and financial reasons. Introduction to different types of Hazards	**05 L**
2	**Establishing Effective chemical safety and security management** Introduction, responsibility of laboratory safety and security, ten step to creating an effective laboratory chemical safety and security management safety	**03 L**
3	**Personnel protective and other safety equipments** Personnel clothing, foot protection, eye and face protection, safety shield, fire safety equipments, heat and smoke detector, respirators, safety showers, eye wash unit	**05 L**
4	**Assessing routes of exposer for toxic chemicals** Inhalation, contact with skin and eye, ingestion, assessing risk with acute	**05 L**

	toxicology, specific chemical hazard, First aid for contact of different chemicals on skin, eyes, and inhalation ingestion	
5	**Assessing hazards and risk in the laboratory** Introduction, consulting source of information, evaluating the toxic risk of laboratory chemicals, assessing flammable, reactive and explosive hazards, Assessing physical hazards, assessing bio hazards	**07 L**
6	**Managing Chemicals** Introduction, green chemistry for every laboratory, purchasing chemicals, inventory and tracking of chemicals, storage of chemicals, transfer, transport, shipment of chemicals	**05 L**

References:

1) Chemical Laboratory Safety and Security, A Guide Prudent Chemical Management Edited by Lisa Moran and Tina Masciangioli Available Online www.nap.edu

2) Hand Book, Good Laboratory Practice (GLP) Available Online

23ScCheP422: Safety in Chemical Laboratory (Practical) (2 Credits)

Experiment No.	Safety in Chemical Laboratory (Practical) (2 Credits)
1	Synthesis of sulphanilamide from acetanilide and assay its purity by titrimetry.
2	Determination of Monosodium Glutamate in food by potentiometric titration.
3	Analysis of Ni chrome alloy with respect to Nickel and Chromium.
4	Limit Tests: i) Iron from $CaCO_3$ ii) Sulphate and Chloride from Paracetamol, Dextrose or any pharmaceutical preparation
5	Synthesis and characterization of Tris acetylacetonato manganese
6	Synthesis and characterization ofPostassium trioxalato chromate
7	Determination of iron by solvent extraction techniques using 8- hydroxyquinoline reagent.
8	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).

9	Estimation of phosphate from waste water by calibration curve method.
10	Amperometric titration of Pb(II) with potassium dichromate solution.
11	Pharmacokinetic study of drug action
12	Estimation of amines using bromate bromide solution
13	Estimation of phenols using bromate bromide solution
14	Estimation of sucrose (cane sugar) using Fehling solution
15	Estimation of amino acid by Formol titration