Parvatibai Chowgule College of Arts and Science
(Autonomous)
Margao – Goa

MINUTES OF MEETING OF THE BOARD OF STUDIES IN CHEMISTRY HELD ON 16TH OCTOBER, 2023 at 10:00 a.m.

Vide Chowgule College notice F.133(C)/780, dated 30th September, 2023, a meeting of the BoS of Department of Chemistry was convened on 16th October 2023 at 10:00 a. m. in the Flipped Classroom D-103. Since the number of members present represented the quorum, the BoS began its proceedings.

Members present:

1. Dr. G. K. Naik – Chairman
2. Dr. Sunder Dhuri – Vice-Chancellor Nominee
3. Dr. Vikas J. Pissurlekar – Expert from outside the college
4. Dr. Sridhar M. Gurav - Expert from outside the college
5. Ms. Divya Sawant – Postgraduate meritorious alumnus
6. Dr. Roopa S. Belurkar – Member
7. Dr. Manjita R. Porob – Member
8. Dr. Lactina R Gonsalves – Member
9. Dr. Mayuri M. Naik – Member
10. Miss Kamaksha D. Borker – Member
11. Miss Ashvini Y. Pujari – Member
12. Mr. Anurag Madhukar Naik – Member
13. Miss Limora Niyonyka D'Souza – Member
14. Miss Harsha Arun Chari – Member
15. Mrs. Suvarna Prajay Jog – Member
16. Dr. Sachin B. Kakodkar – Member Secretary

Member Absent with Intimation

1. Dr. A. K. Srivastava – Expert nominated by Academic Council
2. Dr. Rajesh Pednekar – Expert nominated by Academic Council
3. Mr. Yashwant Phadke – Representative from Industry/Corporate sector
4. Mrs. Padmini C. Panjikar – Member (On Leave)

Proceedings

The Chairperson welcomed the members of the Board of Studies (BOS). The Chairperson introduced and explained the agenda for the meeting and read out the minutes of the previous B.O.S meet. The meet continued taking up the following agenda.

Agenda Items:

1. To approve the syllabus of Semester II under NEP 2020.
2. To approve the revised course names under approved course structure at UG programmes of Semester III and Semester IV, under the Nomenclatures: Core (Major and Minor), and Vocational Education and Training under NEP 2020.
3. To approve the UG syllabus for Semester III and IV under NEP 2020.
4. To approve the Multi Disciplinary Course, Skill Enhancement Course and Vocational Education and Training syllabus under NEP 2020.
5. To approve the Semester III and IV syllabus for PG Programme.
6. A.O.B.

PART A: The BOS passed the resolutions as follows:

1. It was proposed to change the course name of **UG-CHE-203 Comprehensive Inorganic Chemistry** to **UG-CHE-203 Selected Topics in Physical Chemistry**
2. It was proposed to change the course name of **UG-CHE-204 Comprehensive Organic Chemistry** to **UG-CHE-203 Selected Topics in Organic Chemistry**
3. It was proposed to change the course name of **UG-CHE-205 Comprehensive Physical Chemistry** to **UG-CHE-203 Selected Topics in Inorganic Chemistry**
4. **UG-CHE-203 Selected Topics in Physical Chemistry**
   It was suggested to remove **Unit IV: Solid state** and replace it with **Photochemistry.**
5. It was proposed to change the course code of **CHAE-504 Calibrations and Validations** to **CHAE-501: Calibrations and Validations.**
6. It was proposed to include two practical courses each of 04 credits under Research Specific Elective (RSE).
7. It was proposed to merge **CHRE-501 Research Methodology** (02 Credits) and **CHRE-502: Academic writing** (02 Credits) as one course (04 Credits) under Research specific elective (RSE).
8. It was proposed to add one more course (02 Credits) under Generic Elective so that the students will have an option of selecting one of the two courses.
9. Discipline specific elective course **CHAE-501: Separation Techniques**
   Title for unit 1 should be changed from '**Advanced Chromatographic Techniques**' to '**Chromatographic Techniques**'.

10. Discipline specific elective course **CHAE-504: Advanced NMR spectroscopy**

    It was proposed to include sub topics on ^{F}NMR and ^{P}NMR in unit I.

11. Research specific elective course **CHRE-503: Synthesis of inorganic materials**

    It was proposed to include sub topic on 'co-precipitation'

PART B: Important Points/ recommendations of BOS that require consideration/ approval of Academic Council:

1. To approve the syllabus of UG-CHE-SEC2: Basic Laboratory Methods and Safety in Chemistry of Semester II under NEP 2020.
2. To approve the revised course names under approved course structure at UG programmes of Semester III and Semester IV, under the Nomenclatures: Core (Major and Minor), and Vocational Education and Training under NEP 2020.
3. To approve the UG syllabus for Semester III and IV under NEP 2020.
4. To approve the Multi Disciplinary Course, Skill Enhancement Course and Vocational Education and Training syllabus under NEP 2020.
5. To approve the Semester III and IV syllabus for PG Programme.

The following members of the Board of Studies in Chemistry were present for the meeting.

Members present:

1. Dr. G. K. Naik – Chairman
2. Dr. Sunder Dhuri – Vice-Chancellor Nominee
3. Dr. Vikas J. Pissurlekar – Expert from outside the college
4. Dr. Sridhar M. Gurav - Expert from outside the college
5. Ms. Divya Sawant – Postgraduate meritorious alumnus
6. Dr. Roopa S. Belurkar – Member
7. Dr. Manjita R. Porob – Member
8. Dr. Lactina R Gonsalves – Member
9. Dr. Mayuri M. Naik – Member
10. Miss Kamaksha D. Borker – Member
11. Miss Ashvini Y. Pujari – Member
12. Mr. Anurag Madhukar Naik – Member
13. Miss Limora Niyonyka D'Souza – Member

14. Miss Harsha Arun Chari – Member

15. Mrs. Suvarna Prajay Jog – Member

16. Dr. Sachin B. Kakodkar – Member Secretary

Member Absent with Intimation

1. Dr. A. K. Srivastava – Expert nominated by Academic Council
2. Dr. Rajesh Pednekar – Expert nominated by Academic Council
3. Mr. Yashwant Phadke – Representative from Industry/Corporate sector
4. Mrs. Padmini C. Panjikar – Member (On Leave)

Member Secretary
Board of Studies

21.10.2023
Chairperson
Board of Studies

Dated: 21st October, 2023

PART C: The remarks of the Dean of the Faculty:

a. The minutes are in order.

b. The minutes may be placed before the Academic Council with remark, if any.

c. Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 21st October, 2023

Signature of the Academic Dean:

Dr. Meghana Devli

PART D: The remarks of the Members Secretary of the Academic Council:

a. The minutes are in order.

b. The minutes may be placed before the Academic Council with remark, if any.

c. Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 21st October, 2023

Signature of the Member Secretary
of Academic Council

Mr. V.C. Kumaresh

Annexure A (UG Programmes)
Name of the Programme: B. Sc. in Chemistry

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE
(AUTONOMOUS)
DEPARTMENT OF CHEMISTRY
ACADEMIC YEAR: 2023-2024

APPROVED COURSE STRUCTURE TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2023-2024 ONWARDS

COURSE STRUCTURE

SEMESTER	MAJOR CORE	MINOR/ VOCATIONAL	MULTIDISCIPLINARY COURSE (MDC)	VALUE ADDED COURSES (VAC)	ABILITY ENHANCEMENT COURSE (AEC)	SKILL ENHANCEMENT COURSE (SEC)
I	**UG-CHE-101** General Physical and Inorganic Chemistry	**Minor Stream UG-CHE-101** General Physical and Inorganic Chemistry	**UG-CHE-MDC1** Basics in Chemistry **UG-CHE-MDC2** Selected Topics in Organic and Inorganic Chemistry	-	-	**UG-CHE-SEC1** Skill Development in Chemistry
II	**UG-CHE-102** General Organic and Inorganic Chemistry	**Minor Stream UG-CHE-102** General Organic and Inorganic Chemistry	**UG-CHE-MDC3** Selected Topics in Food Chemistry			**UG-CHE-SEC2** Basic Laboratory Methods and Safety in Chemistry
III	**UG-CHE-201** Concepts in Chemistry - I	**Minor Stream UG-CHE-201** Concepts in Chemistry - I	**UG-CHE-MDC3** Fundamentals of Chemistry			**UG-CHE-SEC3** Basics of Analytical Chemistry
	UG-CHE-202 Concepts in Chemistry - II					
IV	**UG-CHE-203** Selected Topics in Physical	**Minor Stream UG-CHE -VOC1** Spectroscopic				

	Chemistry	Techniques				
	UG-CHE-204 Selected Topics in Organic Chemistry					
	UG-CHE-205 Selected Topics in Inorganic Chemistry					
	UG-CHE-206 Introduction to Pharmaceutical Chemistry					
V	**UG-CHE-301** Advanced Physical Chemistry -I	**Minor Stream UG-CHE -VOC2** Electroplating and Corrosion				
	UG-CHE-302 Advanced Organic Chemistry -I					
	UG-CHE-303 Advanced Inorganic Chemistry -I					
	UG-CHE-304 Applied Chemistry- III					
VI	**UG-CHE-305** Advanced Physical Chemistry -II	**Minor Stream UG-CHE -VOC3** Industrial Process				
	UG-CHE-306 Advanced Organic Chemistry -II					
	UG-CHE-307 Advanced Inorganic Chemistry -II					
	UG-CHE-PRJ Project **UG-CHE-308** Applied Chemistry- IV					

VII	**UG-CHE-401** Bio-Inorganic Chemistry/ Coordination Chemistry	**Minor Stream UG-CHE-409** Selected Topics in Inorganic and Organic Chemistry				
	UG-CHE-402 Surface Chemistry and Catalysis					
	UG-CHE-403 Stereochemistry and Name Reaction					
	UG-CHE-404 Research Methodology					
VIII	**UG-CHE-405** Organometallic Chemistry	**Minor Stream UG-CHE-410** Selected Topics in Analytical and Physical Chemistry				
	UG-CHE-406 Electrochemistry					
	UG-CHE-407 Heterocyclic Chemistry OR Synthetic Organic Chemistry					
	UG-CHE-408 Nanomaterials and Solid State Reactions					

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE
(AUTONOMOUS)
DEPARTMENT OF CHEMISTRY
ACADEMIC YEAR: 2023-2024
BoS APPROVED SYLLABI TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2023-2024

SEMESTER II

SKILL ENHANCEMENT COURSE

Course Title: Basic Laboratory Methods and Safety in Chemistry
Course Code: UG-CHE-SEC2
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:
1. To develop experimental skills in different purification techniques and basic laboratory methods.
2. To acquire knowledge about laboratory safety.

Course Outcomes:
On successful completion of the course the students will be able to:
CO1: Understand the concepts of diverse purification techniques and laboratory methods.
CO2: Understand the importance of laboratory safety.
CO3: Acquire laboratory skills by performing various purification techniques.

UNIT I: Purification techniques and basic laboratory methods **15 hours**
Recrystallization: principle, procedure, choice of solvent, advantages, disadvantages. Sublimation: principle, procedure, advantages, and disadvantages. Distillation: principle, procedure, types, advantages and disadvantages. Physical constants: Importance of melting point and boiling point, advantage of mixed melting point, cleaning and drying methods for laboratory apparatus. Solvent extraction technique: principle, procedure and importance in separation of organic compounds. Various methods used for heating and cooling, filtration methods for separation of compounds, and methods for drying of compounds, their advantages and disadvantages.

UNIT II: Laboratory Safety **15 hours**
Risks in the laboratory, importance of laboratory safety, safety symbols of chemicals, safety symbols of equipment/area, SDS, MSDS, CAS RN, safety gadgets-PPE, fume hoods, emergency equipment's, general laboratory safety rules, do's and dont's in laboratory, Laboratory waste: characterization of laboratory waste, handling, collection and storage, segregation of chemical, glass and other waste and its proper disposal, special attention to Hazardous Waste Minimization, laboratory emergency: spills and fires, precautionary steps and emergency measures, laboratory accidents (case studies with key lessons).

PRACTICALS

Course Title: Basic Laboratory Methods and Safety in Chemistry

Course Code: UG-CHE-SEC2

Credits: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS

1. Purification of solids by Recrystallization including determination of a suitable solvent and recording melting point (any two solids) **(4 Hours)**
2. Purification of solids by Sublimation and recording its melting point (any two solids) **(4 Hours)**
3. Purification of solvent by Distillation and recording its boiling point (any two liquids) **(4 Hours)**
4. Separation of a mixture of volatile and non-volatile solvents by Distillation (any two mixture) **(4 Hours)**
5. Separation of a mixture of organic compounds using solvent extraction technique **(8 Hours)**
   a) Acid and Phenol b) Phenol and Neutral c) Base and Neutral d) Acid-Phenol-Neutral
6. Determination of physical constants: Melting point and Boiling point (1 solid and 1 liquid) **(2 Hours)**
7. Determination of mixed melting point of benzoic acid and β-naphthol **(4 Hours)**

TEXT BOOK:

Vogel, A. I.; Tatchell, A. R.; Furnis, B. S.; Hannaford, A. J. Smith, P. W. G., *Textbook of Practical Organic Chemistry*, 5th Edition, Prentice Hall.

REFERENCES BOOKS:

1. MANN, F. G.; SAUNDERS, B. C., *Practical Organic Chemistry*, 2nd Edition, Longman Inc., New York.
2. GATTERMANN, L., *The Practical Methods of Organic Chemistry*, 2nd Edition, Macmillan and Co., Ltd.

WEB REFERENCES:

1. https://people.chem.umass.edu/mcdaniel/chem269/experiments/recrystallization/Recrystallization.pdf
2. https://acikders.ankara.edu.tr/pluginfile.php/75185/mod_resource/content/0/Distillation.pdf
3. https://soe.unipune.ac.in/studymaterial/ashwiniWadegaonkarSelf/BSC%20821%20Ch%201.pdf
4. https://www.ncbs.res.in/sitefiles/labsafety.pdf

SEMESTER III

CORE COURSE

THEORY
Course Code: UG - CHE-201
Course Title: Concepts in Chemistry-I
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. Will have knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or related fields.
2. Attain practical skills in some classical and instrumental techniques.
3. Will gain knowledge about the chemistry of aromatic compounds.
4. Will write the mechanisms involved in electrophilic aromatic substitution reactions.
5. Will learn the chemistry of alcohols and diols.
6. Will comprehend the chemistry of 3d transition metals and compare them with their 4d and 5d analogues.
7. Will have an understanding of ionic solids in terms of their structure, ionic radii, packing efficiency, coordination number and their defects.

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Illustrate and apply the first law of thermodynamics and understand the concept of properties of liquids.
CO2: Interpret the Gibb's phase rule and pressure temperature diagrams in unary and binary systems.
CO3: Utilize the concept of aromaticity and apply the theoretical knowledge to write the synthesis of aromatic compounds and alcohols.
CO4: Identify given unknown organic compounds (liquids) by carrying out various chemical tests and synthesize some organic derivatives.
CO5: Explain the trends in periodic properties of transition elements with respect to their ionic radii, oxidation state, spectral properties and magnetic properties.
CO6: Describe crystalline solids in terms of their structure, ionic radii and coordination and explain the defects in their crystal structures.

SECTION- I (PHYSICAL CHEMISTRY)

UNIT I: Thermodynamics **10 hours**

Thermodynamic terms: system, surrounding, types of systems, intensive and extensive properties, State and path functions and their differentials, Thermodynamic process, Concept of work and heat, First law of thermodynamics: Definition and statements of internal energy and enthalpy, Heat capacities at constant volume and pressure and their relationships, Joule Thomson effect, Joule Thomson coefficient and inversion temperature, Calculation of w, q, dU, dH, for the expansion of ideal gases under isothermal and adiabatic conditions for reversible processes; Thermochemistry:

Standard state, standard enthalpy of formation, Hess's law of heat summation and its applications, Heat of reaction at constant pressure and at constant volume, Enthalpy of neutralisation, bond dissociation energy and its calculation from thermodynamic data, Temperature dependence of enthalpy, Kirchoff's equation (Numerical expected).

UNIT II: Phase Equilibria **05 hours**

Statement, meaning of terms: phase, components, degrees of freedom, Gibbs phase rule, derivation of Gibbs phase rule, Phase equilibria of one component system: water system, sulphur system, Phase equilibria of two component system, simple eutectic system, Pb/Ag system, Nernst distribution law, deviations from Nernst distribution law, applications of the law.

SECTION- II (ORGANIC CHEMISTRY)

UNIT III: Arenes and Aromaticity **08 hours**

The aryl group, structure of benzene: Molecular formula and Kekule structure, stability and carbon-carbon bond lengths of benzene, resonance structure, molecular orbital picture, Huckel's rule, polycyclic aromatic hydrocarbons, physical properties of arenes, electrophilic aromatic substitution reactions-reactions and mechanisms of nitration, halogenations, sulphonation and Friedel Craft's reactions, activating and deactivating substituents, orientation and ortho/para ratio, side chain reactions of benzene derivatives, Birch reduction.

UNIT IV: Study of Alcohols and Diols **07 hours**

Alcohols: Classification, structure and bonding, physical properties, methods of preparation- catalytic hydrogenation, metal hydride reduction, Grignard reaction (using formaldehyde, other aldehydes, ketones, esters, nitriles and epoxides), reactions of alcohols- oxidation reactions using chromic acid, $KMnO_4$, PCC and PDC (structures of PCC and PDC), conversion of alcohols to ethers, Fischer Esterification.

Diols: Classification, methods of preparation (syn and anti diols), reactions of vicinal diols-Pinacol-Pinacolone rearrangement (with mechanism) and periodic oxidative cleavage.

SECTION- III (INORGANIC CHEMISTRY)

UNIT V: Chemistry of transition elements **07 hours**

Chemistry of elements of the first transition series: properties, their binary compounds, oxidation states and their stability, coordination number and geometry, comparative study with 4d and 5d analogues with respect to the ionic radii, magnetic behaviour, oxidation states and spectral properties.

UNIT VI: Ionic Solids: Structure and Bonding **08 hours**

Introduction to bonding in solids, types of bonds, properties of ionic substances, structure of ionic solids (NaCl, CsCl, ZnS, CaF_2), lattice energy, factors affecting radii of ions, packing efficiency, radius ratio and coordination number, limitations of radius ratio, Fajan's rules, defects in solids: point defects, color centres, extended defects, non-stoichiometric defects, conductivity in ionic solids.

PRACTICALS
Course Code: UG CHE-201
Course Title: Concepts in Chemistry -I
Credit: 1
Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

PHYSICAL CHEMISTRY

1. To determine the partition coefficient of I_2 between $C_2H_4Cl_2$ and H_2O. **(4 hours)**
2. To investigate the molecular condition of benzoic acid in a mixture of water and toluene. **(4 hours)**
3. To determine the heat of neutralization of strong acid with strong base. **(2 hours)**

ORGANIC CHEMISTRY

1. Purification techniques for organic compounds (Liquids) and determination of physical constant. **(4 hours)**

   Distillation: a. Separation of acetone and toluene
   b. Separation of ethyl acetate and nitrobenzene
2. Organic Synthesis: **(6 hours)**

   a. p-Bromo acetanilide from acetanilide
   b. Oxime from cyclohexanone
   c. 2,4-DNP hydrazone derivative of benzaldehyde

INORGANIC CHEMISTRY

Semi-micro qualitative analysis: To analyse inorganic mixtures containing four ions only (two cationsand two anions). **(10 hours)**

Cations: Pb^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+}.

Anions: Cl^{-}, Br^{-}, I^{-}, NO_2^{-}, NO_3^{-}, SO_3^{2-}, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}.

Note: Minimum five inorganic compound mixtures to be analyzed covering different groups of cations.

PHYSICAL CHEMISTRY TEXT BOOK:

Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

ORGANIC CHEMISTRY TEXT BOOK:

Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.

INORGANIC CHEMISTRY TEXT BOOKS:

1. Lee, J. D., *Concise Inorganic Chemistry*, ELBS Publications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., *Shriver and Atkins' Inorganic Chemistry*, Oxford University Press.

ADDITIONAL READING:

1. Bahl, A., Bahl, B. S. and Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company Ltd., New Delhi.
2. Puri B. R., Sharma L. R. and Pathania M. S., *Principles of Physical Chemistry*, Vishal Publishing Co.
3. Raj G., *Advanced Physical Chemistry*, Goel Publishing House, Meerut.
4. Bruice, P. Y., *Organic Chemistry*, Pearson India.

5. Carey, F. C. and Giuliano, R. M. *Organic Chemistry*, Tata McGraw-Hill India.
6. Finar, I. L., *Organic Chemistry*, Pearson India
7. Greenwood, N. N., Earnshaw, A., *Chemistry of Elements*, Pergamon, Oxford.
8. Cotton, F. A. and Wilkinson, G., *Advanced Inorganic Chemistry*, Wiley Publications.

WEB REFERENCES:

1. https://www.livescience.com/50881-first-law-thermodynamics.html
2. https://www.thoughtco.com/surface-tension-definition-and-experiments-2699204
3. https://www.chem.uci.edu/~lawm/263%206.pdf
4. http://ion.chem.usu.edu/~sbialkow/Classes/3600/Overheads/Titration/Volumetric.html
5. https://facultystaff.richmond.edu/~rdominey/301/local/Titrimetry_Methods.pdf
6. https://www.khanacademy.org/science/organic-chemistry/aromatic-compounds
7. https://www.khanacademy.org/science/organic-chemistry/alcohols-ethers-epoxides-sulfides
8. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2013.pdf
9. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2011.pdf

PRACTICAL BOOK:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, S. Chand and Co., New Delhi
2. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.
3. Furniss, B., Brian, S., Vogel's Textbook of Practical Organic Chemistry, Pearson education.
4. Svehla, G. and Sivasankar, B., Vogel's Qualitative Inorganic Analysis, Pearson
5. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis.

THEORY
Course Code: UG CHE 202
Course Title: Concepts in Chemistry -II
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. Will have a working knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or related fields.
2. Will help to get better understanding about the basics of Physical and Inorganic Chemistry.
3. Will learn important classes of organic compound i.e., alkyl halides, ethers and carbonyl compounds.
4. Will obtain a comprehensive and detail understanding of the properties and compounds of the f-block elements i.e. the lanthanoids and actinoids.
5. Will gain understanding of coordination compounds, their nomenclature and the types of

isomerism in coordination compounds.

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Apply symmetry rules used in X-ray diffraction studies to various examples.
CO2: Employ the theoretical concept to study solutions and to determine the properties of liquids
CO3: Apply the theoretical knowledge to write the synthesis of alkyl halides, ethers, and carbonyl compounds.
CO4: Identify given unknown organic liquid compounds by carrying out various chemical tests and synthesize some organic derivatives.
CO5: Explain trends in periodic properties of f-block elements and outline the extraction of lanthanoids and actinoids from its ore.
CO6: Name any coordination compound or write the formula based on its name and predict the isomers of a coordination compound.

SECTION- I (PHYSICAL CHEMISTRY)

UNIT I: The Solid State **07 hours**

Introduction: difference between crystalline and amorphous solids; laws of crystallography: law of constancy of interfacial angles, law of symmetry and law of rationality of indices, Miller and Wei indices; Elements of symmetry and symmetry operations, introduction to point groups, lattice and unit cells; X ray diffraction by crystals and Bragg's equation. (Numerical expected).

UNIT II: Solutions and Colligative properties **07 hours**

Liquid-liquid - ideal solutions, Raoult's law. Ideally dilute solutions, Henry's law. Non ideal solutions, activity and activity coefficient. Colligative properties: Elevation in boiling point, depression in freezing point, relative lowering of vapour pressure, osmotic pressure (Thermodynamic derivations expected). Abnormal molecular mass, Van't Hoff factor. Applications in calculating the molar masses of solutes in solution (Numerical expected).

SECTION- II (ORGANIC CHEMISTRY)

UNIT III: Alkyl Halides **04 hours**

Classification, structure and bonding, physical properties, methods of preparation- using alcohols and hydrogen halides, $SOCl_2$, PCl_3, halogenation of alkanes, mechanism for chlorination of methane, relative reactivity and selectivity with respect to chlorination and bromination of propane, mechanisms of nucleophilic substitution reactions of alkyl halides, S_N^1 and S_N^2 reactions with energy profile diagrams.

UNIT IV: Ethers **03 hours**

Properties of ethers; Symmetric and asymmetric ethers; crown ethers; Preparation of ethers: Williamson ether synthesis, alkoxymercuration-demercuration; Reaction of ethers with acids (HX); applications of ethers.

UNIT V: Aldehydes and Ketones **08 hours**

Properties of aldehydes and ketones; Geometry and polarity of the carbonyl group; Preparation of

aldehydes: Oxidation of alcohols, reduction of acid chlorides, Ozonolysis of alkene; Preparation of ketones: oxidation of alcohols, Friedel-Crafts acylation, Reaction of acid chloride with organocopper compounds; Reactions of aldehydes and ketones: General mechanism of nucleophilic addition at carbonyl group; Oxidation and reduction of aldehydes and ketones; Reaction with amine derivative (imine formation with mechanism); Cannizaro reaction; Addition of carbanions (Aldol condensation) chlorination and bromination, mechanisms of nucleophilic substitution reactions of alkyl halides, SN1 and SN2 reactions with energy profile diagrams.

SECTION- III (INORGANIC CHEMISTRY)

UNIT VI: Chemistry of f-block elements **07 hours**

Electronic structure, oxidation states and ionic radii; physical and chemical properties; occurrence and isolation of lanthanides from monazite ore; Lanthanide compounds; General properties and chemistry of actinides; Chemistry of extraction of Thorium and Uranium from its ore; Compounds of Th and U; comparison between lanthanides and actinides.

UNIT VII: Introduction to Coordination Compounds **08 hours**

Werner's coordination theory; effective atomic number concept; nomenclature of coordination compounds; constitution and geometry; Isomerism and chirality in coordination compounds; chelates and macro cyclic effect.

PRACTICALS
Course Code: UG CHE-202
Course Title: Concepts in Chemistry -II
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:
PHYSICAL CHEMISTRY

1. To determine the amount of weak acid (CH_3COOH) present in the given solution by conductometric titration using standard NaOH solution. **(3 hours)**
2. To study the effect of surfactant on the surface tension of Toluene. **(3 Hours)**
3. To study the effect of different solutes on the boiling point of liquid. **(2 Hours)**
4. To study the solubility of benzoic acid at room and below room temperature by volumetric method. **(2 Hours)**

ORGANIC PRACTICALS

Qualitative Analysis (any five liquids): **(10 hours)**

Haloalkane and haloarene: Chloroform, carbon tetrachloride, chlorobenzene, bromobenzene
Nitro Compounds: Nitrobenzene
Alcohols: Methanol, ethanol, 2-propanol, cyclohexanol
Carbonyl compounds (Neutral compounds): Benzaldehyde, acetone
Esters: Methyl acetate, ethyl acetate, ethyl benzoate, methyl salicylate

Bases: Aniline, *N*-methylaniline

INORGANIC CHEMISTRY

1. Preparation of Hexamine nickel (II) chloride complex **(2 hours)**
2. Estimation of Nickel in hexamine nickel (II) chloride by EDTA method **(2 hours)**
3. Preparation of Tetraamine copper (II) sulphate monohydrate **(2 hours)**
4. Gravimetric estimation of Fe as Fe_2O_3 **(2 hours)**
5. Gravimetric estimation of Ni as Ni-DMG **(2 hours)**

PHYSICAL CHEMISTRY TEXT BOOK:

Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

ORGANIC CHEMISTRY TEXT BOOK:

Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., *Organic Chemistry*, Pearson India.

INORGANIC CHEMISTRY TEXT BOOKS:

1. Lee, J. D., *Concise Inorganic Chemistry*, ELBS Publications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F. *Shriver and Atkins' Inorganic Chemistry*, Oxford University Press.

ADDITIONAL READING:

1. Bahl, A., Bahl, B. S. and Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company Ltd., New Delhi.Puri B. R., Sharma L. R. and Pathania M. S., *Principles of Physical Chemistry*, Vishal Publishing Co.
2. Raj G., *Advanced Physical Chemistry*, Goel Publishing House, Meerut.
3. Bruice, P. Y., *Organic Chemistry*, Pearson India.
4. Carey, F. C. and Giuliano, R. M., *Organic Chemistry*, Tata McGraw-Hill India.
5. Fina, r I. L., *Organic Chemistry*, Pearson India.
6. Greenwood, N. N., Earnshaw, A., *Chemistry of Elements*, Pergamon, Oxford.
7. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson.
8. Cotton, F. A. and Wilkinson, G., *Advanced Inorganic Chemistry*, Wiley Publications.
9. Puri, B. R., Sharma, L. R., Kalia, K. C., *Principles of Inorganic Chemistry*, Vishal Publishing Co.
10. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, Prentice Hall.

WEB REFRENCES:

1. https://www.thoughtco.com/surface-tension-definition-and-experiments-2699204
2. https://www.chem.uci.edu/~lawm/263%206.pdf
3. https://www.khanacademy.org/science/organic-chemistry/alkenes-alkynes
4. https://www.khanacademy.org/science/organic-chemistry/substitution-elimination- reactions
5. https://www.khanacademy.org/science/organic-chemistry/aromatic-compounds
6. https://www.khanacademy.org/science/organic-chemistry/alcohols-ethers-epoxides- sulfides
7. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2013.pdf
8. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%

2011.pdf
9. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/magnetic-property
10. https://www.toppr.com/guides/chemistry/the-solid-state/imperfections-or-defects-in-a-solid/
11. https://www.quora.com/What-is-fajans-rule-in-chemistry
12. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Crystal_Lattices/Thermodynamics_of_Lattices/Lattice_Energy%3A_ The_Born-Haber_cycle
13. https://www.chem.fsu.edu/chemlab/chm1046course/solids.html

PRACTICAL BOOK:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, S. Chand and Co., New Delhi
2. Svehla, G. and Sivasankar, B., Vogel's Qualitative Inorganic Analysis, Pearson
3. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis
4. Furniss, B., Brian, S., Vogel's Textbook of Practical Organic Chemistry, Pearson education.

THEORY

Course Code: UG-CHE-MDC3

Course Title: Fundamentals of Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. Will learn fundamentals of Chemistry.
2. Will learn to prepare solutions.
3. Will learn to theory of titrations.
4. Will be able to get a deeper understanding of the theory with practical knowledge.

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Understand states of matter

CO2: Calculate density

CO3: State gas laws

CO4: Write chemical formulae and equations

CO5: Prepare solutions

CO6: Perform chemical analysis

UNIT I: Matter **7 hours**

Extensive and intensive properties, physical and chemical properties, solids, liquids and gases, density and its uses, calculation using density of an unknown liquid, classification of matter, physical and chemical changes, measurement and notation, units and dimensions in chemistry, introduction to

scientific notation, converting units, uncertainty in measurement, significant figures (numerical expected).

UNIT II: Atom **4 hours**

Atoms, elements and the nucleus, atom and atomic mass, (numerical expected).

UNIT III: Chemical Formulas and Equations **8 hours**

Chemical formulae and their arithmetic, empirical and molecular formulae, formula and mass composition, calculating mass percent, molecular and empirical formula from mass percent, chemical nomenclature, stoichiometry and limiting reagents, chemical equations and calculations, calculating molar mass and number of moles, balancing chemical reactions, stoichiometry, calculating amounts of reactants and products (numerical expected).

UNIT IV: States of Matter **7 hours**

Gases and Gas Laws, observable Properties of Gases, basic gas laws, ideal gas equation, Charles law, Boyle's law and Avogadro's law, partial pressure, kinetic molecular theory (only postulates), Phase Changes, states of matter, liquid state, introduction to surface tension and viscosity, solid state, introduction to crystal systems (numerical expected).

UNIT V: Acid-base reactions **4 hours**

Acids and bases, aqueous Solutions, pH, definition of pH, acid-base neutralization reaction (numerical expected).

PRACTICALS
Course Code: UG-CHE-MDC3
Course Title: Fundamentals of Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Titration of HCl against Na_2CO_3
2. Titration of potassium hydrogen phthalate against NaOH
3. Titration of succinic acid with NaOH
4. Measurement of pH using pH meter (any 2 buffer solutions)
5. Sublimation of any 2 solids
6. Melting point of a solid
7. Boiling point of a liquid
8. Measurement of density
9. Measurement of surface tension
10. Measurement of viscosity
11. Theoretical calculation of molarity, normality, molality and ppm.
12. Dilution of solution from higher concentration to lower concentrations.
13. Standardization of $KMnO_4$ with oxalic acid.
14. Standardization of $Na_2S_2O_3$ with $K_2Cr_2O_7$.
15. Preparation of solutions based on theoretical calculations

*** All the experiments are of 2 hours each**

TEXT BOOK:

Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

ADDITIONAL READING:

1. Bahl, A., Bahl, B. S. and Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company Ltd., New Delhi.
2. Puri B. R., Sharma L. R. and Pathania M. S., Principles of Physical Chemistry, Vishal Publishing Co.
3. Raj G., Advanced Physical Chemistry, Goel Publishing House, Meerut.

PRACTICAL BOOK:

Rajbhog S. W. and Chondekar T. K., Systematic Experimental Physical Chemistry

WEB REFERENCES

1. https://sciencenotes.org/states-of-matter/
2. https://www.geeksforgeeks.org/mole-concept/
3. https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_General_Chemistry%3A_Principles_Patterns_and_Applications_(Averill)/04%3A_Reactions_in_Aqueous_Solution/4.07%3A_Acid_Base_Reactions
4. https://physics.info/viscosity/
5. https://www.thoughtco.com/overview-of-ph-measurements-608886

SKILL ENHANCEMENT COURSE

THEORY

Course Code: UG-CHE-SEC3
Course Title: Basics of Analytical Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. Will learn principles of Analytical Chemistry and its applications in various processes.
2. Will be able to apply the principles of Analytical Chemistry to chemical analysis.
3. Will be able to get a deeper understanding of the theory with practical knowledge.

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Understand fundamentals of titrimetric analysis

CO2: Interpret titration curves

CO3: Choose indicator for a particular type of acid base titration

CO4: Perform separation of compounds

CO5: Perform qualitative and quantitative analysis

UNIT I: Introduction to Analytical Chemistry and some basic concepts **05 hours**

Analytical Chemistry and its role in sciences, some important units of measurement, solutions and their concentrations, stoichiometric calculations (Numerical expected)

UNIT II: Titrimetric methods of analysis **10 hours**

Some general aspects of volumetric titrimetry, standard solutions, volumetric calculations; titration curves in titrimetric methods, Theory and applications of neutralization titrations: solutions and indicators for acid/base titrations, titration curves for strong acids and strong bases, buffer solutions, titration curves for weak acids, titration curves for weak bases, composition of buffer solutions as a function of pH, reagents for neutralization titrations, applications of neutralization titrations; Complex formation titrations, redox titrations.

UNIT III: Separation techniques **15 hours**

Solvent extraction: Factors affecting extraction, principle, apparatus and applications; Paper chromatography: Principle, technique and applications; Thin layer chromatography: Principle, technique and applications; Ion exchange chromatography: Introduction, types of ion exchangers, properties of resins, factors affecting separation of ions, ion exchange capacity, applications.

Course Code: UG-CHE-SEC3
Course Title: Basics of Analytical Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS

1. Preparation of standard solution based on molarity and normality. **(2 hours)**
2. Standardisation of strong acid with strong base. **(2 hours)**
3. Standardisation of strong acid with weak base. **(2 hours)**
4. Standardisation of weak acid with strong base. **(2 hours)**
5. Standardisation of weak acid with weak base. **(2 hours)**
6. Complexometric titrations. (any 2) **(4 hours)**
7. Redox titration. **(2 hours)**
8. Separation using solvent extraction (any 2) **(4 hours)**
9. Separation and identification using paper chromatography **(2 hours)**
10. Separation and identification using thin layer chromatography **(2 hours)**
11. Quantitative estimation using ion exchange chromatography **(2 hours)**
12. Separation and quantitative estimation using ion exchange chromatography **(4 hours)**

ANALYTICAL CHEMISTRY TEXT BOOK:

1. Skoog, D. A., West, D. M., Holler F. J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 8th Edition, Saunders College Publishing.

REFERENCE BOOKS:

1. Willard, H. H., Merritt, L. L., Dean, J. A., Settle, F. A., Instrumental Methods of Analysis, CBS Publishing, New Delhi, 7th Edition.
2. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis.

3. Christian, G. D., Analytical Chemistry, John Wiley.

PRACTICAL TEXT BOOK:

Popat P. R., *Practical Book of Analytical Chemistry (First Edition)* Notion Press

WEB REFRENCES

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Analytical_Chemistry_2.1_(Harvey)/09%3A_Titrimetric_Methods/9.01%3A_Overview_of_Titrimetry
2. https://microbenotes.com/paper-chromatography/
3. https://www.embibe.com/exams/solvent-extraction/
4. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Instrumental_Analysis_(LibreTexts)/28%3A_High-Performance_Liquid_Chromatography/28.06%3A_Ion-Exchange_Chromatographyhttps://www.bing.com/search?q=types+of+acid+base+titrations&FORM=QSRE1
5. https://www.britannica.com/science/thin-layer-chromatography

SEMESTER IV

THEORY

Course Code: UG-CHE-203

Course Title: Selected Topics in Physical Chemistry

Credits: 3

Duration: 45 Hours

Maximum Marks: 75

Course Objectives:

1. Will learn principles of Physical Chemistry and its applications in various processes.
2. Will be able to apply the principles of Physical Chemistry to industrial processes.
3. Will be able to get a deeper understanding of the theory with practical knowledge.

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Understand Second and Third law of Thermodynamics

CO2: Formulate conditions for maximum yield in industrial processes

CO3: Explain theory of strong and weak electrolytes.

CO4: Explain photochemical processes

CO5: Explain properties of colloids

CO6: Perform instrumental and non-instrumental analysis

UNIT I: Thermodynamics **10 hours**

Second law of thermodynamics: Different statements of the law; Carnot cycle and its efficiency, Carnot theorem; Thermodynamic scale of temperature; Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T, entropy change in

physical processes, entropy as a criterion of spontaneity and equilibrium; Entropy changes for ideal gases. Third law of thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data; Gibbs and Helmholtz functions; A and G as criteria for thermodynamic equilibrium and spontaneity, their advantages over entropy change; Variation of G and A with P, V and T (Numerical expected).

UNIT II: Chemical Equilibrium **08 hours**

Reversible reactions, equilibrium constant, Equilibrium constant and free energy; Thermodynamic derivation of law of mass action; Reaction isotherm and reaction isochore - Clapeyron equation and Clausius - Clapeyron equation; Le Chatelier's principle and its applications to some industrial processes (Numerical expected).

UNIT III: Electrochemistry **10 hours**

Electrical transport-conduction in metals and in electrolyte solutions, weak and strong electrolytes; conductance, specific conductance and equivalent conductance and measurements; variation of specific and equivalent conductance with dilution; Arrhenius theory of electrolyte dissociation and its limitations; Ostwald's dilution law, its uses and l imitations; Migration of ions and Kohlrausch's law; Debye-Huckel-Onsager's equation for electrolytes; Transport number, determination of transport number by Hittorf's method, Applications of conductance measurements: degree of dissociation, dissociation constant of acids; Solubility and solubility product of a sparingly soluble salts; Conductometric titrations (Example: Strong acid and strong base) (Numerical expected).

UNIT IV: Photochemistry **07 hours**

Interaction of radiation with matter, difference between thermal and photochemical processes, Laws of photochemistry: Grothus–Drapper law, Stark–Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions. (Numerical expected).

UNIT V: Colloid Chemistry **10 hours**

Colloidal state; colloidal solution; classification of colloids; lyophobic and lyophilic colloids; true solution, colloidal solution, and suspension; preparation of sols; purification of sols; stability of colloids; protective action; Hardy- Schulze Law; gold number; general properties; electrical properties; electrical double layers; kinetics of coagulation; inhibition; general applications of colloids on size of colloidal particles; Emulsions- definition, types, preparation; gels- definition; classification, preparation and properties; applications of colloids, emulsions, and gels.

PRACTICALS
Course Code: UG-CHE-203
Course Title: Selected Topics in Physical Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To determine the cell constant of a conductivity cell. **(2 hours)**
2. To verify Ostwald's dilution law by determining the equivalent conductance of a weak mono basic acid at different concentrations. **(2 hours)**
3. To determine the equivalent conductance of a strong electrolyte at several concentrations and hence verify Onsager's equation. **(2 hours)**
4. To determine solubility product of sparingly soluble salt by conductometric method **(2 hours)**
5. To determine hydrolysis constant of sodium acetate by conductometric method. **(2 hours)**
6. To estimate the amount of dibasic acid present in given solution against standard NaOH solution by conductometric method. **(2 hours)**
7. To determine hydrolysis constant of ammonium chloride by conductometric method. **(2 hours)**
8. To estimate the concentration of NH_4Cl salt by titration against NaOH by conductometric method. **(2 hours)**
9. To estimate the concentration of KCl salt by titration against $AgNO_3$ by conductometric method. **(2 hours)**
10. To estimate the concentration of Fe3+ salt by titration against $K_2Cr_2O_7$ by conductometric method. **(2 hours)**
11. To study the solubility of benzoic acid in water at different temperatures and to calculate the heat of solution. **(2 hours)**
12. To determine the energy of activation for acid catalysed hydrolysis of methyl acetate. **(4 hours)**
13. To estimate the amount of monobasic (HCl) and dibasic acid (Oxalic acid) present in the mixture solution against NaOH by conductometric method. **(2 hours)**
14. To estimate the amount of H_2SO_4, CH_3COOH and $CuSO_4$ present in the mixture against NaOH by conductometric method. **(2 hours)**

TEXT BOOK:

Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

ADDITIONAL READING:

1. Bahl, A., Bahl, B. S. and Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company Ltd., New Delhi.
2. Puri B. R., Sharma L. R. and Pathania M. S., *Principles of Physical Chemistry*, Vishal Publishing Co.
3. Raj G., *Advanced Physical Chemistry*, Goel Publishing House, Meerut.

WEB REFERENCES

1. https://www.britannica.com/science/second-law-of-thermodynamics
2. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Equilibria/Le_Chateliers_Principle/The_Haber_Process
3. https://www.nobelprize.org/uploads/2018/06/arrhenius-lecture.pdf
4. https://www.edinst.com/blog/jablonski-diagram-2/
5. https://openstax.org/books/chemistry-2e/pages/11-4-colligative-properties

6. https://www.toppr.com/guides/chemistry/surface-chemistry/colloids/

CORE COURSE

THEORY
Course Title: Selected Topics in Organic Chemistry
Course Code: UG-CHE-204
Credits: 3
Duration: 45 hours
Maximum Marks: 75

Course Objectives:

1. To make students understand about chemistry of carboxylic acids.
2. To deliver knowledge about chemistry of functional derivatives of carboxylic acids.
3. To provide knowledge about chemistry of amines, diazonium salts and nitro compounds.
4. To discuss the chemistry of cyanides and isocyanides.
5. To discuss the chemistry of thiols and thioethers.
6. To provide basic practical knowledge by performing experiments in laboratory.

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Apply the chemistry of carboxylic acids.

CO2: Analyze the chemical reactions of functional derivatives of carboxylic acids.

CO3: Apply the chemistry of amines, diazonium salts and nitro compounds.

CO4: Understand the chemistry of cyanides and isocyanides.

CO5: Understand the chemistry of thiols and thioethers.

CO6: Develop practical skill by performing organic chemistry experiments in laboratory.

UNIT I: Carboxylic Acids **10 hours**

Carboxylic acids: Structure and nomenclature of aliphatic and aromatic carboxylic acids, dicarboxylic acids, physical properties, industrial source, Preparation of acids: Oxidation of primary alcohols and alkyl benzenes, hydrolysis of nitriles with mechanism; Reaction of acids: Salt formation, conversion to different functional groups (esters, amides, acid chlorides and anhydrides), Hell-Volhard-Zelinsky reaction, ring substitution in aromatic acids, reduction of acids.

UNIT II: Functional derivatives of carboxylic acids **10 hours**

General physical properties of carboxylic acid derivatives: acid anhydrides, esters, amides and acid halides; nucleophilic acyl substitution (role of carbonyl group of carboxylic acid derivatives), alkyl vs. acyl nucleophilic substitution.

Preparations of acid anhydrides, esters, amides and acid halides.

Reactions of acid chlorides: Conversion to acids (hydrolysis), conversion to amides (ammonolysis), conversion to esters (Alcoholysis), formation of ketones (Friedel Craft's acylation), reduction to aldehydes (Rosenmund reduction).

Reactions of acid anhydrides: conversion into acids (hydrolysis), conversion into amides (ammonolysis) and formation of ketones (Friedel Craft's acylation).

Reactions of esters: Conversion to acids (acidic and alkaline hydrolysis along with mechanism), conversion to amides (ammonolysis), conversion to esters (Trans-esterification), reaction with Grignard reagents, reduction to aldehydes and alcohols.
Reactions of amides: Hydrolysis, conversion into imides, Hofmann degradation of amides, conversion to amine having same number of carbon atoms, conversion to nitriles.
Interconversion reactions of acid anhydrides, esters, amides and acid halides, comparative study of nucleophilicity of acyl derivatives.

UNIT III: Amines, diazonium salts and nitro compounds 15 hours

Amines: Structure, classification, nomenclature, physical properties and industrial source of amines. Preparation of alkyl and aryl amines by reduction of nitro compounds, nitriles and amides, reductive amination of carbonyl compounds, salts of amines, alkylation, conversion into amides, ring substitution in aromatic amines, Hinsberg test reactions, Hoffman elimination, reaction with nitrous acid, Gabriel phthalimide reaction and Hofmann rearrangement. Basicity of amines, effect of substituents on basicity of amines.
Diazonium salts: Structure, preparation using aromatic amines, Sandmeyer reaction, conversion to phenol and arene; reduction reaction.
Nitro compounds: Preparation of nitroalkanes and nitroarenes, chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid: preparation and properties.

UNIT IV: Cyanides and Isocyanides 05 hours

Alkyl cyanides: structure, nomenclature, methods of preparation, physical and chemical properties. Alkyl isocyanides: structure, nomenclature, methods of preparation, physical properties and chemical properties. Distinguishing points between Cyanides and Isocyanides.

UNIT V: Thiols and Thioethers 05 hours

Thiols: structure, nomenclature, methods of preparation, physical and chemical properties. Thioethers: structure, nomenclature, methods of preparation, physical and chemical properties. Mustard gas.

PRACTICAL

Course Title: Selected Topics in Organic Chemistry
Course Code: UG-CHE-204
Credits: 1
Duration: 30 hours
Maximum Marks: 25
LIST OF EXPERIMENTS

1. Qualitative analysis of organic compounds: (any two) **(04 hours)**
   Solids (examples: Benzoic acid, Nitro-benzaldehyde, Benzophenone) Liquids (Acetone, ethyl acetate, benzaldehyde)
2. Identification of type and separation of mixture of organic compounds:
   a) Solid-solid (Soluble-insoluble, insoluble-insoluble) (any three) **(06 hours)**
   b) Solid-liquid (Solid and low boiling liquid) (any two) **(04 hours)**
   c) Liquid-liquid) (High boiling and low boiling liquid) (any two) **(04 hours)**
3. Organic preparations:
   a) Iodoform: Preparation of Iodoform from acetone **(02 hours)**

b) Esterification: Preparation of ethyl benzoate from benzoic acid and ethanol **(02 hours)**
c) Hydrolysis: Preparation of benzoic acid and ethanol from ethyl benzoate **(02 hours)**
d) Aldol condensation reaction: Preparation of chalcone from benzaldehyde and acetophenone **(02 hours)**

4. Organic estimations:
   a) Estimation of Ester by Titration method**.** **(02 hours)**
   b) Estimation of Amide by Titration method. **(02 hours)**

TEXT BOOK:

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., *Organic Chemistry*, Pearson India.

REFERENCE BOOKS:

1. Bruice,, P. Y., *Organic Chemistry*, Pearson India.
2. Carey, F. C. and Giuliano, R. M., *Organic Chemistry*, Tata McGraw-Hill India.
3. Finar, I. L., *Organic Chemistry*, Pearson India.

PRACTICAL TEXT BOOK:

Furniss, B. Brian, S., *Vogel's Textbook of Practical Organic Chemistry*, Pearson education.

WEB REFERENCES:

1. https://ncert.nic.in/textbook/pdf/lech203.pdf
2. https://www.angelo.edu/faculty/kboudrea/index_2353/Chapter_05_2SPP.pdf
3. https://www2.unbc.ca/sites/default/files/sections/todd-whitcombe/chapter_21_acid_derivatives.pdf
4. https://ncert.nic.in/textbook/pdf/lech204.pdf
5. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202003291608409191arun_sethi_Diazonium_compounds.pdf

THEORY
Course Code: UG - CHE-205
Course Title: Selected Topics in Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75
Course Objectives:

1. Understand the acid and base concepts with respect to aqueous and non-aqueous solvent systems.
2. Understand the magnetic behavior of metal complexes and determine its magnetic properties.
3. Acquire knowledge about metal-ligand bonding in metal complexes with reference to VBT and CFT and calculate the CFSE for octahedral complexes.
4. Understand the thermodynamic and kinetic aspects of metal complexes that governs their stability.
5. Develop practical skills to carry out separation of metal ions by ion exchange method and analyze them using titrimetry or gravimetry.

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Understand and integrate concepts of Acids and Bases and non-aqueous solvents wherever applicable in chemistry.
CO2: Analyze the magnetic properties of transition metal complexes as well as interpret the effect of temperature on magnetic properties.
CO3: Predict the magnetic behavior of metal complexes and calculate the magnetic moment of metal ions.
CO4: Employ the VBT and CFT theories that govern metal-ligand bonding in order to explain the stability of metal complexes.
CO5: Illustrate the crystal field splitting in tetrahedral and octahedral complexes and calculate the crystal field stabilization energy (CFSE).
CO6: Differentiate between thermodynamic stability and kinetic stability and apply it to transition metal complexes.
CO7: Determine the factors that govern the stability and lability of transition metal complexes and predict their reaction mechanism.
CO8: Develop practical skills to separate and estimate the amount of metal ions in solution and determine the stability and instability of complexes using spectrophotometry.

UNIT I: Acids, Bases and Non-Aqueous Solvents 08 hours
Acids and Bases: Arrhenius theory, Bronsted-Lowry theory, Lewis's concept of acid and bases; Solvent System: Physical properties of a solvent; Solvents and their general characteristics; Reactions in non-aqueous solvent with respect to liquid NH_3 and liquid SO_2.

UNIT II: Metal-Ligand Bonding in Transition Metal Complexes 15 hours
Principles and limitations of Valence bond theory, Crystal field theory (CFT) splitting of d orbitals in octahedral, tetrahedral and square planar complexes. Crystal Field Stabilization Energy (CFSE), Measurement of 10 Dq for octahedral complexes, Factors affecting 10 Dq, spectrochemical series, Effect of crystal field splitting on properties of octahedral complexes: Magnetic, Spectral.

UNIT III: Magnetic Properties of Metal Complexes 07 hours
Types of magnetic behaviour, magnetic susceptibility, effect of temperature on magnetic properties, Curie temperature, Neel temperature, Curie-Weiss law, methods of determining magnetic susceptibility, Guoy's balance, spin only formula, calculation of magnetic moment of transition metal ions, application of magnetic moment data for 3d-metal complexes.

UNIT IV: Thermodynamic and Kinetic Aspects of Metal Complexes 15 hours
Thermodynamic and kinetic stability of metal complexes, equilibrium constants, formation constants, labile and inert complexes, factors affecting the stability, Ligand substitution reactions in tetrahedral and octahedral complexes, Factors affecting the rate of substitution reactions. Electron transfer reactions- inner sphere mechanism and outer sphere mechanism. Trans effect with respect to square planar complexes.

PRACTICALS
Course Code: UG CHE-205
Course Title: Selected Topics in Inorganic Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Separation and determination of transition metal ions: Separation of Mg^{2+} and Zn^{2+} by ion exchange and its estimation. **(4 hours)**
2. Estimation of metal ions in a mixed metal ion solution (Co+2 and Fe+2) by employing gravimetric and volumetric methods. **(4 hours)**
3. To estimate the amount of barium as BaSO4 gravimetrically in a solution of Barium chloride containing ferric chloride and free HCl. **(4 hours)**
4. Determination of stability constant of Fe(III)- salicylic acid complex spectrophotometrically (Job's Method). **(2 hours)**
5. Determination of stability constant of Fe(II)-1,10-phenanthroline complex spectrophotometrically. **(2 hours)**
6. Determination of instability constant for the reaction between Cu^{2+} and NH_3 **(2 hours)**
7. Determination of instability constant for the reaction between Cu^{2+} and ethylene diamine. **(2 hours)**
8. Preparation of trisethylenediamine nickel(II) complex. **(2 hours)**
9. Preparation of potassium trioxalato ferrate(III) complex. **(2 hours)**
10. Preparation of zinc oxalate complex. **(2 hours)**
11. Estimation of oxalate from the zinc oxalate complex. **(2 hours)**
12. Preparation of tris(thiourea) copper(I) sulphate. **(2 hours)**

INORGANIC CHEMISTRY TEXT BOOKS:

1. Lee, J. D., *Concise Inorganic Chemistry*, ELBS Publications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., Shriver and Atkins' Inorganic Chemistry, Oxford University Press.

ADDITIONAL READING:

1. Greenwood, N. N., Earnshaw, A., *Chemistry of Elements,* Pergamon, Oxford.
2. Cotton F. A and Wilkinson G., Basic Inorganic Chemistry, Wiley Eastern Ltd.
3. Huheey J. E, Keiter E. A, Keiter R. L, Medhi O. K, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Edu.

WEB REFERENCES:

1. https://www.rsc.org/images/EiC%20v1i2%20The%20Theory%20of%20Acids%20and%20Bases_tcm18-230799.pdf
2. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Map%3A_Inorganic_Chemistry_(Housecroft)/09%3A_Non-aqueous_Media/9.04%3A_Acid-Base_Behaviour_in_Non-Aqueous_Solvents
3. https://unacademy.com/content/nda/study-material/chemistry/theories-based-on-the-concept-of-acids-and-bases/
4. https://unacademy.com/content/cbse-class-12/study-material/chemistry/magnetic-properties-of-coordination-compounds/#:~:text=The%20coordination%20compound%20complexes%20show,are%20in%20the%20d%20orbitals.
5. http://home.iitk.ac.in/~madhavr/CHM102/Lec5.pdf
6. https://chemistnotes.com/inorganic/crystal-field-splitting-of-d-orbitals-octahedral-and-tetrahedral-complexes/

7. https://chemistrywithwiley.com/crystal-field-splitting/
8. https://unacademy.com/content/jee/study-material/chemistry/stability-of-complexes/#:~:text=Charge%20on%20the%20metal%20ion,stability%20to%20the%20coordination%20compound.
9. https://utkaluniversity.ac.in/wp-content/uploads/2022/03/Stability_Const_NDas.pdf

PRACTICAL BOOK:

1. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.
2. Svehla, G. and Sivasankar, B., Vogel's Qualitative Inorganic Analysis, Pearson
3. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis

Course Code: UG-CHE-206
Course Title: Introduction to Pharmaceutical Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. The main objective of this course is to study the Chemistry and data treatment involved in pharmaceutical industries.
2. This course gives blend of chemical and pharmaceutical principles necessary for understanding structure–activity relationships and molecular mechanisms of drug action.
3. Will gain knowledge about the classes of drugs and synthesis of some selected drugs.

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Outline the significance of terminologies and regulation in pharmaceutical chemistry.
CO2: Discuss Safety in Pharmaceutical laboratories.
CO3: Handle and treat the statistical data of analysis
CO4: Apply practical knowledge for the synthesis of some pharmaceutical drugs.
CO5: Understand the medicinal chemistry in plants.

UNIT I: Introduction and Drug Design Strategies **15 Hours**

Importance of Chemistry in Pharma, definition of terminologies: Pharmacology: Pharmacokinetics, Pharmacodynamics; Pharmacognosy, Dosage forms and Routes of administration, Advantages, and disadvantages. Pharmacopoeia. Risks in a pharmaceutical Laboratory, Personal Protective Equipment (PPE), General preparation for Emergencies, Laboratory Emergencies: Spills and Fires.
Drug designing; General pathways of drug metabolism: Oxidative reactions, reductive reactions, hydrolytic reactions, Phase II or conjugation reactions.

UNIT II: Statistical Data Treatment **15 Hours**

Errors: absolute error, relative error, constant and proportionate errors; determinate errors, classification of determinate errors, indeterminate error, minimization of errors.
Significant figures and rounding off, replicate analysis, reliability of analytical data, mean, mode, median & range, precision and accuracy, methods of expressing precision and accuracy: deviation, mean deviation, relative mean deviation, and standard deviation, Gaussian distribution curve and its

characteristics, Histogram and Frequency polygon; Measures of central tendency and dispersion, Confidence limit; Test of significance: Students t, F test; Rejection of the results: 2.5d & 4d rule and Q test; Linear least squares and Method of averages (Numerical are expected)

UNIT III: Introduction to Medicinal Chemistry of plants and different classes of drugs 15 Hours

Historical background to medicinal chemistry of plants; type of plants; active ingredient structure, IUPAC names and their medicinal properties: Capsicum, Garlic, turmeric.

Anti-Infective Agents (definition): Antifungal agents (definition): Haloprogin and Flucytosine (structures and uses); Antibacterial agents (definition): Ciprofloxacin and Furazolidone (structures and uses); Anti protozoal agents (definition): Metronidazole (structure and uses); Antihelmintics (definition): Thiabendazole (structure and uses); Synthesis of Flucytosine.

Cardiovascular agents (definition): Antianginal Agents and Vasodilators (definition): Nitroglycerin, Nifedipine (structures and uses); Antiarrhythmic Drugs (definition): Quinidine sulfate (structure and uses); Antihypertensive Agents (definition): Prazosin (structure and uses); Synthesis of Nifedipine by Hantsch synthesis.

Central nervous system stimulant and depressants: Central sympathomimetic agents (psychomotor stimulants) (definition): Pentylenetetrazole (structure and uses); Antidepressants (definition): Desipramine Hydrochloride and Clomipramine Hydrochloride (structures and uses); Anxiolytic (definition): Paroxetine (structure and uses); Sedative and hypnotic agents (definition): Propofol, Methaquolone (structures and uses); Synthesis of clomipramine.

PRACTICALS
Course Code: UG- CHE-206
Course Title: Introduction to Pharmaceutical Chemistry
Credit: 1
Duration: 30 hours
Maximum Marks: 25

LIST OF EXPERIMENTS

1. Synthesis of Aspirin. **(2 Hours)**
2. Synthesis of Benzocaine. **(4 Hours)**
3. Synthesis of Paracetamol. **(2 Hours)**
4. Synthesis of Acetaminophen. **(2 Hours)**
5. Synthesis of benzophenone oxime. **(2 Hours)**
6. Synthesis of phenytoin. **(2 Hours)**
7. Synthesis of benzimidazole. **(2 Hours)**
8. Estimation of acetyl salicylic acid in the given aspirin tablet by potentiometry. **(4 Hours)**
9. Estimation of alkali content in antacid tablet. **(2 Hours)**
10. UV Absorbance Standard Curve of Salicylic Acid. **(2 Hours)**
11. Assay of the following drugs by titrametry: Ibuprofen, aspirin. **(4 Hours)**
12. Quantitative estimation of ascorbic acid in given tablet. (**2 Hours)**

TEXT BOOK:

1. Beale J. Jr., Block J., Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition, Baltimore: Lippincott Williams and Wilkins.
2. Skoog D. A., Leary J. J., Principles of Instrumental Analysis, Philadelphia: Saunders College

Publishing.

REFERENCES BOOKS:

1. Indian Pharmacopoeia.
2. D. Lednicer, The Organic Chemistry of Drug Synthesis, New Jersey: John-Wiley and Sons, Inc.
3. Gennaro, A. R., Remington: The Science and Practice of Pharmacy, London: Mack Publishing Company.
4. Williams, D. A., Foye, W. O., Lemke, T. A., Foye's Principles of Medicinal Chemistry, Lippincott Williams and Wilkins.

REFERENCES BOOKS:

1. Indian Pharmacopoeia Commission, Indian Pharmacopoeia 2007.
2. Prichard Elizabeth, B. V., Quality Assurance in Analytical Chemistry. John Wiley and Sons.
3. Beckett A.H., StenlakeJ.B., Practical Pharmaceutical Chemistry, London: The Athlone Press.
4. Christian, G. D.; Analytical Chemistry, 6th Edition, New Jersey: John-Wiley and Sons, Inc.
5. Prabhu D.V, Raghuraman K., Basic Principles of Analytical Chemistry, Shet Publishers.
6. Lednicer D., Mitscher L., The Organic Chemistry of Drug Synthesis, New Jersey: John- Wiley and Sons, Inc.
7. Gennaro, A. R., Remington: The Science and Practice of Pharmacy, London: Mack Publishing Company.
8. Sharma, B. K., Instrumental Methods of Chemical Analysis, Meerut: Goel Publishing House.
9. Higuchi T., E. B.-H., Pharmaceutical Analysis. New York: Interscience Publishers.

WEB REFERENCES:

1. http://www.chemistryexplained.com/Ny-Pi/Pharmaceutical-Chemistry.html
2. https://www.pharmatutor.org/articles/significance-of-pharmaceutical-regulatory-bodies-a- review
3. https://www.pharmatutor.org/articles/pharmaceutical-regulatory-agencies-and- organizations-around-world-scope-challenges-in-drug-development
4. https://luxury.rehabs.com/drug-abuse/classifications/
5. https://www.europeanpharmaceuticalreview.com/article/868/pharmaceutical-analysis-in- quality-control/
6. https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl
7. https://www.pharmatutor.org/articles/chromatography-introduction
8. https://www.labmanager.com/lab-health-and-safety/2017/12/science-laboratory-safety- rules-guidelines#.XiUvXcgzaM8
9. http://www.lawplainandsimple.com/legal-guides/article/health-and-safety-in-the- pharmaceutical-industry

VOCATIONAL COURSES

THEORY
Course Code: UG-CHE-VOC1
Course Title: Spectroscopic Techniques
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. Understand the dual nature of light and the interaction of electromagnetic radiation with matter.
2. Learn the basic components of a spectroscopic instruments and their function.
3. Understand the principles and instrumentation of UV-Vis spectroscopy and Atomic Spectroscopic methods.
4. Solve numerical problems based on EMR theory and Beer-Lamberts law
5. Operate and carry out analysis on an UV-visible spectrophotometer.

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Understand the theory of spectroscopy, electromagnetic radiation and the function of various components of a spectrophotometer.

CO2: Understand the principles and instrumentation of UV-Visible spectroscopy.

CO3: Solve numerical problems based on electromagnetic radiation theory and Beer-Lambert's law.

CO4: Understand the principles, instrumentation and applications of AES, AAS, ICP and Fluorimetry.

CO5: Develop skills to carry out qualitative and quantitative analysis based on absorbance measurements using a UV-visible spectrophotometer

UNIT I: General Introduction **15 hours**

Overview of spectroscopy; meaning of electromagnetic radiation; interaction of electromagnetic radiation with matter; wave properties of electromagnetic radiation; particle properties of electromagnetic radiation; the electromagnetic spectrum; regions of spectrum; atomic and molecular spectra; representation of spectra; photons as a signal source; basic components of spectroscopic instruments; sources of energy; sources of electromagnetic radiation; sources of thermal energy; chemical sources of energy; wavelength selection; wavelength selection using filters; wavelength selection using monochromators; interferometers; detectors; photon transducers; thermal transducers; signal processors; solvents for spectrometry; quantitative calculations; spectrometric errors in measurements.

UNIT II: UV-Visible Spectroscopy **15 hours**

UV-Visible spectroscopy: Beer-Lambert's Law; validity and limitations of Beer-Lambert's law; Deviations from Beer-Lambert's Law; electronic transitions in a molecule; chromophores and auxochromes; Bathochromic, hypsochromic, hyperchromic and hypochromic shifts; solvent effect; effect of temperature. Instrumentation: spectrophotometers; single and double beam instruments. Applications of UV and visible spectroscopy- identification of structural groups, cis- trans isomerism, chemical kinetics, qualitative and quantitative analysis; limitations of UV and visible spectroscopy, quantitative analysis, study of co-ordination compound; photometric titrations. (Numerical problems based on Beer-Lambert's law to be solved)

UNIT III: Atomic Spectroscopy **15 hours**

Atomic Spectroscopy: origins of atomic spectra, production of atoms and ions; Atomic Emission Spectrometry (AES): Introduction, principle, instrumentation, applications, advantages and

limitations of flame photometry. atomisation methods and sample introduction methods used in atomic spectroscopy. Atomic Absorption Spectrometry (AAS): Introduction, principle, instrumentation, applications, internal standard and standard addition calibration method, limitations; Fluorimetry: Introduction, principles, instrumentation and applications. Inductively coupled plasma spectroscopy: principle, instrumentation and applications.

PRACTICALS
Course Code: UG-CHE-VOC1
Course Title: Spectroscopic Techniques
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To test the validity of Beer-Lambert Law using spectrophotometer and determine the unknown concentration of a solution.
2. To calibrate the UV- Visible spectrophotometer for control of absorbance and limit of stray light.
3. Determination of Mn2+ ion concentration, by periodate method using spectrophotometer.
4. Determination of Fe3+ ion concentration by salicylic acid method using spectrophotometer.
5. To estimate the amount of nitrite in water sample by spectrophotometric method.
6. To determine the amount of K2CrO4 present in given sample by using UV-Visible spectrophotometer.
7. To estimate the amount of paracetamol in tablet by spectrophotometric method.
8. To estimate the amount of aspirin in the given tablet by spectrophotometric method.
9. To verify the law of additivity of absorbance (KMnO4 and K2Cr2O7) at λmax of K2Cr2O7 and determine molar absorptivity.
10. To determine the phosphate concentration in a soft drink by spectrophotometric method.
11. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by continuous variation method.
12. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by mole ratio method.
13. To determine the dissociation constant of methyl red indicator by spectrophotometric method.
14. To determine the amount of Cr (VI) in the given solution as dichromate by least square method spectrophotometrically.
15. To determine the amount of nitrobenzene from the organic sample by spectrophotometric method.

*** All the experiments are of 2 hours duration.**

TEXT BOOK:

1. Skoog, D. A., West, D. M., Holler F. J., Crouch, S. R., Fundamentals of Analytical Chemistry, 8th Edition.

REFERENCE BOOKS:

1. Holler, F. J., Skoog, D. A., Crouch, S. R., Principles of Instrumental Analysis, 6th Edition,

Thomson Books.
2. Willard, H. H., Merritt, L. L., Dean, J. A., Settle, F. A., Instrumental Methods of Analysis, CBS Publishing, New Delhi, 7th Edition.
3. Christian, G. D., Analytical Chemistry, John Wiley, 5th Edition.
4. Ewing, G. W., Instrumental Methods of Chemical Analysis, 5th Edition, Mc-Graw Hill International Edition.
5. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis, 4th Edition, ELBS and Longman.

PRACTICAL BOOK:

Yadav, J. B., Advanced Practical Physical Chemistry, 14th Edition, Goel Publishing House.

WEB REFERENCES:

1. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Spectrpy/UV- Vis/spectrum.htm
2. https://chemdictionary.org/beer-lambert-law/
3. https://www.indiastudychannel.com/resources/146681-Principle-working-and-applications- of-UV-spectroscopy.aspx
4. https://www.slideshare.net/manishpharma/application-of-uv-spectroscopy
5. http://liskeard.cornwall.sch.uk/images/Liskeard-Sixth-Form/Atomic-Absorption-Spectrometry.pdf

Annexure A (PG Programmes)
Name of the Programme: M. Sc. in Chemistry

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE
(AUTONOMOUS)
POST GRADUATE DEPARTMENT OF CHEMISTRY
ACADEMIC YEAR: 2023-2024
APPROVED M. Sc. ANALYTICAL CHEMISTRY COURSE STRUCTURE TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2024-2025 ONWARDS

COURSE STRUCTURE
SEMESTER III AND IV

COURSES	SEMESTER III	SEMESTER IV
Discipline Specific Electives (DSE)	8	
Generic Electives (GE)	4	
Research Specific Electives (RSE)	8	4
Discipline Specific Dissertation (DSD)/Internship (I)		16
Total	**20**	**20**

SEMESTER III

COURSES	CREDITS	HOURS
Discipline Specific Electives (DSE)		
CHAE-501: Calibrations and Validation	**2**	**30**
CHAE-502: Methods of Analysis	**2**	**30**
CHAE-503: Diffraction Methods	**2**	**30**
CHAE-504: Advanced NMR Spectroscopy	**2**	**30**
CHAE-505: Separation Techniques	**2**	**30**
CHAE-506: Quality Assurance and Quality Control in Analytical Chemistry	**2**	**30**
CHAE-507: Chemometrics	**2**	**30**
CHAE-508: Bio analytical Chemistry	**2**	**30**
Generic Electives (GE)		
CHGE–501: Food chemistry and Nutrition	**2**	**30**
CHGE–502: Environmental Chemistry	**2**	**30**
CHGE-503: Application of Chemistry in Everyday Life	**2**	**30**

Research Specific Electives (RSE)		
CHRE–501: Research Methodology and Academic writing	**4**	**60**
CHRE–502: Experiments in Analytical Chemistry	**4**	**120**
CHRE–503: Experiments on analytical instrumentation	**4**	**120**

SEMESTER IV

COURSES	CREDITS	HOURS
Research Specific Electives (RSE)		
CHRE–504: Synthesis of inorganic materials	**2**	**30**
CHRE–505: Catalysis	**2**	**30**
CHRE-506: Applied organic chemistry	**2**	**30**
CHRE-507: Nanomaterials	**2**	**30**
Discipline Specific Dissertation (DSD)/Internship (I)	**16**	**384**

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE
(AUTONOMOUS)
POST GRADUATE DEPARTMENT OF CHEMISTRY
ACADEMIC YEAR: 2023-2024
BoS APPROVED SYLLABI TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2024-2025

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Course Code: CHAE-501
Course Title: Calibrations and Validation
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:
1. To enable students to understand the validation characteristics of some procedures used in laboratory
2. To enable students to have an idea about ICH guidelines used in pharmaceutical industry

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Understand the qualification of laboratory equipment as a precondition of reliable analytical testing
CO2: Understand the basic rules of documentation in QA
CO3: Calibrate the instruments of industrial importance
CO4: Have the knowledge of ICH guidelines in method development

UNIT I: Regulations and Qualifications **15 Hours**
Regulations: Regulatory requirements for analytical method validation; validation of analytical methods; complete method validation package, analytical data, protocol, plan, revisions and change controls; International Conference on Harmonization (ICH) Guideline Q2A: Validation of analytical procedures; linearity and range criteria and their role in instrumental method validation; GMP (US), Qualification: Overview of qualification of instruments; installation, operation and performance qualification (IQ, OQ, PQ) of analytical equipments; method validation for UV Visible Spectrophotometer, IR Spectrophotometer, Spectrofluorometer, HPTLC, GC, HPLC; qualitative and quantitative method validation; parameters of validation; statistics in validation; detailed discussion on accuracy and precision role in method validation; protocols and interpretation.

UNIT II: Calibration **15 Hours**
Calibration of analytical balance and pH meter; role of quantification limit and specificity; Limit of Detection (LOD) and Limit of Quantification (LOQ); Robustness and method validation; Ruggedness of chromatographic method; Ruggedness of sample preparation procedure; Calibration verses Qualification verses Validation; Case study for HPLC, UV; calibration of various instruments used for drug analysis like HPTLC, UV-Visible Spectrophotometer, IR Spectrophotometer, Spectro fluorimeter, GC, HPLC.

REFERENCE BOOKS:

1. The Theory and Practice of Industrial Pharmacy Lachman Edition
2. Web Resources in Pharmacy, In Pharma Publication, Bangalore
3. Schedule M
4. WHO Guideline
5. Analytical Method Development and Validation, Michael E. Swartz
6. Pharmaceutical Process Validation, Loftus and Nash
7. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denny, J.D. Banes, Thomas; 6th Edition, ELBS
8. Pharmaceutical Process Validation, Alfred H. Wachter
9. Validation and Qualification in Analytical Laboratories, Ludwig Huber; 2nd Edition, Wiley Publisher.

WEB REFERENCE:

1. https://uc.xyz/1mhmZR?pub=link
2. https://www.researchgate.net/publication/8508200_Qualification_of_analytical_instruments_for_use_in_the_pharmaceutical_industry_A_scientific_approach/link/02bfe50f872c59f953000000/download
3. https://www.slideshare.net/mobile/dhavalrock24/concept-of-ursdqiqoqpq
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4670047/
5. https://www.pharmaguideline.com/2010/05/calibration-of-uv-visible.html?m=1
6. https://nvlpubs.nist.gov

Course Code: CHAE-502
Course Title: Methods of Analysis
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:

1. To provide students with knowledge of thermal analysis to enable them to understand the principle of operation.
2. Obtaining basic knowledge on thermos-analytical methods
3. Application of thermos-analytical instruments in practice

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Choose the experimental conditions for the measurements and combine different Thermos-analytical techniques
CO2: Analyze and present the results of the measurements.
CO3: Understand the principles of thermo-analytical techniques and combine different Thermos-analytical techniques
CO4: Apply theoretical knowledge for practical analysis
CO5: Analyze and present the results of the measurements

UNIT I: Thermogravimetric Analysis and Differential Thermal Analysis 15 Hours

Thermogravimetric Analysis- introduction; definition; instrumentation (all components to be discussed); interpretation of TGA curve; factors affecting TGA curves- instrumental, characteristics of sample; advantages and limitation of TGA; calculation of compound composition, percent decomposition; applications of thermogravimetry; Derivative Thermogravimetry (DTG)- definition, comparison between TG and DTG.

Differential Thermal Analysis- introduction, definition; theoretical basis of DTA; DTA instrumentation (all components to be discussed); factors affecting the DTA curve; advantages and disadvantages of DTA; applications of DTA.

UNIT II: Differential Scanning Calorimetry, Thermometric Titrations and Electrogravimetry 15 Hours

Differential Scanning Calorimetry- definition; instrumentation of DSC, types, factors affecting DSC curves; comparison between DTA and DSC techniques; applications. Thermometric Titrations- introduction; definition; instrumentation (all components to be discuss); Electro gravimetry- basic principles, completeness in deposition, composition of electrolyte, separation with controlled potentials, constant current electrolysis;

Numerical based on TGA and DTA curves to calculate percent loss and fix the formula of the sample are to be solved.

TEXT BOOK:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R.Crouch; 8th Edition

REFERENCE BOOKS:

1. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd., London
2. Vogel's Textbook of Quantitative Chemical Analysis; 6 th Edition
3. Analytical Chemistry, G. D. Christian; 5 th Edition, John Wiley, NY
4. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
5. Instrumental Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House

WEB REFERENCES:

1. 1.http://web.abo.fi/instut/biofuelsGS2/kursen/%C5A/lectures/Lectrure_Thermal%20Analysis.pdf
2. https://www.pslc.ws/macrog/dsc.htm
3. https://www.brainkart.com/article/Thermometric-Titrations-(TT)_30858/

Course Code: CHAE-503
Course Title: Diffraction Methods
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:

1. To give students an overview of diffraction methods in solid state chemistry for solving structural problem

2. To enable students to learn the use of excel in solving problems on X-ray diffraction

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Understand the working of XRD
CO2: Interpret the XRD spectra
CO3: Handle the software like origin used in determination of crystal structure
CO4: Use Microsoft Excel to get X-ray analysis

UNIT I: X-ray diffraction analysis **15 Hours**
Introduction, packing of spheres - cubic and hexagonal close packing; radius ratio rule, unit cell, types of unit cells and their characteristics; description of crystal structure; Bravias lattice; Bragg's Law, powder method, single-crystal X-ray diffraction; principle, instrumentation, scope and limitations of the method; X-ray scattering factors; calculations of unit cell dimensions from powder diffraction patterns for cubic, tetragonal and orthorhombic systems; reciprocal lattice concept; X-ray intensity calculations to decide the ionic configurations.

UNIT II: Problem solving through diffraction methods **15 Hours**
Introduction to spreadsheet-based software; Microsoft Excel; development of spreadsheets for some simple test cases like Gaussian curve (study the effect of standard deviation and centre of Gaussian), plotting of trigonometric functions like sin, cos and their linear combinations (Fourier synthesis for crystal structure determination); precise lattice parameter measurements; crystal structure determination- cubic; FCC, BCC, Hexagonal and other important crystal structure.

TEXT BOOK:
1. Solid State Chemistry and its Applications; A. R. West, John-Wiley and Sons,Chinchester

REFERENCE BOOKS:
1. X-ray diffraction: A practical Approach, C. Suryanarayana and M. Grant, Norton Plenum Press, New York
2. Elements of X- ray Diffraction, B. D. Cullity; Addison Wesley
3. Principles of Solid State Chemistry, H. V. Keer; New Age International Ltd, New Delhi

WEB REFERENCES:
1. https://www.originlab.com/Origin
2. https://books.google.co.in/books?id=vk9fnLH56DYC&printsec=frontcover&dq=powder+diffraction+theory+and+practice&hl=en&sa=X&ved=0ahUKEwisvu--mpHnAhXPyDgGHW3XDMoQ6AEIZzAJ#v=onepage&q&f=false
3. https://link.springer.com/chapter/10.1007/978-1-4614-3954-7_12
4. https://epdf.pub/queue/powder-diffraction-theory-and-practice.html

Course Code: CHAE-504
Course Title: Advanced NMR Spectroscopy
Credits: 2
Maximum Marks: 50
Duration: 30 Hours
Course Objectives:
1. To enable students to understand basic aspects of nuclear magnetic resonance spectroscopy

2. To enable students to understand one-dimensional NMR, Chemical shifts, J-coupling, Interpretation of 1D NMR spectrum, basics of 2D NMR, different 2D NMR experiments and their application/interpretation

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Define the basic principles of NMR spectroscopy.

CO2: List the fundamental components and processes involved in NMR experiments.

CO4: Summarize the differences between 1D and 2D NMR experiments.

CO3: Interpret NMR spectra to extract information about chemical shifts, coupling constants, and peak integration.

CO4: Evaluate the appropriateness of NMR spectroscopy as a tool for solving particular chemical problems.

CO5: Innovate in the integration of NMR with other analytical techniques to solve interdisciplinary research problems.

UNIT I: ^{13}C-NMR, ^{19}F-NMR and ^{31}P-NMR Spectroscopy 20 Hours

Nuclear magnetic resonance- theory, quantum description; classical description of NMR; types of NMR spectra; applications of proton NMR in qualitative and quantitative analysis (in general); CW and PFT techniques; Types of CMR spectra-undecoupled- proton decoupled-off-resonance decoupled (SFORD)-selectivity decoupled and gated ^{13}CJ) and heteronuclear (^{13}C-^{1}H, ^{13}C-^{2}H) J couplings, nuclear overhauser effect, ATP (attached proton test), DEPT.

^{19}F and ^{31}P NMR Spectroscopy: Introduction, Fluorine coupling, coupling between Fluorine and Carbon, single fluorine and the CF_2 group substituents- alkyl fluorides, carbonyl compounds, phosphorus compounds, multifluoroalkenes; Trifluoromethyl group. Origin of the ^{31}P NMR spectra, coupling with hydrogen, carbon, metals, transition metal complexes containing phosphorus.

UNIT II: 2D-NMR Spectroscopy 10 Hours

Classification of 2D experiments- 2DJ resolved spectroscopy- HOMO and HETERO- 2DJ Resolved Spectra: correlation spectroscopy (COSY) - HOMO-COSY, 2D-INADEQUATE and NOESY.

TEXT BOOK:

1. 1.Spectroscopic Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. M. Morril
2. Introduction to Spectroscopy, Donald l. Pavia, Gary M. Lampman, George S. Kriz, James A.Vyvyan.

REFERENCE BOOKS:

1. Spectroscopic Identification of Organic Compounds, R. M. Silverstein and Webster
2. NMR in Chemistry- A Multinuclear Introduction, William Kemp
3. ^{13}C NMR for Organic Chemists, G. C. Levy, G. L. Nelson
4. Understanding NMR Spectroscopy, James Keeler; 2nd Edition
5. Guide to Fluorine NMR for Organic Chemists. By William R. Dolbier
6. Phosphorus-31 NMR Spectroscopy-A Concise Introduction for the Synthetic Organic and
7. Organometallic Chemist, Olah Kühl, 2008 Springer-Verlag Berlin Heidelberg

WEB REFERENCES:

1. http://chem.ch.huji.ac.il/nmr/techniques/2d/2d.html
2. http://chem.ch.huji.ac.il/nmr/techniques/2d/noesy/noesy.html

Course Code: CHAE-501
Course Title: Separation Techniques
Credits: 2
Maximum marks: 50
Duration: 30

Course Objectives:

1. To give students a theoretical and practical introduction to the techniques of separation
2. To address modern challenges across the chemical, biological, and physical sciences as it is often necessary to isolate and examine chemical and biological species as pure substances

Course Outcomes:

On successful completion of the course, the student will be able to,

CO1: Describe the methods of separation and their applications
CO2: Acquire technical knowledge, practical experience with respect to chromatography
CO3: Understand various chromatographic techniques employed
CO4: Learn applications of various processes for separation and purification of compounds

UNIT I: Chromatographic Techniques **15 Hours**

Introduction to theory and principle of chromatographic technique; terms and parameters used in chromatography, band broadening and column efficiency; variables that affect column efficiency; Gas Chromatography- introduction, principle, theory, instrumentation; columns in GC; detectors- ionization, flame ionization, thermal conductivity, electron capture; evaluation of gas chromatogram; identification of chromatogram; comparison of GSC and GLC; applications; High Performance Liquid Chromatography- introduction; principle; instrumentation; pumps, column and column packing; column efficiency and selectivity; characteristics of liquid chromatography; types of detectors- UV, RI, and fluorescence detectors; advantages, comparison of HPLC and GLC; applications.

UNIT II: Miscellaneous Separation Techniques and Hyphenated Techniques **15 Hours**

Gel chromatography- introduction, theory; principle of gel permeation chromatography- instrumentation and applications; theory and mechanism of ion exclusion; applications of ion exclusion technique; inorganic molecular sieves; principle; types of sieves; applications. Supercritical Fluid Chromatography-introduction; theory, principle; properties of supercritical-fluids; instrumentation and operating variables; comparison of SFC and other column methods, applications; Field-flow fractionation - theory, mechanism, types, and applications; Hyphenated Techniques- introduction; principle, instrumentation, applications of GC-FTIR; GC-MS; LC-MS, TG-MS.

TEXT BOOK:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler; 9th Edition

REFERENCE BOOKS:

1. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons, NY
2. Khopkar, S. M. (1998). *Basic concepts of analytical chemistry*. New Age International.
3. Harvey, D. (2000). *Modern analytical chemistry*. McGraw Hill.
4. Chemical Instrumentation: A Systematic Approach, H. A. Strobel

5. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
6. Vogel's Text Book of Quantitative Chemical Analysis; 6th Edition
7. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, J. A. Dean
8. Instrumental Methods of Chemical Analysis, B. K. Sharma; Goel Publishing House

WEB REFERENCES:

1. https://www.nottingham.ac.uk/-sczsteve/Ohlendieck%20and%20Harding%202018.pdf
2. http://www.chem1.com/acad/webtext/solut/solut-5.html
3. https://www.ijarnd.com/manuscripts/v2i4/V2I4-1168.pdf
4. Column Chromatography Made Simple: An Easy to Follow Guide (bitesizebio.com)
5. What is Column Chromatography ? A Beginners guide (studyread.com)
6. Types of distillation columns | Headlands Distilling Co.
7. Raoult's Law and ideal mixtures of liquids (chemguide.co.uk)
8. https://www.pharmatutor.org/pharma-analysis/explain-electrophoresis-its-principle-and- factors-governing-it
9. https://www.iitk.ac.in/dordold/index.php?option=com_content&view=category&layout=blog&id=220&Itemid=239

Course Code: CHAE-506
Course Title: Quality Assurance and Quality Control in Analytical Chemistry
Credits: 2
Maximum Marks: 50
Duration: 30 Hours
Course Objectives:

1. To enable students to understand the basics of quality control and quality assurance
2. To enable students to describe the types of packaging and regulatory aspects in food and pharmaceutical industries

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Explain the basics of quality assurance and quality control
CO2: Know the types of packaging and regulatory aspects in food and pharmaceutical industries
CO3: Handle reagents and chemicals appropriately
CO4: Evaluate the quality assurance data

UNIT I: Introduction to Quality Assurance and Quality Control 15 Hours

Introduction to basic concepts, quality assurance; aspect of specification and tolerance; quality acceptance; sampling reality; cost aspect of quality decisions; quality control in raw materials; finished product; laws related to quality control; case studies of quality control in various industries like pharmaceuticals, agrochemicals, petrochemicals, dyes, plastics, polymers; safety in laboratory; importance of laboratory note book; cleaning and marking laboratory ware; measuring volume; calibrating volumetric flask; selecting and handling reagents and chemicals; methods of quality assessment- internal and external; evaluating quality assurance data- prescriptive approach and performance based approach.

UNIT II: Standard Method, Analysis; Packaging and Regulatory Aspects 15 Hours

Development of a standard method and analysis- introduction; optimizing experimental procedure (Standard Operating Procedures); verifying the method- single-operator characteristics; blind analysis of standard samples; ruggedness testing; validating standard method; two-sample collaborative testing and analysis of variance.
Packaging and Regulatory Aspects- introduction; types of packing material and regulations; acts in food and pharmaceutical industries; testing of material for packing; legal aspects in packing; regulatory aspects of foods, drugs and cosmetics; food safety and Standards Act, 2006; I.S.I., AGMARK, Government authorities concerned with testing, G.M.P. and C.G.L.P.S.; Department of WHO certification.

TEXT BOOK:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R.Crouch; 8thEdition

REFERENCE BOOKS:

1. Quality Assurance in Analytical Chemistry, W. Funk, V. Dammann, G. Donnevert; VCH Weinheim
2. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd. London
3. Vogel's Textbook of Quantitative Chemical Analysis; 6th Edition
4. Modern Analytical Chemistry, D. Harvey; McGraw-Hill Education
5. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons, NY
6. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
7. Pharmacopeia of India, Volume I and II
8. Quality in the Analytical Chemistry Laboratory, E. Prichard; John Wiley
9. Principals of Package Development, Gribbinetal
10. Modern Packaging Encyclopaedia and Planning Guide- MacqraWreyco
11. Government of India Publications of Food Drug Cosmetic Acts and Rules

WEB REFERENCES:

1. https://asq.org/quality-resources/quality-assurance-vs-control
2. https://nvlpubs.nist.gov/nistpubs/Legacy/IR/nbsir85-3105.pdf
3. https://www.who.int/water_sanitation_health/resourcesquality/wqmchap9.pdf
4. https://www.who.int/medicines/areas/quality_safety/quality_assurance/control/en/
5. https://www.who.int/tdr/publications/documents/glp-handbook.pdf

Course Code: CHAE - 507
Course Title: Chemometrics
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:

1. To provide students with a basic tool in solving problems

Course Outcomes:
On successful completion of the course, the student will be able to:

CO1: Handle computers and data sheet
CO2: Handle statistical arrangements of data

UNIT I: Introduction to Data and Statistics **15 Hours**

Introduction; univariate statistics review; probability; variance and sampling, linear regression and calibration data, digitization, and the Nyquist Theorem, detection limit, S/N ratio, and signal filtering; review of linear algebra: scalars, vectors, and matrices, matrix notation and matrix operations orthogonality, analysis of variance (ANOVA)- 1 variable, analysis of variance- 2 variables; introduction to Matlab™: programmed, basics and layout, matrix operations in Matlab™ the diary command and examples, ANOVA in Matlab™ experimental design: factorial design, simple versus complex models, factorial design in Matlab™; half-factorial design.

UNIT II: Multivariate Methods **15 Hours**

Introduction to various multivariate methods; the six habits of a chemometrician; principle component analysis (PCA); data pretreatment- mean centering and normalization; PCA in Matlab™. Classical least squares (CLS), CLS in Matlab™, inverse least squares (ILS).
Multiple linear regression (MLR); principle component regression (PCR); partial least squares, examples in Matlab™; summary of multivariate methods; pattern recognition- supervised versus unsupervised pattern recognition, K nearest neighbours (KNN); soft independent modelling for chemical analysis (SIMCA), summary of pattern recognition.

TEXT BOOK:

1. Chemometrics, A Practical Guide; Kenneth R. Beebe, Randy J. Pell, and Mary Beth Seasholtz, JohnWiley and Sons, Inc., New York

REFERENCE BOOK:

1. The computer program MATLAB™ will be required for some portions of the course

WEB REFERENCES

1. 1.https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Chemometrics_Using_R_(Harvey)/00%3A_Front_Matter/What_is_Chemometrics_and_Why_Study_it%3F
2. https://www.frontiersin.org/articles/10.3389/fchem.2018.00576/full
3. https://www.mn.uio.no/astro/english/services/it/help/mathematics/matlab/matlab_prog.pdf

Course Code: CHAE-508
Course Title: Bio analytical Chemistry
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:

1. To enable students to the techniques routinely used in bio analytical laboratories
2. To enable students to study various bio analytical techniques used for diagnosis of diseases

Course Outcome:

On successful completion of the course, the student will be able to:
CO1: Have valuable training inforensic science and biotechnology
CO2: Understand antibody-antigen interactions
CO3: Understand various bio analytical techniques used for medical diagnosis and research

CO4: Understand the working of various biosensors used to detect biological compounds

UNIT I: Antibodies, Spectroscopic Methods for Matrix Characterization 15 Hours

Antibodies- Introduction, structural, functional properties of antibodies, polyclonal and monoclonal antibodies; antibody- antigen interactions; analytical applications of secondary antibody-antigen interactions: agglutination reactions and precipitation reactions; keys to immunochemical measurements; analytical applications of biological tracers; principle and applications of radioimmunoassay (RIA); enzyme linked immune sorbent assay (ELISA); Introduction to the concept of RTPCR; immuno histochemistry- important diagnostic tool; introduction to protein; method for total protein- Lowry, Smith, Bradford; protein quantification methods; methods for total DNA- fluorometric, diphenylamine; total RNA; determination of total carbohydrate- ferricyanide, phenol sulphuric acid; Purpald assay for bacterial polysaccharides; free fatty acids.

UNIT II: Biosensors and Bio Analytical Approaches 15 Hours

Introduction to biosensors; examples of biosensor; configurations; response of enzyme-based biosensors; ferrocene-mediated amperometric glucose sensor; potentiometric biosensor for phenyl acetate; potentiometric immune sensor for digoxin; evanescent-wave fluorescence biosensor for bungaro toxin; optical biosensor for glucose based on fluorescence energy transfer; piezoelectric sensor for nucleic acid detection, enzyme thermistors; clinical genomics; proteomics and metabolomics; clinical diagnosis and screening; research and development; emerging pharmaceutical products, future perspectives; structure and characteristics of key transition metals, importance of transition metals in physiological processes, transition metals as mediators of disease processes, therapeutic implications of transition metals, determination of transition metals in nature

TEXT BOOK:

1. Understanding Bio analytical Chemistry, V. A. Gault; John-Wiley and Sons

REFERENCE BOOK:

1. Analytical Biochemistry, D. J. Holme; Pearson Education Ltd.
2. The principles of ion-selective electrodes and membrane transport, W. E. Morf
3. Bio analytical Chemistry, S. R. Mikkelsen; John-Wiley and Sons

WEB REFERENCES:

1. https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/
2. Mehrotra, P. (2016, January 6). Biosensors and their applications – A review. Journal of OralBiology and Craniofacial Research. doi:10.1016/j.jobcr.2015.12.002
3. https://www.radiologyinfo.org/en/info.cfm?pg=bodymr
4. https://www.iaea.org/topics/radiotracers
5. https://www.antibodies-online.com/resources/17/1215/radioimmunoassay-ria/

GENERIC ELECTIVES (GE)

Course Code: CHGE-501
Course Title: Food chemistry and Nutrition
Credits: 2

Maximum marks: 50
Duration: 30 Hours

Course Objectives:
The Course will enable the students to

1. Recall the essential macronutrients and micronutrients required for human nutrition.
2. Identify the classification of carbohydrates, proteins, fats, vitamins, minerals, and water in the diet.
3. Explain the functions and roles of carbohydrates in the human body, including dietary fiber.
4. Describe the different types of lipids and their significance in nutrition.
5. Analyze the nutritional significance of macro and micro nutrients in maintaining overall health.
6. Infer the effects of natural colors and flavouring agents on consumer choices and food safety.

Course Outcome:
On successful completion of the course, the student will be able to:
CO1: Identify the major classifications of dietary fibers, lipids, water-soluble and fat-soluble vitamins, major minerals, and trace minerals.
CO2: Explain the functions of macro and micro nutrients in the human body, specifically in digestion, absorption, and overall health.
CO3: Describe the nutritional significance of these nutrients and their roles in changing trends in dietary intake.
CO4: Interpret recommended dietary allowances and their importance in maintaining a balanced diet.
CO5: Apply knowledge of intentional additives, incidental additives, natural colors, flavoring agents, and their roles in food products.
CO7: Analyze the hazards in the food supply chain and identify potential sources of contamination.

UNIT I: Macro and Micro Nutrients 15 hours
Introduction to macro and micro nutrients- Carbohydrates - Introduction, classification and dietary fibers; Proteins introduction, classification; Fats- Introduction and types of lipids; Vitamins- water soluble and fat-soluble vitamins; Minerals - Major minerals and trace minerals and their functions; Water and its functions. Role in human body-digestion and absorption. Nutritional significance and changing trends in dietary intake. Recommended dietary allowances.

UNIT II: Additives and Contaminants 15 hours
Intentional additives, Incidental additives or contaminants, Natural colors and flavouring agents, Toxic trace elements, Metal uptake in canned foods, Plant protective agents- Pesticides; monitoring pesticides in food, Veterinary drugs, Persistent environmental chemicals, Naturally occurring toxicants; control and measures, Hazard identification in the food supply chain, Organic and inorganic contaminants in food- metals and metalloids, nitrates, hydrocarbons, Chemical migration from food packaging.

TEXT BOOK:

1. Srilakshmi, B. (2006). *Nutrition Science*. New Age International.
2. Principles of food chemistry third edition by John M.deMan, Phd
3. Basic food chemistry, 2nd edition, Frank A. Lee, PhD

REFERENCE BOOKS:

1. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
2. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease, 9th edition. Williams and Williams. A Beverly Co. London.
3. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York
4. World Reviews of Nutrition and Dietetics.
5. WHO Technical Report Series.
6. Indian Council of Medical Research. Recommended Dietary Intakes for Indians - Latest Recommendations.
7. Indian Council of Medical Research. Nutritive Value of Indian Foods - Latest Publication.
8. Berdanier, C.D. and Haargrove, J.L. (ed) (1996): Nutrients and Gene Expression: Clinical Aspects. Boca Raton, FL CRC Press.
9. Baeurle, P.A. (ed) (1994) Inducible Gene Expression. Part I: Environmental Stresses and Nutrients. Boston: Birkhauser.
10. Chandra, R.K. (ed) (1992): Nutrition and Immunology. ARTS Biomedical. St. John's Newfoundland.
11. International Life Sciences Institute Present Knowledge in Nutrition – latest edition

JOURNALS:

1. Nutrition Reviews
2. Journal of Nutrition
3. American Journal of Clinical Nutrition
4. British Journal of Nutrition
5. European Journal of Clinical Nutrition
6. International Journal of Vitamin and Nutrition Research
7. International Journal of Food Science and Nutrition
8. Nutrition Research
9. Annals of Nutrition and Metaboli

Course Code: CHGE-502
Course Title: Environmental Chemistry
Credits: 2
Maximum marks: 50
Duration: 30 Hours

Course Objectives:

The Course will enable the students to

1. Identify and define various types of pollution, such as air, water, soil, noise, radioactive and microplastic pollution.
2. Recall key pollutants associated with each type of pollution.
3. Explain the causes and sources of different types of pollution.
4. Interpret the environmental and health impacts of pollution on ecosystems and human populations.
5. Evaluate the effectiveness of pollution control measures in various industries and sectors.

Course Outcome:

On successful completion of the course, the student will be able to:

CO1: Recognize the methods and technologies used to monitor and control air pollution, including those for SO2, NOx, CO, and SPM.
CO2: Identify various types of pollution, including air, water, soil, noise pollution etc.
CO4: Explain the causes and sources of different types of pollution.
CO5: Summarize the impact of pollution on ecosystems, human health, and the environment.

UNIT I: Air Pollution, Water Pollution and Soil Pollution 15 Hours

Air pollution- natural and anthropogenic sources of pollution, primary and secondary pollutants, transport and diffusion of pollutants, Methods of monitoring and control of air pollution, SO_2, NOx, CO, SPM.

Water pollution – Introduction to water pollution; sources and consequences, types of pollutants in ground water, Geological and anthropogenic pollutants in ground water - movements of contaminants in ground water; Heavy metals in aquatic systems - cycling, interactions and transport - factors affecting, sewage and wastewater treatment and recycling; advanced waste water treatment.

Soil pollution: Types, sources and consequences, Transport processes — biological process-microbial transformation of heavy metals, industrial waste effluents and heavy metals and their interactions with soil components, analysis of soil quality, soil pollution control.

UNIT II: Noise Pollution, Radioactive Pollution and Microplastics 15 Hours

Noise pollution - sources of noise pollution, measurement and indices, Marine pollution, sources of marine pollution and its control, Effects of pollutants on human beings, plants, animals and climate, air quality standards and air pollution

Radioactive Pollution- Radioactivity in the environment, Radionuclides- sources, types of radiation, Radioactive fallout, Ecological risks from radiation, effects on humans, exposure standards. nuclear power plants and fuel production; waste generation from nuclear power plants; radioactive waste treatment, disposal options.

Microplastic: occurrence, fate and waste management

The Microplastic Cycle: An Introduction, Microplastics in Terrestrial and Freshwater Environments, Marine Microplastics, Exposure, The interactions of microplastics and chemical pollutants, Analysis and Techniques for Collection, Removal and Degradation.

TEXTBOOK:

1. De Anil, K. (2003). *Environmental chemistry*. New Age International.

REFERENCE BOOK:

1. Murali Krishna, K. V. S. G. (1995). Air pollution and control. Kaushal & Co., Kakinda AP, 215215.Manahan, S. E. (2022). Environmental chemistry. CRC press.
2. Bell, L. H., & Bell, D. H. (2017). Industrial noise control: Fundamentals and applications. CRC Press.
3. Bank, M. S. (2022). Microplastic in the environment: pattern and process (p. 354). Springer Nature.
4. Masters, G. M. (1998). Introduction to environmental engineering and science.
5. Andrady, A. L. (2011). Microplastics in the marine environment. Marine pollution bulletin, 62(8), 1596-1605.
6. Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: a review. Marine pollution bulletin, 62(12), 2588-2597

REFERENCE LINK:

1. Water pollution | Definition, Causes, Effects, Solutions, Examples, & Facts | Britannica
2. Causes, Effects and Solutions of Groundwater Pollution - Conserve Energy Future (conserve-energy-future.com)
3. Soil Pollution: Definition, Causes, Effects and Solutions - Conserve Energy Future (conserve-energy-future.com)
4. Soil - Detoxification, Pathways, Microorganisms | Britannic

Course code: CHRE-503
Course Title: Application of Chemistry in Everyday Life
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objective:
The course will enable the students to

1. Identify common chemical compounds found in everyday products.
2. Impart knowledge of Chemistry and related sciences.
3. Describe the significance of pH in household applications and environmental impact.
4. Develop scientific attitude to make the students open minded, critical and curious.
5. Examine chemical processes in household products and their impact on health and the environment.

Course Outcomes
On successful completion of the course students will be able to
CO1: Recall common chemical concepts and terminology used in daily life.
CO2: Recognize the chemical properties of everyday substances.
CO3: Comprehend the principles of chemical reactions and their relevance to daily experiences.
CO4: Explain how chemical processes affect various aspects of daily life, such as health, environment, and technology.
CO5: Analyze the impact of chemical processes on society, the environment, and industry.
CO6: Evaluate the safety and ethical considerations associated with the use of chemicals in everyday life.

UNIT I: Applications, Uses and Impact of Chemistry **15 Hours**
Pharmaceuticals- Historical developments in medicine, Contribution of chemistry to human health, Classification of drugs and some common drugs used in our daily life.
Plastics and Polymers - Introduction, types of polymers, Plastic in daily use: HDPE, LDPE, PVC, PET, PP. Environmental Hazards of plastics, Biodegradable plastics.
Cosmetics - Basic concepts-composition and classification of creams-sunscreen and suntan Lotions, deodorants, talcum powder- Identifiers, lipsticks, oils, face creams, skin products, dental cosmetics, hair dyes, shaving cream, shampoo.

UNIT II: Impact Of Chemistry in Other Fields **15 Hours**
Chemistry and Art – History of colour, Use of colour to decorate the body and surroundings. Relationship between light and colour. Electromagnetic Spectrum, Cause of colour in objects, Properties of Light.

The Nature and behaviour of light, mixing colours: Light vs. Pigments, Colorants: Pigments and Dyes. Chemistry of art conservation and restoration, Fakes and Forgeries in art.
Chemistry and Sports - Chemistry of sports materials, Use of performing enhancing drugs in sports
Gobar gas: Production, feasibility and importance of Biogas with special reference to Rural India; Fertilizers: Definition, classification - Urea, NPK and Super phosphates, uses and hazards.

TEXTBOOK:

1. Singh, K. (2012). *Chemistry in daily life*. PHI Learning Pvt. Ltd.

REFERENCE BOOKS:

1. Chemical Process Industries - Norris Shreve Joseph A. Brine. Jr.
2. Environmental Chemistry - A. K. DE.
3. Industrial Chemistry, B. K. Sharma- Goel publishing house Meerut.
4. Food Science - B. Srilakshmi - III Edition - New Age International Publishers, 2005.
5. Food Chemistry, Lillian Hoagland Meyer - CBS publishers & distributors, 2004.
6. Fundamental Concepts of Applied Chemistry - Jayashree Ghosh, S. Chand & Co Ltd., New Delhi - 2010.
7. Applied chemistry - K. Bagavathi Sundari - MJP Publishers (2006). Course Materials

WEB REFERENCES

1. https://ncert.nic.in/ncerts/l/lech207.pdf
2. https://www.researchgate.net/publication/244480193_An_Introduction_to_Toothpaste_-_Its_Purpose_History_and_Ingredients
3. https://www.academia.edu/29067197/Plastic_pdf
4. https://www.susana.org/_resources/documents/default/2-1799-biogasplants.pdf

RESEARCH SPECIFIC ELECTIVES (RSE)

Course Code: CHRE-501
Course Title: Research Methodology and Academic writing
Credit: 4
Maximum Marks: 100
Duration: 60 Hours

Course Objectives:
The Course will enable the students to

1. Understand the fundamental concepts and components of research methodology, including research types, approaches, and the significance of research.
2. Apply knowledge to design sample surveys, considering sampling errors, measurement scales, data collection methods and the development of measurement tools.
3. Recognize the components of an academic paragraph and their role in conveying ideas effectively.
4. Recall the importance of referencing and citing sources in academic writing.
5. Understand the concept of plagiarism and its ethical implications.
6. Synthesize information from various sources to construct a well-structured academic paper.

Course outcomes:

Upon successful completion of this course students will

CO1: Demonstrate knowledge of research objectives, types, and approaches through the analysis of research significance and the application of criteria for quality research.

CO2: Create a compelling theory for a given research challenge.

CO3: Conduct research projects in accordance with research ethics and without engaging in any wrong doing.

CO4: Evaluate and critique academic writing to ensure adherence to established rules and standards.

CO5: Differentiate between various research writing styles and choose the most suitable for specific contexts.

CO6: Analyze the structure of paragraphs in academic writing and construct coherent and organized paragraphs.

CO7: Assess the credibility of sources, including journals and digital content, for research purposes.

CO8: Apply proper referencing and citation techniques throughout the writing process.

UNIT I: Understanding Research **15 Hours**

Research methodology – introduction, objectives, types of research, research approaches, significance of research, research process, criteria of a good research

Defining a research problem- selecting the problem, necessity of defining the problem, technique involved in defining the problem

Research design – meaning, need of research design, features of a good design, concepts related to research design, types

Design sample surveys- Introduction, sample design, sampling and non- sampling errors, types of sampling designs.

UNIT II: Tools and Techniques of Research Writing **15 Hours**

Measurement and scaling, quantitative and qualitative data, classification of measurement scales, goodness of measurement scales, sources of errors in measurement, techniques of developing measurement tools, scaling – classification and techniques

Data collection – introduction, experiments in surveys, collection of primary and secondary data, selection of appropriate methods for data collection, case study method

Data preparation process – questionnaire checking, editing, coding, classification, tabulation, graphical representation, data cleaning, data adjusting, problems in preparation process, types of analysis

Interpretation and report writing- techniques, different steps in writing report, layout of research report, types of report, oral presentation, precautions for writing research reports

UNIT III: Introduction to Scientific Writing and Literature Review **15 Hours**

Importance and Rules of Academic Writing, styles of research writing, paragraph structure, Quotation plagiarism, sources- journals, digital content; Author metrics, style of research writing, impact factors, types of index, challenged in research Process and Source of Literature- journal, digital, web, periodicals; referencing, citations, the writing process.

UNIT IV: Thesis and Model Writing **15 Hours**

Inclusions - cover and title pages, abstract, introduction, table and figure formats, text, objectives, methodology, analysis, summary, conclusion, bibliography; plagiarism, Layouts – fonts, spacing, visual effects, labelling, visual presentation of data, creating images using apps, and related aspects, paraphrasing; Writing model-formal letter, CVs, designing in report surveys, and comparison essay.

TEXT BOOK:

1. Kotahri, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Ed.Reprint, New Age International Publishers
2. Singh YK. 2006. Fundamentals of Research Methodology and Statistics. New Age International Publishers.

REFERENCE BOOKS:

1. Krishnan V. 2011. Statistics for Beginners. Atlantic Publishers and Distributors (P) Ltd.
2. Jackson SL. 2012. Research Methods and Statistics: A Critical Thinking Approach. Fourth Edition. Wadsworth Cengage Learning.
3. Mathukutty M Monippally, Academic Writing: A Guide for Management Students and Researchers, ISBN 9788132104414, Sage Publications, New Delhi, India.
4. Bell, J., & Waters, S. (2018). *Ebook: doing your research project: a guide for first-time researchers*. McGraw-hill education (UK).
5. Kumar, R. (2018). Research methodology: A step-by-step guide for beginners. *Research methodology*, 1-528.
6. Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: an introduction (8. utg.). *AE Burvikovs, Red.) USA: Pearson*

WEB REFERENCES:

1. https://egyankosh.ac.in/handle/123456789/35677
2. https://docstate.academy/courses/qualitative-analysis-and-review-writing/
3. https://shop.elsevier.com/books/writing-research/clare/978-0-443-07182-9
4. https://www.scribbr.com/dissertation/methodology/#:~:text=It%20involves%20studying%20the%20methods,surveys%2C%20and%20statistical%20tests).
5. https://www.indeed.com/career-advice/career-development/research-methodology
6. https://gradcoach.com/what-is-research-methodology/
7. https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf
8. https://research.com/research/how-to-write-research-methodology
9. https://euacademic.org/BookUpload/9.pdf
10. https://www.slideshare.net/RonitRKharade/research-tools-and-techniques-245926961

Course Code: CHRE-502
Course Title: Experiments in Analytical Chemistry
Credits: 4
Duration: 120 Hours
Maximum Marks: 100

Course Objectives:

1. To enable students in understanding the knowledge of separation and characterization
2. To enable students to carry out, record and analyze the result of analytical experiments

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the quantitative approach towards various instruments
CO2: Identify appropriate method to carry out quantitative analysis for desired samples
CO3: Perform titrimetric and spectrophotometric analysis
CO4: Develop good laboratory practices, both conceptually and practically

UNIT I: Analysis of Pharmaceutical Tablets / Samples

1. Estimation of calcium from dietary supplements using Murexide indicator
2. Estimation of Ibuprofen / Paracetamol
3. Estimation of sulphadiazine / sulphonamide
4. Determination of neutralizing power of tablets of different brands and compare effectiveness
5. Determination of iron using Zimmermann-Reinhardt reagent by titrating againstpotassium permanganate
6. Estimation of iron from given pharmaceutical drug sample using thioglycolic acid

UNIT II: Ion Exchange Chromatography and Solvent Extraction Method

1. To determine the capacity of a cation exchange resin
2. To determine the capacity of an anion exchange resin
3. To determine the Fe ion as Fe-oxine complex using Butyl acetate/ $CHCl_3$ asextracting solvent.
4. To separate the acidic, basic and neutral compounds from the mixture by solvent extraction.

UNIT III: Electrochemical Method

1. pH-metric determination of hydrolysis constant of aniline hydrochloride
2. pH-metric determination of the acid-base dissociation constant and isoelectric point of amino acid
3. pH metric determination of dissociation constant of dibasic, oxalic acid
4. Potentiometric estimation of carbonate and bicarbonate from the mixture
5. Potentiometric determination of dissociation constant for Cu-ammonia complex
6. To determine the critical micelle concentration of the detergent using conductometer.

UNIT IV: Simple Chromatography

1. To separate alpha amino acids by paper chromatography
2. To separate the two organic compounds from the mixture by TLC
3. To separate the leaf pigments: chlorophyll 'a' chlorophyll 'b', carotene and xanthophylls by paper chromatography
4. To determine the R_f value of glycine by ascending paper chromatography
5. To separate sugars and amino acids by paper and thin layer chromatography
6. To separate the mixture of o- and p- nitro anilines by column chromatography
7. To study the presence of lactose in milk by descending paper chromatography

UNIT V: Spectrophotometric Method

1. To determine pka value of methyl red indicator at room temperature
2. To determine the indicator constant and isobestic point of an indicator
3. To determine the stoichiometry and stability constant of ferric salicylic acid complex byJob`s method and mole ratio method
4. To determine the amount of each p-nitrophenol and m-nitrophenol from the mixtureby spectrophotometric titration using standard NaOH solution at λ_{max}= 280 nm
5. To record the UV absorption spectrum of acetone in n-hexane and identify the various transitions
6. To estimate the amount of aspirin and caffeine from APC tablet by UV-Visible

spectrophotometry
7. To study the iodination of acetone by spectrophotometric method
8. To estimate the amount of arsenic in dried shrimp by UV-Visible spectrophotometryusing molybdenum blue method.

UNIT VI: Interpretation Exercise

1. X-ray powder diffraction analysis of cubic compound:
    a. Determination of Lattice constants and crystallite Size
    b. Density
2. Interpretation of Mossbauer spectrum with reference to determination of: isomer shift; quadruple splitting; internal magnetic field; general comment
3. Interpretation of IR spectrum with reference to stretching vibration of: C=N; C=O; N-O;M-O
4. Interpretation of NMR spectrum with reference to calculation of chemical shifts andgeneral comments
5. Interpretation of absorption spectra for:
    a. Verification of the position of ligands in spectrochemical series
    b. Calculation of spectral splitting parameters
    c. Determination of geometry of a given compound (octahedral, tetrahedral, squareplanar)
6. Statistical revaluation of spectrophotometric data

REFERENCE BOOKS:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition
2. Comprehensive Experimental Chemistry, V. K. Ahluwalia; New Age Publications
3. Experimental Physical Chemistry, F. Daniels and J. Williams
4. Experimental Physical Chemistry, R. C. Das and B. Behera
5. Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan
6. An Introduction to Practical Biochemistry, D. T. Plummer; 3rd Edition, Tata McGraw-Hill, New Delhi
7. Advanced Physical Chemistry, J. B. Yadav; 14th Edition, Goel Publishing House
8. Systematic Experimental Physical Chemistry, S. W. Rajbhoj, T. K. Chondhekar; Anjali Publication, Aurangabad.

VIDEO REFERENCES:

1. https://www.youtube.com/watch?v=lha8dEBNFS4&t=251s

Course Code: CHRE-503
Course Title: Experiments on analytical instrumentation
Credits: 4
Duration: 120 Hours
Maximum Marks: 100

Course Objectives:

1. familiarize students with principles, components, and operation of spectroscopy, potentiometry, chromatography and thermal methods of analysis.
2. Teach students to prepare and handle samples for analysis, including proper techniques for

sample collection, extraction and pre-treatment.
3. Give students opportunities for hands on experience with the instruments, ensuring proficiency in their use.

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Demonstrate proficiency in operating and maintaining analytical instruments
CO2: Analyze various types of chemical samples, demonstrating proper techniques
CO3: Interpret data obtained from instruments and use appropriate software for data processing and presentation.
CO4: Develop research skills including ability to conduct literature reviews, plan experiments and draw conclusions from data.
CO5: Exhibit awareness of laboratory safety practices and follow protocols while working with hazardous chemicals.

UNIT I: IR Spectroscopy
1. Quantification of acetyl group from polymers using IR
2. Plasticizer from PVC using IR
3. Determination of ethanol in gasoline
4. Spectral analysis of different compounds (synthesized inorganic complexes and organic compounds)
5. Microscale analysis of patterning reactions via FTIR imaging

UNIT II: Potentiometry
1. Potentiometric determination of reducing sugars
2. Potentiometric titration using graphite sensor
3. Kinetics of bromination reaction: A potentiometric study
4. Non-aqueous titration containing mixture of aniline and ethanolamine

UNIT III: Gas Chromatography
1. To develop and validate the analytical method of any one drug using GC
2. Synthesis of high boiling organic compound by derivatization and analyses by GC
3. Separation of alcoholic mixtures
4. Determination of alcoholic content in: i. Beer ii. Wine iii. Local drinks
5. Gas chromatographic analysis for: i. automobile exhaust ii. Cigarette smoke
6. Analysis of preservatives from solid and liquid samples (extraction, sample preparation andanalysis)
7. Internal normalization for the quantitative analysis of solvents using GC.
8. Determination of trace amounts of metals as their chelate complexes using GC.
9. Gas chromatographic analysis for a mixture of gases like O_2, N_2 and CO_2

UNIT IV: High Performance Liquid Chromatography
1. Determination of caffeine content in: i. Tea ii. Coffee iii. Soft drinks iv. Chocolates
2. Purity of the solvents using HPLC
3. Optimum flow rate for the determination of chloroform using Van Deemter equation
4. Quantitative analysis of a mixture of chloroform and carbon tetrachloride
5. Analysis of mixture of alcohols using HPLC
6. To study the quantitative assay of ampicillin injection powder by using HPLC

7. To analyze the mixture of two hydrocarbons (Toluene and Nitrobenzene) by HPLC
8. Analysis of Ibuprofen/Paracetamol (analgesics) in a commercial sample/tablet by HPLC
9. To develop and validate the analytical method of any one drug using HPLC
10. To determine the number of theoretical plates by HPLC using acetophenone as reference material
11. Quantitative analysis of aspirin, phenacetin and caffeine in a mixture by using HPLC.

UNIT V: TG/DTA/DSC

1. Determination of the purity of pharmaceuticals samples
2. Thermal decomposition of calcium oxalate monohydrate
3. Thermal decomposition of copper sulphate pentahydrate
4. Thermal decomposition of nickel oxalate dihydrate
5. Determination of calcium and magnesium in dolomite
6. Glass transition temperature of polymers (polymer to be used in preparation of membranesensor)
7. Determination of water of crystallization in coordination compounds/ inorganic salts Studies on thermal decomposition of Zinc NTA salt
8. DSC study on pharmaceutical product
9. Determination of calcium sulphate dihydrate in cement
10. Determining the purity of pharmaceutical drug: Phenacitin

UNIT VI: Atomic Absorption Spectroscopy

1. Analysis of Na, K and Ca in water samples
2. Analysis of metal ion from soil /ore
3. Analysis of metal ion from alloys: Fe and Cr from steel
4. Analysis of total metals in soil sample: Zn and Cu
5. Determination of metals in food products
6. Determination of K in fertilizers
7. Analysis of Lead and cadmium in toys

REFERENCE BOOKS:

1. Vogel, A. I., & Jeffery, G. H. (1989). Vogel's textbook of quantitative chemical analysis.
2. Kealey, D. (2013). *Experiments in modern analytical chemistry*. Springer.
3. Meloan, C. E. (1999). *Chemical separations: Principles, techniques, and experiments* (p. 155). Wiley.
4. Comprehensive Experimental Chemistry, V. K. Ahluwalia; New Age Publications

WEB REFERENCES:

1. Department of Polymer Science at the University of Southern Mississippi Web Site, the Macrogalleria; http://www.psrc.usm.edu/macrog/pvc.htm
2. Microscale analysis of patterning reactions via FTIR imaging: Application to intelligent hydrogel systems – ScienceDirect
3. Lab 14 (terrificscience.org)
4. 4.6 Determination of sodium, potassium, magnesium, and calcium in precipitation (nilu.no)

SEMESTER IV

Course Code: CHRE-504
Course Title: Synthesis of Inorganic Materials
Credit: 2
Maximum marks: 50
Duration: 30 Hours

Course Objectives:
The course will enable the student to:

1. Define key terms and concepts related to reactions employed in synthesis, ceramic procedures, precursor methods, and various synthesis techniques.
2. Explain the principles and underlying mechanisms of various synthesis methods.
3. Describe the advantages and limitations of different synthesis techniques.
4. Apply the knowledge of synthesis methods to design and conduct experiments in the laboratory.

Course Outcome:
Upon successful completion of this course, the students will be able to:
CO1: Recall key reactions involved in synthesis methods for ceramic materials.
CO2: List the different precursor methods for material synthesis.
CO3: Identify the principles and processes of combustion synthesis.
CO4: Explain the concept of intercalation chemistry and its significance in material synthesis.
CO5: Analyze the advantages and limitations of various synthesis methods in the context of material properties and applications.

UNIT I: Methods of Synthesis – I **15 Hours**
Introduction, reactions employed in synthesis, ceramic procedures, precursor methods, combustion synthesis, Intercalation chemistry, sol-gel synthesis, ion exchange method, co-precipitation.

UNIT II: Methods of Synthesis – II **15 Hours**
Electrochemical methods; nebulized spray pyrolysis; arc and skull methods; Reactions at high pressures; intergrowth structures; Metal borides, carbides, and nitrides; metal fluorides; metal silicides, phosphides, sulfides, and related materials.

TEXTBOOK:

1. Abbott, E. H., & Rao, C. N. R. (1995). Chemical Approaches to the Synthesis of Inorganic Materials.
2. Rao, C. N. R., & Biswas, K. (2015). *Essentials of inorganic materials synthesis*. John Wiley & Sons.

REFERENCE BOOKS:

1. Schubert, U. S., & Hüsing, N. (2019). Synthesis of inorganic materials. John Wiley & Sons.
2. Lalena, J. N., Cleary, D. A., Carpenter, E., & Dean, N. F. (2008). Inorganic materials synthesis and fabrication. John Wiley & Sons.
3. Van der Put, P. J. (1998). The inorganic chemistry of materials: How to make things out of elements. Springer Science & Business Media.
4. Sambandan, E. (2008). *Inorganic Materials Chemistry: General Concept and Research Topics*. iUniverse.

WEB REFERENCES

1. https://link.springer.com/chapter/10.1007/978-1-4899-0095-1_8
2. https://pubs.acs.org/doi/10.1021/jacs.1c04888
3. https://www.nature.com/articles/s41597-022-01317-2
4. https://www.mdpi.com/1420-3049/27/7/2045
5. https://par.nsf.gov/servlets/purl/10040699

Course Code: CHRE-505
Course Title: Catalysis
Credit: 2
Maximum Marks: 50
Duration: 30 hours

Course Objectives:

The course will enable the student to

1. Define the general principles of catalysis.
2. Explain the thermodynamic considerations related to catalysis.
3. Identify various types of solid catalysts.
4. Compare and contrast monolayer and multilayer adsorption processes.
5. Apply knowledge of thermodynamics to assess the feasibility of catalytic reactions.
6. Analyse the kinetic mechanisms of catalytic reactions, including rate-determining steps and rate expressions.

Course Outcomes:

On successful completion of the course, the student will be able to

CO1: Explain the general principles of shape-selective catalysis and its application in zeolites.
CO2: Demonstrate an understanding of the thermodynamic considerations in catalytic reactions.
CO3: Describe the various types of solid catalysts.
CO4: Understand the properties and applications of clays in catalysis, including intercalation and pillared clays and identify catalyst deactivation mechanisms.
CO5: Compare and contrast different types of adsorptions, including monolayer adsorption and multilayer adsorption.
CO6: Evaluate the role of surface area and catalyst texture in catalytic reactions.

UNIT I: Fundamentals in catalysis **15 Hours**

Catalysis - general principle, thermodynamic considerations, types of solid catalysts, catalyst deactivation, types of adsorptions - monolayer adsorption, monolayer adsorption on homogeneous and heterogeneous surface; multilayer adsorption- polyani's theory of adsorption: adsorption on porous solids, catalyst texture, surface area - volumetric method, gravimetric method, flow method; pore size distribution- pore size from adsorption, mercury porosity meter, chemisorption - chemisorption of hydrogen, O_2, N_2 and CO, unsaturated hydrocarbons, chemisorption bond- covalent bond, ionic bond, quantum mechanical approach participation of d electrons.

UNIT II: Reaction kinetics and role of Catalyst **15 Hours**

Reaction kinetics- the rate determining step, rate expressions, geometric factor in catalysis balandin's multiplet theory, electronic effect in catalysis by metals, band theory, pauling's valence bond method, electronic structure and catalysis. catalysis by semiconductors; boundary layer theory of chemisorption, catalysis by acidic solids, zeolites – structure, zeolite pores, synthesis, acidity of

zeolites, shape selective catalysis, zeolite based processes, aluminophosphate molecular sieves, clays-intercalation of clays, pillared clays, catalysis with clays, mesoporous materials, preparation of catalysts precipitation method, impregnation method, role of support, loading of the support, microporous solids- mesoporous solids role of diffusion.

TEXTBOOK:

1. D. K. Chakrabarty & B. Viswanathan, Heterogeneous Catalysis, New Age International Publishers, 2008.

REFERENCES:

1. G. A. Somorjai, *Introduction to Surface Chemistry and Catalysis*, John Wiley, 2002
2. M. Thomas & W. J. Thomas, Principles and Practice of *Heterogeneous Catalysis*, VCH Publishers, 1996.
3. Bhatnagar, M. S. (2004). *A Textbook of Polymer Chemistry*. S. Chand Publishing.
4. Shelef, M., & Otto, K. (1971). *The theory of adsorption and catalysis*: By Alfred Clark, Academic Press, New York

WEB REFERENCES:

1. https://www.britannica.com/science/catalysis/Classification-of-catalysts
2. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/14%3A_Chemical_Kinetics/14.07%3A_Catalysis
3. https://www.sciencedirect.com/topics/engineering/catalyst-preparation
4. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Principles_of_Modern_Chemistry_(Oxtoby_et_al.)/Unit_5%3A_Rates_of_Chemical_and_Physical_Processes/18%3A_Chemical_Kinetics/18.7%3A_Kinetics_of_Catalysis
5. https://www.britannica.com/science/silicate-mineral
6. https://www.explainthatstuff.com/zeolites.html

Course Code: CHRE-506
Course Title: Applied organic chemistry
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objective:

The course will enable the student to

1. Recall and define key terms related to retrosynthesis, such as synthons, synthetic equivalents, and disconnection approach.
2. Comprehend the principles of retrosynthetic analysis, including how to perform one-group and two-group C-X disconnections for aromatic compounds.
3. Understand important strategies for amine and alkene synthesis.
4. Develop synthetic routes for complex molecules using retrosynthetic principles, including the selection of appropriate protecting groups and chiral reagents.

Course Outcome:

By the end of this course students will be able to, the student will be able to

CO1: Recall the fundamental principles of retrosynthesis, including the concept of synthons and synthetic equivalents.

CO2: Understand the disconnection approach in retrosynthetic analysis and its application in the synthesis of aromatic compounds, amines, and alkenes.
CO3: Apply important strategies of retrosynthesis for the synthesis of various functional groups and their interconversions.
CO4: Analyze protection and deprotection methods for hydroxyl, carbonyl, and amino groups, as well as chemo and regioselective protection techniques.
CO5: Evaluate the use of common protecting groups in peptide synthesis and methods for determining enantiomeric and diastereomeric excess in cyclic compounds.

UNIT I: Retrosynthetic Analysis and Protecting Group 15 hours

Basic Principles and Terminology of retrosynthesis: Introduction to synthons and synthetic equivalents, disconnection approach, synthesis of aromatic compounds- one group and two group C-X disconnections, Amine and alkene synthesis- important strategies of retrosynthesis, functional group interconversions, functional equivalents and reactivity-Umpolung reaction, Protection and deprotection of hydroxyl, carbonyl and amino groups, Chemo and regioselective protection and deprotection, common protecting groups used in Peptide synthesis.

UNIT II: Asymmetric Synthesis 15 hours

Introduction, enantiomeric and diastereomeric excess- determination, distereoselectivity and enatio-selectivity in cyclic compounds, Cram's rule, Felkin Anh Model, Cram chelate model, stereoselective aldol reaction, asymmetric induction- use of chiral auxiliaries, Chiral reagents and catalysts, asymmetric hydrogenation, epoxidation and dihydroxylation.

TEXTBOOK:

1. Organic Chemistry, Jonathan Clayden, Nick Greeves and Stuart Warren

REFERENCES:

1. R.O.C Norman and J.M Coxon, Principles of organic synthesis, 3rd ed. Blackie Academic & Professional, 1993.
2. J. March, Advanced organic Chemistry: Reaction Mechanism and Structure, 5th ed, New York: John Wiley, 1999.
3. M.B. Smith, Organic Synthesis, McGraw Hill international Edn, 1994.
4. S. Warren, Organic Synthesis, The disconnection approach, John Wiley & Sons, 2004
5. P. Wyatt and S. Warren, Organic synthesis strategy and control, Wiley, 2008

WEB REFERENCES

1. https://www.khanacademy.org/science/class-11-chemistry-india/xfbb6cb8fc2bd00c8:in-in-organic-chemistry-some-basic-principles-and-techniques
2. https://themasterchemistry.com/fundamental-principles-of-organic-chemistry/
3. https://leah4sci.com/organic-chemistry-retrosynthesis/
4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/13%3A_Polyfunctional_Compounds_Alkadienes_and_Approaches_to_Organic_Synthesis/13.10%3A_Protecting_Groups_in_Organic_Synthesis
5. https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/asymmetric-synthesis
6. https://www.britannica.com/science/asymmetric-synthesis

Course Code: CHRE-507
Course Title: Nanomaterials
Credit: 2
Maximum marks: 50
Duration: 30 Hours

Course Objective

The course will enable the student to

1. List and describe the four generations of Nanoproduct development.
2. Explain the concept of Phase transition in nanomaterials.
3. Describe the various manufacturing processes for integrating nanoparticles into nanoproducts.
4. Apply knowledge of magnetization processes in nanoparticles and their role in nanomaterial properties.
5. Demonstrate an understanding of the self-assembly of nanomaterials at macroscopic scales and fabrication techniques.
6. Analyze the various applications of nanoparticles in different fields.
7. Examine the nature of nanoparticles in the environment, including exposure, effects, and risk assessment.

Course Outcome:

By the end of this course students will be able to

CO1: Memorize the fundamental properties and four generations of nanoproduct development.

CO2: Recall the basic principles of magnetization processes in nanoparticles.

CO3: Understand the concept of nanocomposites and their applications.

CO4: Apply knowledge of nanoparticle properties to predict their behaviour in various applications.

CO5: Analyze the phase transition of nanoparticles and its implications.

CO6: Assess the sources and sinks of atmospheric nanoparticles.

CO7: Comprehend the factors affecting the toxicology of nanomaterials.

CO8: Critically analyze the methods for making nanostructures using top-down techniques.

UNIT- I: Nanoscale Materials **15 Hours**

Introduction, Properties; Fundamental importance of size and its influence; Nanoparticles in the Atmosphere and Space, Phase transition, Manufacturing Processes: four generations of Nanoproduct development; integrating nanoparticles into nanoproducts, Types of nanomaterials Titanium dioxide, Zero-valent iron, carbon nanostructures- carbon black, carbon nanotubes, carbon nano-horns, fullerenes; composites and nanocomposites

Magnetism in Nanoparticles-Magnetisation Processes in Nanoparticles, Self-Assembly of Nanomaterials at Macroscopic Scales- Fabrication of Nanomaterials ,2D and 3D Nanomaterial Structures. Making Nanostructures Using Top-Down Methods, Applications of nanoparticles.

UNIT II: Environmental Fate and Transport of Nanomaterials **15 Hours**

Nature of nanoparticles in the environment-Exposure, Effects and Risk, Predicting the behavior of Nanomaterials, Treatment of Nanoparticles in wastewater- Treatment Processes, Factors that affect the toxicology of Nanomaterials- Exposure and effects, Nanoparticles use in Pollution control, Atmospheric Nanoparticles-Sources and sinks; Health effects; New Particle formation and growth in the atmosphere, Measurement of Aerosol nanoparticles.

TEXTBOOK:
Nanotechnology and the Environment, Kathleen Sellers, Christopher Mackay, Lynn L. Bergeson, Stephen R. Clough, Marilyn Hoyt, Julie Chen, Kim Henry, Jane Hamblen, First Indian Reprint, 2012

REFERENCE BOOKS:
1. Introduction to Nanoscience and Nanotechnology, Chris Binns, John Wiley & Sons, 2010
2. Nanomaterials and Nanochemistry, Catherine Bréchignac, Philippe Houdy, Marcel Lahmani.
3. Nanoparticles in Medicine and Environment, Jan C.M. Marijnissen, Leon Gradoǹ, European materials research society.

WEB REFERENCES
1. https://www.emm-nano.org/what-is-nanoscience-nanotechnology/
2. https://pubs.acs.org/doi/10.1021/acsnano.5b01418
3. https://www.worldscientific.com/worldscibooks/10.1142/7364#t=aboutBook
4. https://www.nanowerk.com/nanotechnology-and-the-environment.php
5. https://www.opengrowth.com/resources/how-does-nanotechnology-impact-the-environment

Course Code: CHAD-501
Course Title: Dissertation
Credit: 16
Maximum marks: 400
Duration: 384 Hours

The dissertation must comprise of original research and may be conducted either at the Institute or with approval, in an outside institution or company e. g., the student's employers. The guiding teacher may serve some laboratory hours for industry work.
The dissertation work is to be submitted for: evaluation and Viva Voice examination at the end of Semester IV.
Written test must be conducted regarding the basic principles of techniques or instruments used with respect to the area of dissertation topic.
Students may be assessed based on designing the question bank by students on dissertation topic.

Course Code: CHAI-501
Course Title: Internship
Credit: 16
Maximum marks: 400
Duration: 192 Hours

MODULE A: Internship at Industry; Two weeks per Semester (Semester III and IV) **144 Hours**
MODULE B: Write up of the Internship work per Semester (Semester III and IV) **16 Hours**
MODULE C: Students to design four modules based on their experience at industry **32 Hours**

****