K. C. E. Society's
Moolji Jaitha College
An 'Autonomous College' Affiliated to
K.B.C. North Maharashtra University, Jalgaon.
NAAC Reaccredited Grade - A (CGPA : 3.15 - 3rd Cycle)
UGC honoured "College of Excellence" (2014-2019)
DST(FIST) Assisted College

KNOWLEDGE IS POWER
ESTD. 1945

के. सी. ई. सोसायटीचे
मूळजी जेठा महाविद्यालय
क.ब.चौ. उत्तर महाराष्ट्र विद्यापीठ, जळगाव संलग्नित
'स्वायत्त महाविद्यालय'
नॅकद्वारा पुनर्मानांकित श्रेणी – 'ए' (सी.जी.पी.ए. : ३.१५ – तिसरी फेरी)
विद्यापीठ अनुदान आयोगाद्वारा घोषित 'कॉलेज ऑफ एक्सलन्स' (२०१४-२०१९)
डी.एस.टी. (फीस्ट) अंतर्गत अर्थसहाय्य प्राप्त

Date :- 01/08/2024

NOTIFICATION

Sub :- CBCS Syllabi of M. Sc. in Analytical Chemistry (Sem. III & IV)

Ref. :- Decision of the Academic Council at its meeting held on 27/07/2024.

The Syllabi of M. Sc. in Analytical Chemistry (Third and Fourth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2024-25.

Copy of the Syllabi Shall be downloaded from the College Website (www.kcesmjcollege.in)

Sd/-
Chairman,
Board of Studies

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The office of the COE, M. J. College, Jalgaon.
3) The office of the Registrar, M. J. College, Jalgaon.

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समर्थ कॉलनी जवळ, जळगांव – ४२५ ००२. (महाराष्ट्र, भारत) । दूरध्वनी क्र. : +९१ २५७–२२३७३६३, २२३४२८१ । ई–मेलः mjcollege@kces.in । वेबसाईटः mjcollege.kces.in

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College"

Affiliated to KBC North Maharashtra University, Jalgaon

SYLLABUS

M.Sc. II Analytical Chemistry

Under Choice Based Credit System (CBCS)

And

as per NEP-2020 Guidelines

[w.e.f. AcademicYear:2024-25]

Preface

The curriculum is designed to impart the basic and applied knowledge of the subject to the students. One of the major objectives considered during designing is to make technically educated human resource. Basic analytical chemistry, modern separation science, pharmaceutical analysis, bio and food analysis, environmental analysis may help to find out unseen facts in various environmental, pharmaceutical, food and drug sectors. The courses like instrumental methods of analysis, spectroscopic methods, and special methods of analysis are designed to impart theoretical and practical knowledge of modern scientific advances in the field. Further to enhance skillful human resource with precision, instrumental practical courses are included. Practical courses are based on theory courses and are designed to improve research oriented skills of students.

Program Outcomes (PO) for M.Sc. Program:

Program outcomes associated with an MSc degree are as follows:

1. Student possess an in-depth understanding of advanced theories, concepts, and methodologies in their specific field of study.
2. Student should demonstrate advanced technical skills and proficiency in utilizing specialized equipment, software, and methodologies relevant to their field of study.
3. Student should be capable of critically analyzing complex problems and synthesizing information from various sources.
4. Student should be proficient in effectively communicating scientific information to both technical and non-technical audiences. They should be able to present their experimental findings through oral presentations, scientific writing, and the use of appropriate visual aids.
5. Student should demonstrate leadership qualities and the ability to work effectively as part of a team.
6. Student should have developed advanced research skills and the ability to independently design and conduct rigorous scientific investigations. They should be able to analyze scientific literature, formulate research questions, develop research plans, collect and analyze data, draw valid conclusions and know about IPR.
7. Student should understand and adhere to ethical principles and professional standards in their field.
8. Student should recognize the importance of continuous learning and professional development. They should have the skills and motivation to stay updated with advancements in their field, engage in lifelong learning, and pursue further academic or professional opportunities.

Program Specific Outcome PSO (M.Sc. Analytical Chemistry):

After completion of this course, students are expected to learn/understand:

No.	PSO
1.	To prepare students to develop interpersonal skills, relating to the ability to interact with other people and to engage in team working. To stimulate intellectual development, develop powers of critical analysis and ability to solve problems.
2.	To equip students with the knowledge and generic skills for employment or further training in R&D, science based industry and establishments, education and for training at management levels in other professions.
3.	To understand the instrumental method of analysis like AAS, FES, GC, HPLC, TGA, DTA etc. To introduce students to chemical research methodology through carrying out a research project.
4.	To understand the official method of standardization and quality control. To understand the data handling and knowing accuracy, precision, Standard deviation and regression etc.
5.	To understand and perform analysis of drug cosmetics and food in laboratory. To understand analysis of petroleum product like polymer and plastic. The programme aims to provide a broad and in depth understanding of ideas central to chemistry.
6.	Understanding application of various volumetric and gravimetric analysis in the various field like agriculture and pharmaceutical.

Credit distribution structure for two years/one-year PG MSc programme

Level	Sem	Major (Core) Subjects		Minor Subjects	OJT/Int, RP	Cumulative Credits/Sem	Degree/ Cumulative Cr.
		Mandatory (DSC)	Elective (DSE)				
6.0	I	DSC-1 (4T) DSC-2 (4T) DSC-3 (4T) DSC-4 (2P)	DSE-1(2T) A/B DSE-2(2P) A/B	RM (4T)		22	First-year PG OR One year PG diploma after 3 years UG
	II	DSC-5 (4T) DSC-6 (4T) DSC-7 (4T) DSC-8 (2P)	DSE-3(2T) A/B DSE-4(2P) A/B		OJT/Int (4)	22	
	Cum. Cr.	28	8	4	4	44	
	Exit option: PG diploma (44 Credits) after three-year UG degree						
6.5	III	DSC-9 (4T) DSC-10 (4T) DSC-11 (4T) DSC-12 (2P)	DSE-5(2T) A/B DSE-6(2P) A/B	--	RP (4)	22	Second-year PG after 3 years UG OR PG degree after 4 years UG
	IV	DSC-13 (4T) DSC-14 (4T) DSC-15 (2P) DSC-16 (2P)	DSE-7(2T) A/B DSE-8 (2P) A/B	...	RP (6)	22	
	Cum. Cr.	54	16		4+10	88	
2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree							

Sem- Semester, **DSC**- Department Specific Course, **DSE**- Department Specific Elective, **T**- Theory, **P**- Practical, **RM**- Research Methodology, **OJT**- On Job Training, **Int**- Internship, **RP**- Research Project, **Cum. Cr.** : Cumulative Credits

Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured;

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
6.0	One-year PG Diploma program after 3 Yr Degree	40	44	2	1
6.5	Two-year master's Degree program After 3-Yr UG Or PG Degree after 4- Yr UG	80	88	4	2

Examination Pattern for M.Sc.

Theory Question Paper Pattern:

- 60 (External) +40 (Internal) for 4 credits
  - External examination will be of three hours duration
  - There shall be 5 questions, each carrying equal marks (12 marks each), while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 3 out of 4 sub-questions; each 4 marks
  - Q 2, Q3, Q4 and Q5 Attempt any 2 out of 3 sub-question; each 6 marks.
- 30 (External) +20 (Internal) for 2 credits
  - External examination will be of 1½ hours duration
  - There shall be 3 questions Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
  - Q 2 and Q3 Attempt any 2 out of 3 sub-question; each 6 marks.

Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

1. Continuous & Comprehensive Evaluation (CCE): CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the subject teacher should choose any three assessment methods from the following list, with each method carrying 10/5 marks:

i. Individual Assignments
ii. Seminars/Classroom Presentations/Quizzes
iii. Group Discussions/Class Discussion/Group Assignments
iv. Case studies/Case lets
v. Participatory & Industry-Integrated Learning/Field visits
vi. Practical activities/Problem Solving Exercises
vii. Participation in Seminars/Academic Events/Symposia, etc.
viii. Mini Projects/Capstone Projects
ix. Book review/Article review/Article preparation
x. Any other academic activity
xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

2. Internal Assessment Tests (IAT): IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course. IAT shall be conducted at the end of the semester and will assess the remaining unit of the syllabus that was not covered by the CCEs. The subject teacher can decide which units will be assessed using CCEs and which unit will be assessed based on IAT.

The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.

The subject teachers must communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

Practical Examination Credit 2: Pattern (30+20)

External Practical Examination (30 marks):

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours and shall be conducted as scheduled.
- There shall be 05 marks for journal and viva voce. A certified journal is compulsory to appear for practical examination.
- The practical examination will be of a minimum of 3 hours duration and shall be conducted as per schedule for 2 consecutive days in case of practical where incubation conditions and allied aspects are essential.

Internal Practical Examination (20 marks):

- Internal practical examination of 10 marks will be conducted by the department as per the schedule given.
- For internal practical examination, students must produce the laboratory journal of practicals completed along with the completion certificate signed by the concerned teacher and department head.
- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment can include quizzes, group discussions, presentations and other activities the faculty assigns during regular practicals. For details, refer to internal theory examination guidelines.
- Finally, 40 (10+30) students' performance will be converted into 20 marks.

M.Sc. Analytical Chemistry Course Structure

Semester	Course Module	Credit	Hours/ Week	TH/ PR	Code	Title
I	DSC	4	4	TH	CHA-DSC-511	Advanced Physical Chemistry
	DSC	4	4	TH	CHA-DSC-512	Modern Inorganic Chemistry
	DSC	4	4	TH	CHA-DSC-513	Principles of Organic Chemistry
	DSE	2	2	TH	CHA-DSE-514 (A)	Laboratory Planning and Safety
	DSE	2	2	TH	CHA-DSE-514 (B)	Thermal and Electro Analytical Methods
	DSC	2	4	PR	CHA-DSC-515	Systematic Experimental Physical Chemistry
	DSE	2	4	PR	CHA-DSE-516 (A)	Systematic Experimental Inorganic Chemistry
	DSE	2	4	PR	CHA-DSE-516 (B)	Organic Compound Preparations
	DSC	4	4	TH	CHA-RM-517	Research Methodology for Chemistry
II	DSC	4	4	TH	CHA-DSC-521	Quantum Chemistry and Molecular Spectroscopy
	DSC	4	4	TH	CHA-DSC-522	Applied Inorganic Chemistry
	DSC	4	4	TH	CHA-DSC-523	Organic Reactions and Spectroscopy
	DSE	2	2	TH	CHA-DSE-524 (A)	Symmetry and Group Theory
	DSE	2	2	TH	CHA-DSE-524 (B)	Applications of Nanotechnology
	DSC	2	4	PR	CHA-DSC-525	Advanced Analytical Chemistry Practicals
	DSE	2	4	PR	CHA-DSE-526 (A)	Applied Organic Chemistry Practicals
	DSE	2	4	PR	CHA-DSE-526 (B)	Practicals in Applied Inorganic Chemistry
	DSC	4	8	OJT	CHA-OJT-527	Intership/On Job Trainning
III	DSC	4	4	TH	CHA-DSC-611	Concepts of analytical chemistry
	DSC	4	4	TH	CHA-DSC-612	Modern separation sciences
	DSC	4	4	TH	CHA-DSC-613	Bio – analysis and analysis of foods
	DSE	2	2	TH	CHA-DSE-614 (A)	Instrumental methods of analysis
	DSE	2	2	TH	CHA-DSE-614 (B)	Pharmaceutical analysis
	DSC	2	4	PR	CHA-DSC-615	Classical Methods of Analysis
	DSE	2	4	PR	CHA-DSE-616 (A)	Non Destructive Methods of Analysis
	DSE	2	4	PR	CHA-DSE-616 (B)	Techniques for Quantitative Analysis
	DSC	4	8	RP	CHA-RP-617	Research Project-I
IV	DSC	4	4	TH	CHA-DSC-621	Spectroscopic methods of Analysis
	DSC	4	4	TH	CHA-DSC-622	Special Analytical Methods
	DSE	2	2	TH	CHA-DSE-623 (A)	Essentials in Nanoscience
	DSE	2	2	TH	CHA-DSE-623 (B)	Environmental Analytical Chemistry
	DSC	2	4	PR	CHA-DSC-624	Chemical Methods of Analysis
	DSC	2	4	PR	CHA-DSC-625	Non Instrumental Analytical Techniques
	DSE	2	4	PR	CHA-DSE-626 (A)	Modern Analytical Techniques
	DSE	2	4	PR	CHA-DSE-626 (B)	Environmental Analytical Techniques
	DSC	6	12	RP	CHA-RP-627	Research Project-II

DSC : Department-Specific Core course DSE : Department-Specific elective
TH : Theory PR : Practical
RP : Research project

M.Sc. II (Analytical Chemistry)

Semester III

M.Sc. II (Chemistry)

Semester III

CHA-DSC-611: Concepts of analytical chemistry

Total Hours: 60 **Credits: 4**

Course objectives	• To understand Statistical analysis and method validation tests. • To learn about good laboratory practices. • To impart knowledge about intellectual property rights.	
Course outcomes	After successful completion of this course, students are expected • To learn about research methods. • To know about intellectual property rights. • To acquire skill and accuracy in data handling.	
Unit	**Contents**	**Hours**
Unit I	**Statistical analysis and validation** Errors in chemical analysis, Classification of errors systematic and random, additive and proportional, Absolute and relative, Accuracy and Precision, Mean, Median, Average deviation and Standard deviation, Significant figures and rules to determine significant figures, Calculations involving Significant figures. Confidence limit, Correlation coefficient and regression analysis, Comparison of methods: f-test and t-test, Rejection of data based on q-test, Validation of newly developed analytical method.	**18**
Unit II	**Good Laboratory Practice: Quality Assurance of Analytical Measurements** Introduction to analytical chemistry, Types of analysis-qualitative and quantitativem, Good Laboratory Practice, Validation of analytical methods, Quality assurance, Laboratory accreditation, Electronic records and electronic signatures: 21 CFR, part 11, Official organization.	**12**
Unit III	**Introduction to Intellectual Property Rights** Intellectual property rights, Copyright, Patents, Trademarks, Design, Plant varieties, Geographical indication, Layout design of integrated circuits, Trade secrets, Abuse of intellectual property, Tie-in arrangement, Exclusive supply agreement, Exclusive distribution agreement, World intellectual property organization, Activities of wipo, Plagiarism.	**15**
Unit IV	**Introduction to Patent** Rationale of patent system, History of patent law, Patent act 1970, meaning of patent, Invention, new or novel, Inventive step, Industrial application, Product patent and process patent, patentee, Invention contrary to public order or morality, Concurrent patent.	**15**
Study Resources	• Christian G. D. (2003), Analytical Chemistry, John Wiley & Sons Pvt Ltd, 6th edition. • Braun R. D. (2016), Introduction to Instrumental Analysis, Pharmamed press, 2nd edition. • Ahuja V. K. (2018), Law relating to Intellectual Property Rights, Lexis Nexis, 2nd edition.	

M.Sc. II (Chemistry)
Semester III
CHA-DSC-612: Modern separation sciences

Total Hours: 60 **Credits: 4**

Course objectives	• To understand general principles and terminologies in chromatography. • To know the techniques of Gas Chromatography. • To get the knowledge of High Performance Liquid Chromatography. • To know the Ion Exchange Chromatography.	
Course outcomes	After successful completion of this course, students are expected • To understand general principles and terminologies in chromatography. • To get the knowledge of Gas Chromatography. • To be familiar with the High Performance Liquid Chromatography. • To get the knowledge of Ion Exchange Chromatography.	
Unit	**Contents**	**Hours**
Unit I	**General principles and terminologies in Chromatography** Definition and terminology of chromatography, General principles of Chromatography, Distribution constant (Kc), Types of Chromatographic separations based on mobile phase and stationary phase, Theoretical Principles underlying Chromatographic techniques, Theories of Chromatography:Plate Theory and Rate Theory, Behavior of solutes, Column efficiency and band broadening, Resolution, Qualitative & quantitative analysis, Numerical Problems**.**	**15**
Unit II	**Gas Chromatography** Introduction, Principle, Instrumentation: Carrier gas, Sample injection system, Columns, Optimization of experimental condition, Retention time and retention volume. Detectors:Characteristics of the Ideal Detector, Flame Ionization Detectors (FID), Thermionic detector, Flame Photometric Detector (FPD), Electrolytic Conductivity Detector (ELCD)/ Hall Detector/ Coulson Conductivity Detector, Thermal Conductivity Detectors (TCD), Electron Capture detector (ECD), Qualitative & quantitative analysis, Applications.	**15**
Unit III	**High Performance Liquid Chromatography** Introduction, GC and HPLC, Instrumentation, Refractive index detector, Luminescence detector, Ultraviolet detector and electrochemical detector, Quantitative analysis and data display, Derivatisation technique in HPLC, Chiral columns, C8 and C18 columns, Applications.	**15**
Unit IV	**Ion Exchange Chromatography** Definition, Principle, Cation Exchangers, Anion Exchangers, Regeneration, Ion Exchange Column Used in Chromatographic Separations, Selection of suitable systems, Ion exchange capacity, Ion Exchange Techniques, Applications of Ion exchangers	**15**

Study Resources	● Douglas A. Skoog, F. James Holler, Stanley R. Crouch, (2016), Principle of instrumentation Analysis, Cengage Learning, 6th edition. ● Willard H. H., Merrit L. L., Dean J. D., Settle S. A., (1984), Instrumental Methods of Chemical Analysis, 6th Ed, CBS publishers. ● Braun R. D., (2016), Introduction to Instrumental Analysis, Pharmamed press, 2nd edition. ● Singh Mahinder., (1993), Analytical Chemistry Instrumental techniques. Dominant publishers. ● Sastri M. N., (2006), Separation Methods, Himalaya Publication house 2nd edition. ● Christian G. D., (2003), Analytical chemistry, John Wiley and sons Pvt Ltd 6th edition. ● Chatwal G, R. and Anand S. K., (2019), Instrumental Methods of Chemical Analysis, Himalaya publishing house 5th edition. ● Chan C. C., Lam H. and Zhang Zhang X. M., (2004), Analytical method validation and instrument performance verification, Wiley India pvt ltd.	

M.Sc. II (Chemistry)

Semester III

CHA-DSC-613: Bio – analysis and analysis of foods

Total Hours: 60 **Credits: 4**

Course objectives	● To understand the nutritional value of food products. ● To know about food analysis methods. ● To learn about forensic lab analysis methods	
Course outcomes	After successful completion of this course, students are expected ● To know biological value of food. ● To be able to understand forensic lab analysis techniques. ● To be able to check food adulteration and do food analysis.	
Unit	**Contents**	**Hours**
Unit I	**Biological Value of Food and Food Analysis** Human nutrition, Biological value of food, Estimation of carbohydrates, Fats, Proteins, Amino Acids. Analysis of food: Milk, Cereals, Flour, Spices, Flavors and Condiments, Honey, Jam and Jelly, Non alcoholic beverages (Tea and Coffee).	**15**
Unit II	**Determination of food preservatives** Fluorides, Oxidizing agent- Peroxide, Organic Preservative, Formaldehyde, Formic acid , Ether extractive preservative, Separation of organic preservative and sweetening agents, Volatile fatty acid in bakery product, 2-Aminopyridine in orange.	**15**
Unit III	**Collection of Specimens and Analysis of Blood and urine** Blood: Collection of Blood specimens, Storage and preservation, Urine: Collection of Urine, Physical characteristics of urea, Preservation and Storage. Determination of blood and plasma glucose by glucose oxidase method, Determination of urine for glucose, Determination of ketone bodies in blood, Oral Glucose tolerance test. Determination of blood hemoglobin, Determination of urea in urine by urease method and by direct colorimetry, Estimation of Na, K, Ca by flame photometry, Inorganic phosphate by colorimetry.	**15**
Unit IV	**Forensic Analysis** Introduction, Forensic examination of biological fluids, Stains, Semen, Hair and other materials. **Forensic Toxicology**: Isolation, Identification and determination of following 1) Narcotics- heroin and cocaine. 2) Stimulants- caffeine, amphetamines. 3) Depressants- Barbiturates, Benzodiazepines.	**15**
Study Resources	● Lenhinger, Biochemistry (1997 edition), W. H. Freeman and company ● Homes D. J. and Peck H. (1983), Analytical Biochemistry, Prentice Hall ● Jacobs Morris B. (1978), The chemical analysis of food and food products, 3rd edition. ● Association of official's analytical chemists (AOAC) (1980).	

	13th edition. • Varley Harold. (2005), Practical Clinical Biochemistry- 4th edition • Joshi V. D. & Varad M. R. (1997),Forensic pharmacy and ethics • Dubey R. C. (1993), A Text book of Biotechnology. S. Chand .	

M.Sc. II (Chemistry)
Semester III
CHA-DSE-614(A): Instrumental methods of analysis

Total Hours: 30 **Credits: 2**

Course objectives	● To gain knowledge of the electroanalytical methods. ● To understand the working principle of instrumental analysis methods.	
Course outcomes	After successful completion of this course, students are expected ● To understand various methods of volumetric and titrimetric analysis. ● To be able to understand the instrumental parts of various analysers.	
Unit	**Contents**	**Hours**
Unit I	**Polarography** Introduction, Principle, Instrumentation, Working, Brief description of polarographic measurements, Current-voltage relationship, Polarograms, Equation for the polarographic waves, Half wave potential, Different kinds of currents contributing to polarographic waves, Polarographic cell, Ilkovic Equation.	**10**
Unit II	**Dropping Mercury Electrode** Dropping Mercury Electrode, Advantages of DME, Limitations of DME, Advantages and applications of polarography.	**5**
Unit III	**Electrogravimetric Analysis** Introduction, Polarisation, Causes of Polarisation, The EMF of polarisation, Measurement of Decomposition potential, Importance and significance of decomposition potential, Overvoltage, Electrochemical Overpotential, Importance of Overvoltage.	**8**
Unit IV	**Amperometric Titrations** Principal, Instrumentation, Cell used, Volume correction, Indicator electrodes, Reference Electrodes, Amperometric titrations, Advantages, Disadvantages and Applications of Amperometric titrations.	**7**

References:

- Willard H. H., Merrit L. L., Dean J. D., Settle S. A., (1984). Instrumental Methods of Chemical Analysis, 6th Ed, CBS publishers.
- Braun R. D. (2016). Introduction to Instrumental Analysis- Pharmamed press, 2nd edition.
- Singh Mahinder. (1993), Analytical Chemistry Instrumental Techniques, Dominant publishers.
- Chatwal G. & Anand S. (2019), Instrumental Methods of Chemical Analysis, Himalaya publications, 5th edition.
- Sharma B. K. (2007), Instrumental Methods of Chemical Analysis, Goel publishing house 28th edition.
- Grinberg Nelu, Rodriguez Sonia (2019). Ewing's Analytical Instrumentation handbook, 4th edition, CRC Press.

M.Sc. II (Chemistry)
Semester III
CHA-DSE-614(B): Pharmaceutical analysis

Total Hours: 30 **Credits: 2**

Course objectives	● To learn about pharmaceutical methods of analysis. ● To understand various methods of analysis of drugs, pharmaceuticals.	
Course outcomes	After successful completion of this course, students are expected ● To learn various tests for analysis of drugs. ● To understand analysis techniques using instrumental methods. ● To be able to understand the principle behind lab techniques of analysis.	
Unit	**Contents**	**Hours**
Unit I	**Introduction to pharmaceutical Analysis:** Role of FDA in Pharmaceutical Industries: Definitions of Drugs. Substandard Drugs, Introduction to New Drug, Development of New Drugs- Selection of Area, Phase I, Phase II and Phase III. Application to FDA for formulation and marketing for new drug. Stability studies and Self life fixation.	**8**
Unit II	**Biological Tests & Assay of Drugs** Introduction to biological assay, Biological assay of Heparin sodium, Determination of Amylase activity, Determination of Photolytic Activity, Test for Insulin in solution.	**6**
Unit III	**Official Methods of Standardization and Quality Control** Standardization of finished products and their characterisation, Official methods of Quality control, Dissolution Tests and Kinetics.	**6**
Unit IV	**Assay and Tests for Drugs** Analysis of compounds based on functional groups, Instrumental methods for analysis of drugs, Assays involving chromatographic separations, Proximate assays, Assays of enzyme containing substances, Biological and microbiological assays and tests. Limit tests, Solubility tests, Disintegration tests, Stability studies, Impurity profile of drugs, Bioequivalence and Bioavailability studies.	**10**

References:

- Homes & Peck.(1983). Analytical Biochemistry. Prentice Hall-3rd edition
- George Charalanbous, (1978), Analysis of food and beverages, Academic press
- Kenneth A. Connors, (2007), A Textbook of Pharmaceutical Analysis, Wiley, 3rd edition.

M.Sc. II (Chemistry)
Semester III
CHA-DSC-615: Classical Methods of Analysis

Total Hours: 60 **Credits:2**

Perform any 15 experiments out of the following.

Course Objectives	● To gain proficiency in Classical Methods such as gravimetry, complexometry, volumetric analysis etc. ● To understand the principles and techniques of analytical chemistry applied to alloys and ores. ● To develop skills in sample preparation and handling. ● To practice accurate measurement and data interpretation in analytical chemistry.	
Course Outcomes	After successful completion of this course, students are expected ● To analyze alloy and ore sample for metal content using classical methods of analysis. ● To understanding of the principles of stoichiometry and precipitation reactions in gravimetric analysis. ● To prepare samples, conducting titrations, and calculating results. ● To proficiency in preparing samples, running experiments, and analyzing the results.	
Sr. No.	**Contents (Any 15)**	**Hours**
1	Analysis of alloy or ore (**any one**) a. Analysis of Nichrome alloy:i)Cr by colorimetry ii) Ni by gravimetry. b. Analysis of Zinc blend ore i) Zn by complexometry ii)Fe by volumetry. c. Analysisof Calcite ore i) Ca by complexometry ii) Fe by colorimetry.	**4**
2	Determination of copper in fungicide.	**4**
3	Estimation of mixture of benzoic acid and salicylic acid in pharmaceutical preparation.	**4**
4	Estimation of lactose in milk by iodometry.	**4**
5	Molecular weight of polymer from viscosity measurement.	**4**
6	Separation of Amino acid by two dimensional (2D) chromatography.	**4**
7	Estimate the amount of aniline present in the given solution.	**4**
8	Estimation of aldehydes in lemon/cinnamon oil.	**4**
9	Determination of available chlorine in bleaching powder by Bunsen method.	**4**
10	Determination of total alkalinity of soda ash.	**4**
11	Determination of COD value of given sample of polluted water.	**4**
12	Gravimetric determination of chlorides.	**4**
13	Determination of total chlorine in pesticide formulation.	**4**
14	Analysis of commercial hypochlorite or peroxide solution by iodometric titration.	**4**
15	To determine the lead content of a solder alloy by titration with EDTA.	**4**

16	Estimation of a mixture of Hydrochloric acid and boric acid by acid base titration.	**4**
17	Gravimetric determination of Calcium as Calcium Oxalate.	**4**
18	Determination of iodate in iodized salt by redox titration.	**4**
19	Determination of the active ingredients in commercial anti-acid tablets.	**4**
20	Determination of Hydrogen Carbonate in Blood Using Back-Titration.	**4**

References:

- Pharmacopoeia of India, (2007), British & United States, 5th edition.
- Mahindru S. N. (2003), Hand Book of Food Analysis, Metropolitan book company pvt ltd.
- Homes & Peck, (1983), Analytical Biochemistry, Prentice Hall 3rd edition.
- Patel, Gadre & Turkhia, (1997), Post Graduate Chemistry Practical Part – I.
- De Anil. K.,(2011), Environmental Chemistry, Wiley Eastern Ltd. 3rd edition.
- Jahagirdar D.V. (2003), Experiments in Chemistry, Himalaya Publication.
- Gary D Christian, Purnendu K Dasgupta, Kevin A. Analytical Chemistry

M.Sc. II (Chemistry)
Semester III
CHA-DSE-616(A): Non Destructive Methods of Analysis

Hours: 60 **Credits:2**

Perform any 15 experiments out of the following.

Course Objectives	• To understand the principles and techniques of flame photometry for the determination of alkali metals (Na, K, Li) in samples. • To gain proficiency in colorimetric analysis for the quantification of specific compounds such as p-nitrophenol and phosphorus. • To learn the principles and procedures of pH metry titration and conductometric titration for the determination of acidic and basic substances. • To understand the principles of spectrophotometry and its application in quantitative analysis of copper, phosphate, and Fe^{3+} ions.	
Course Outcomes	After successful completion of this course, students are expected • To accurately determine the concentrations of Na, K, and Li in samples using flame photometry. • To perform colorimetric analysis to determine the concentration of p-nitrophenol in samples and phosphorus in milk powder. • To conduct pH metry titration to quantify the amount of aspirin in drug tablets and to determine the strength of acetic acid in vinegar. • To conduct spectrophotometric analysis to determine the concentrations of copper, phosphate, and Fe^{3+} ions in solution.	
Sr. No.	**Contents (Any 15)**	**Hours**
1	Determination of Na/K/L in given sample by Flame photometry method.	**4**
2	Determination of p-nitrophenol by colorimetry.	**4**
3	Construct the calibration curve (pH-E_{obs}) for quinhydrone electrode, and hence determine the standard oxidation potential of the quinhydrone electrode.	**4**
4	Determination of asprin in drug tablet by pHmetric titration with NaOH.	**4**
5	To find out the strength of sodium carbonate solution (Washing soda) by titrating against HCl pHmetrically.	**4**
6	To find out the dissociation constant of phosphoric acid by titrating with NaOH.	**4**
7	Determination of strength of acetic acid in vinegar by conductometry titration.	**4**
8	To estimate oxalic acid by carrying out suitable conductometric titration in the solution of oxalic acid and HCl.	**4**
9	Synthesis of inorganic/organic molecule and its IR analysis with interpretation.	**4**
10	To study the influence of solvent on the optical rotation of a solute.	**4**
11	To measure refractometrically average polarisability of some of the common	**4**

	solvents.	
12	Determination of phosphate in Detergents by UV-Visible spectrophtometer.	**4**
13	Estimation of copper Spectrophotometrically.	**4**
14	Determination of Fe^{3+} amount in the given sample by means of calibration diagram.	**4**
15	Determination of viscosity of ointment/syrup/oils (minimum 3 samples) using Brookfield viscometer.	**4**
16	Separation and identification of the monosaccharides present in the given mixture by paper chromatography.	**4**
17	Separation and identification of a mixture of dyes by TLC.	**4**
18	Spectrophotometric estimation of nickel.	**4**
19	Determine the pH of a buffer solution (with pH less than 8) using a quinhydrone electrode.	**4**
20	To determine concentration of given $K_2Cr_2O_7$ solution in 0.1 N NaOH solution.	**4**

References:

- Vogel A. I. (2012), A Text Book of Qualitative Inorganic Analysis, 3rd Edition, Pearson education India.
- Welcher F. J. (2006), Standard Methods of Chemical Analysis (A Series of Volumes), Krieger publishing.
- Kolthoff I. M. & Ewing P. J. (1963), Treatise on Analytical Chemistry (A Series of Volumes),Wiley Blackwell.
- Association of Official Analytical Chemistry (AOAC),13th Edition 1980.
- Willard H. H. & Merritt L. L. (1984), Instrumental Methods of Analysis 6th Edition, CBS publisher.

M.Sc. II (Chemistry)
Semester III
CHA-DSE-616(B): Techniques for Quantitative Analysis

Hours: 60 **Credits:2**

Perform any 15 experiments out of the following:

Course Objectives	● To understand the principles and techniques of potentiometric titration using a glass electrode for determining pKa values. ● To gain practical experience in verifying Ostwald's dilution law and determining dissociation constants. ● To learn the procedure for determining the formula of a silver ammonia complex using potentiometric methods. ● To understand the concept of critical micelle concentration (CMC) and its determination from conductivity measurements. ● To grasp the principles of Hammett constant determination and its application in pH measurements.	
Course Outcomes	After successful completion of this course, students are expected • To accurately determine the pKa values of phosphoric acid through potentiometric titration with sodium hydroxide. • To verify Ostwald's dilution law and determining dissociation constants of given substances. • To determine the formula of a silver ammonia complex using potentiometric methods. • To determine the critical micelle concentration of sodium lauryl sulfate from conductivity measurements. • To determine the Hammett constants of m- and p- amino benzoic acid/nitro benzoic acid through pH measurements.	
Sr. No.	**Contents (Any 15)**	**Hours**
1	To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.	**4**
2	To verify Ostwald's dilution law and to determine the dissociation constant.	**4**
3	To determine the formula of silver ammonia complex by potentiometric method.	**4**
4	To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.	**4**
5	To determine Hammette constant of m- and p- amino Benzoic acid/nitro Benzoic acid by pH measurement.	**4**
6	To determine the Michaelis – Menten's constant value (Km) of the enzyme Beta Amylase spectrophotometrically.	**4**
7	To determine the amount of Fe(II) and Fe(III) in a mixture using1,10-phenanthroline spectrophotometrically.	**4**
8	Simultaneous determination of Cr(VI) and Mn(VII) in a	**4**

	mixture spectrophotometrically.	
9	To determine the percentage composition of HCl and H_2SO_4 on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$.	**4**
10	To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.	**4**
11	Determination of Calcium by Atomic Absorption Spectrophotometry.	**4**
12	Analysis of Analgesics Using High-Performance Liquid Chromatography.	**4**
13	Fluorometric Determination of Riboflavin (Vitamin B2).	**4**
14	Determination of Silver in an Alloy: Volhard's Method.	**4**
15	Spectrophotometric determination of Inorganic Phosphorus in Serum.	**4**
16	Potentiometric Titration of a Mixture of Chloride and Iodide.	**4**
17	Gravimetric Determination of SO_3 in a Soluble Sulfate.	**4**
18	Determination of Antimony by Titration with Iodine.	**4**
19	Analysis of Commercial Hypochlorite or Peroxide Solution by Iodometric Titration.	**4**
20	Phenacetin, and Caffeine in APC Tablets Using Solvent Extraction.	**4**

References:

- Quantitative Chemical Analysis by Daniel C. Harris
- Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch
- Analytical Chemistry: Principles and Techniques by Robert A. Day and Underwood
- Instrumental Methods of Analysis by B. K. Sharma
- Analytical Chemistry by Gary D. Christian
- Chemical Analysis: Modern Instrumentation Methods and Techniques by Francis Rouessac and Annick Rouessac
- Practical Pharmaceutical Analytical Techniques by Md. Saiful Islam and Md. Saiful Islam Arman
- Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz, and James R. Vyvyan
- Practical Analytical Chemistry by A. B. C. Ltd

M.Sc. II (Chemistry)

Semester III

CHA-RP-617 Research Project- I

Hours: 120 **Credits: 4**

Course Objectives

1. To give exposure to the students to research culture and technology
2. To introduce students to how to select a research topic, plan, perform experiments, collect and analyze the data
3. To foster self-confidence and self-reliance in the students as they learn to work and think independently

Course outcomes

After successful completion of this course, students are expected to:

- Conceive a problem based on published research and conduct a comprehensive literature survey.
- Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.
- Learn handling of instruments, use of chemicals and how to conduct the experiments
- Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.

Credit distribution (1 credit for each unit)

- Identification of a research topic, formulation of research problem,objectives, sample size and hypothesis, etc
- Preparation of Outline
- Review of literature
- Bibliography

The systematic approach towards the execution of the project should be as follows: (Wherever applicable)

1. The complete tenure of the research project should be one year. It should be allotted during the third semester and completed in the fourth semester.
2. Weekly 8 hours should be allotted to the research project in a regular timetable.
3. In the third semester, students will be evaluated based on a credit distribution mentioned above.In the fourth semester,students should perform further research work, collect and analyze the data, compile the resultsand prepare and submit the final dissertation.
4. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.
5. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
6. Each research group should have a different research topic with some possible level of novelty.
7. The student should select the topic relevant to priority areas of concern or allied subjects with the guidance of supervisor/ head of the department.

8. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
9. At the beginning, students should submit the outline of the research work to be carried out in the project. (Writing in order: Title, Aim and objectives, Literature to be collected, Experimental plan or method design, expected outcome etc.)
10. Write and submit a Literature Review Report and Research outline

Tentative order for review: Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim of the Project, Materials and Methods, Bibliography/reference etc.

Tentative order for research outline: Title page, introduction, background and significance of study, problems to be investigated, objective, hypothesis, chapter scheme, bibliography.

11. At the end of the third semester, each student should submit a detailed Literature Review Report and research outline.
12. An appropriate and essentialconclusive statement must be drawn at the end of the study.
13. Students should maintain lab notebooks, and the Supervisor may ask them to submit the mid-semester progress report.
14. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
15. Three copies of the Literature Review Report, research outline should be prepared (one copy for each department, guide, and student).
16. At the end of the semester, the candidate should prepare and present research work using a PowerPoint presentation with modern ICT tool sand present the same in front of his/ her respective department during the Internal Examination.
17. For external examination the candidate will have to present the research work and face viva voce.
18. Students may present their research work in Avishkar/Webinars/Conferences.
19. Students should note that plagiarism is strictly prohibited.

Internal examination (40 marks): Components of continuous internal assessment:

- Draft Research Outline (10 marks)
- Draft Review of literature (10 marks)
- Working Bibliography (10 marks)
- PowerPoint presentation, and oral examination (10 marks)

External examination (60 marks)and Components of external assessment:

- Final submitted review report, research outline in bound form at the time of examination **(40 marks)**
- Overall presentation reflecting the contribution of work, response to questions **(20 marks)**

M.Sc. II (Analytical Chemistry)

Semester IV

M.Sc. II (Chemistry)
Semester IV
CHA-DSC-621: Spectroscopic methods of Analysis

Total Hours: 60 **Credits: 4**

Course objectives	● To learn about spectroscopic methods of analysis. ● To know the principle of various spectroscopic methods	
Course outcomes	After successful completion of this course, students are expected ● To learn about the working principle of spectroscopy methods. ● To get familiar to the construction of spectroscopic instruments..	
Unit	**Contents**	**Hours**
Unit I	**Electron spectroscopy** Introduction, Principle of ESCA, Electron spectroscopy for chemical analysis, ESCA satellite peaks, Spectral splitting, ESCA chemical shifts, Apparatus used for ESCA, X-ray source, Samples, Analyzers, Detectors, Chemical analysis using ESCA, Applications, Auger electron microscopy.	**15**
Unit II	**Atomic Mass Spectroscopy** Features of atomic mass spectroscopy, Atomic weight in mass spectroscopy, mass to charge ratio, Types of atomic mass spectroscopy, Mass spectrometers, Transducer for mass spectroscopy, Quadruple mass analyzer, Time of flight mass analyzer, Inductively coupled mass spectroscopy (ICPMS), Instrumentation for ICPMS, Atomic mass spectra and interferences, Applications of ICPMS.	**15**
Unit III	**Nuclear magnetic resonance spectroscopy** **1H-NMR**: Introduction, Theory, Instrumentation, Chemical shifts, spin-spin splitting, Protons on heteroatom's, Coupling protons with other nuclei, solvents, Qualitative and quantitative analysis. ^{13}C NMR: Introduction, interpretation of ^{13}C NMR spectra, Chemical shifts, Spin coupling, Quantitative analysis. **2D NMR**: introduction, ^{1}H - ^{1}H connectivity, ^{1}H - ^{13}C connectivity, ^{13}C - ^{13}C connectivity.	**15**
Unit IV	**Atomic Absorption Spectrophotometry (AAS)** Principle-Spectral line width, Doppler and pressure broadening, Instrument-sources-line and continuous, Electrodeless discharge lamps, Hollow cathode lamps, Temperature gradients, Cells, Flames, Furnaces, Detectors, Interferences and modifications in instrumentations, Applications.	**15**

Reference:

- Homes & Peck.(1983). Analytical Biochemistry. Prentice Hall-3rd edition
- Analysis of food and beverages. (1978). George Charalanbous, Accademic press Harry's Cosmetology, Longman scientific co.
- Formulation and Function of cosmetics, Sa Jellineck.
- Encyclopedia of industrial chemical analysis. (1998).
- Govt. of India publications of food drug cosmetic act and rules (2003).

M.Sc. II (Chemistry)
Semester IV
CHA-DSC-622: Special Analytical Methods

Total Hours: 60 **Credits: 4**

Course objectives	● To learn the methods of analysis of complex materials. ● To know about thermometric methods of analysis.	
Course outcomes	After successful completion of this course, students are expected ● To learn about validation and verification of methods of analysis. ● To know about dissolution and decomposition of samples.	
Unit	**Contents**	**Hours**
Unit I	**UV-Visible Spectrophotometer Performance Verification and Method Validation** Introduction, Performance Attributes: Wavelength Accuracy, Stray light, Resolution, Noise, Baseline flatness, Stability, Photometric Accuracy, Linearity, Practical Tips in UV- Vis Performance verification.	**15**
Unit II	**Thermal Methods of Analysis** Thermogravimetriy[TG], Differential thermal analysis [DTA], Differential Scanning calorimetry [DSC], Thermomechanical analysis [TMA] Instrumentation and application, Thermometric titrations.	**10**
Unit III	**Gas Volumetric Methods of Analysis** Apparatus employed in gas analysis – Orsat, Bunt and Hampel apparatus, Absorbents for various gases, Determination by explosion, slow explosion and fractional combustion.	**15**
Unit IV	**Decomposition and Dissolution of Inorganic and Organic Samples** Introduction, Acids as solvent, oxidizing and non-oxidizing, alkaline fluxes and acid fluxes, Use of Chlorine and Bromine at high temperature. Introduction, Dry and wet ashing methods, Specials reagents, Peroxide bomb, Alkali metal fusion, Lamp method, Lisbeg method.	**10**

References

- Chan C. C., Lam H. and Zhang Zhang X. M. (2004), Analytical method validation and instrument performance verification, Wiley India pvt ltd.
- Willard H. H. & Merritt L. L. (1984), Instrumental Methods of Analysis, CBS-6th edition.
- Welcher F. J. (2006), Standard Methods of Analysis (Volume Two Part –A), Krieger publishing company.
- Braun R. D. (2016), Introduction to Instrumental Analysis Pharmamed press 2nd edition.
- Chatwal G. & Anand S. (2019), Instrumental Methods of Chemical Analysis, Himalaya publications, 5th edition.

M.Sc. II (Chemistry)

Semester IV

CHA-DSE-623(A): Essentials in Nanoscience

Total Hours: 30 **Credits: 2**

Course objectives	● To familiar with Nanoscience and Nanotechnology. ● To study Nanomaterial: General Synthetic Approach. ● To get the knowledge of Characterization Tools for Nanomaterials. ● To know the Toxicity and Environmental Issues of Nanomaterial.	
Course outcomes	After successful completion of this course, students are expected ● To familiar with Nanoscience and Nanotechnology. ● To get the knowledge of Nanomaterial: General Synthetic Approach. ● To understand Characterization Tools for Nanomaterials. ● To get the knowledge of Toxicity and Environmental Issues of Nanomaterial.	
Unit	**Contents**	**Hours**
Unit I	**Nanoscience and Nanotechnology** Definition of Nanoscience and Nanotechnologies, Uniqueness of the Nanoscale, Naturally Occurring Nanomaterials, Nanoparticles, Nanowires and Nanotubes, Nanolayers/Nanocoatings, Nanoporous Materials, Strategies for Synthesis of Nanomaterials, Properties of Nanomaterials, Significanc of Nanoscience, Commercial Applications: Food Industry, Cosmetics, Textile, Medicine, Electrical and Electronic Goods, Potential Health Hazards and Environmental Risks, Futuristic Outlook.	**15**
Unit II	**Nanomaterial: General Synthetic Approach** Introduction, Bottom-Up Approaches: Chemical Vapor Deposition (CVD), Inert Gas Condensation (IGC), Sol–Gel Method, Sonochemical Method Top-Down Approach: Mechanical Milling, Mechanochemical Processing (MCP), Electro-Explosion, Sputtering, Etching, Laser Ablation, Lithography, Aerosol-Based Techniques, Electrospinning,	**15**
Unit III	**Characterization Tools for Nanomaterials** Introduction, imaging through electron microscopy, Scanning Electron Microscope (SEM), Transmission electron microscopy (TEM), Scanning Tunnelling Microscope (STM), Atomic Force Microscope (AFM), X-ray Diffraction (XRD), UV–Visible Plasmon Absorption and Emission, Zeta Potential Analysis.	**15**
Unit IV	**Toxicity and Environmental Issues** Nanotoxicology, Toxicity of Nanoparticles, sources of Nanoparticles and their health effects: Natural Sources of Nanoparticles (Dust, Forest Fires, Volcanoes, Ocean and water evaporation, Biological species), Human Made Nanomaterials (Diesel and engine, Indoor pollution, Cosmetics and other consumer products),Health hazards.	**15**

References:

- Kumar, N., &Kumbhat, S. (2016), Essentials in nanoscience and nanotechnology, John Wiley & Sons.
- Varghese, P. I., and Pradeep, T. (2003), A textbook of nanoscience and nanotechnology,

Tata McGraw-Hill Education.
- Murty, B.S., Shankar, P., Raj, B., Rath, B.B. and Murday, J., (2013). Textbook of nanoscience and nanotechnology. Springer Science & Business Media.
- Sharma P. K., (2008), Prospects of Nanotechnology, Vista International Publishing House.
- Heller, K., (2008), The University Textbook of Nanotechnology. Dominant Publishers and Distributors.

M.Sc. II (Chemistry)
Semester IV
CHA-DSE-623(B): Environmental Analytical Chemistry
Total Hours: 30 **Credits: 2**

Course objectives	● To aware of the surrounding environmental conditions. ● To learn about methods of pollutants analysis.	
Course outcomes	After successful completion of this course, students are expected ● To do qualitative and quantitative analysis of pharmaceuticals. ● To do elemental analysis.	
Unit	**Contents**	**Hours**
Unit I	**Determination of Hydrocarbons, Carbonyl Compounds, Nitrogen Compounds, and Sulphur Compounds** a) Hydrocarbons – Carbon & Hydrogen by combustion method. b) Carbonyl compounds – Estimation by oxidation, Bisulphate addition, Gravimetric DNP method& saponification method. c) Nitrogen compounds – Estimation by Kjeldahl & Duma's methods, Aromatic amines by diazotization& nitrosation, Reduction method for azo, hydrazo & nitro compounds by titanous chloride method. Sulphur compounds – Oxygen flask method, Bregel method, Mercaptans by silver sulphate method.	**8**
Unit II	**Analysis of petroleum products** Cloud point, pour point, flash point, vapour pressure, specific gravity and their determination, Estimation of 'S' and 'Pb' in petrol, octane number, cetane number.	**5**
Unit IV	**Standardization and quality control of different raw materials and dosage form** Analysis of raw materials with respect to identification, other or related substances, loss on drying, and Assay as per IP, i) adrenaline, ii) Niacinamide iii) Cephalexin, iv) ferrous fumarate, v) isoniazid and vi) paracetamol. Brief introduction to different dosage forms with the IP requirements. Analytical methods for the following- Tablets, different types of tablets, uniformity in weight (aspirin) additives used in tablet manufacture, capsules, types of capsules, (Rifampicin), Powders (Sodium benzoate), Solutions (saline NaCl) Suspensions (barium sulphate –limit test for impurity), Mouthwashes, Ointments (salicylic acid) and creams (Dimethicone), Injections (Mannitol), ophthalmic preparations (sulphacteamine), Aerosols (salbutamol), Blood products and reporting protocols.	**10**
Unit V	**Analysis of Vitamins and Enzyme assay methods (ELISA and RIA)** a) Assay of Vitamin such as Vitamin A, Vitamin B, Vitamin B2, Vitamin B6, Vitamin B12, Vitamin C, Vitamin D, Vitamin E. b) Enzyme assay methods – Ratio amino assay and ELISA method.	**7**

References

- Welcher F. J. (2006), Standard Methods of Chemical Analysis (Vol. Two Part A)-Krieger publishing.
- Welcher F. J. (2006), Standard Methods of Chemical Analysis (Vol. Two Part B) Krieger publishing.
- Welcher F. J. (2006), Standard Methods of Chemical Analysis (Vol. Three Part B) Krieger publishing.
- Homes D. J. and Peck H. (1983), Analytical Biochemistry. Prentice Hall.

M.Sc. II (Chemistry)
Semester IV
CHA-DSC-624: Chemical Methods of analysis

Hours: 60 **Credits:2**

Perform any 15 experiments out of the following:

Course Objectives	● To understand the principles and techniques of isolating saccharin in beverages. ● To gain practical experience in determining organic carbon in soil using the Walkley and Black method. ● To learn the procedure for titrimetric analysis of Vitamin C tablets. ● To understand the Sorensen formal titration method for estimating amino acids in proteins. ● To grasp the Lane and Eynone method for estimating glucose and fructose in honey.
Course Outcomes	After successful completion of this course, students are expected • To isolate saccharin from beverages using appropriate extraction and purification techniques. • To determine organic carbon content in soil samples using the Walkley and Black method. • To determine the concentration of Vitamin C in tablets through titrimetric analysis. • To estimate amino acid content in proteins using the Sorensen formal titration method. • To estimate the concentrations of glucose and fructose in honey using the Lane and Eynone method.

Sr. No.	Contents (Any 15)	Hours
1	Isolation of saccharine in beverages.	**4**
2	Determination of organic carbon in soil by Walkley and black method.	**4**
3	Titrimetric analysis of Vit-C tablet.	**4**
4	Estimation of amino acid in protein by Sorensen formal titration method.	**4**
5	Estimation of Glucose and fructose in honey by Lane and Eynone method.	**4**
6	Isolation of tannin or caffeine in tea.	**4**
7	Micro scale quantitative analysis of hard water samples using an indirect potassium permanganate Redox titration.	**4**
8	Determine the amount of copper in the given sample iodometrically.	**4**
9	Estimate the amount of phenol present in the given solution.	**4**
10	Estimate the amount of ethyl methyl ketone present in the given solution.	**4**
11	Estimate the amount of glucose present in the given solution.	**4**
12	Determination of Ascorbic Acid by Redox Titration.	**4**

13	Determine the amount of boric acid (H_3BO_3) in the given sample.	**4**
	Determine the purity of given $CaCO_3$ solution.	**4**
15	Titrimetric determination of H_3PO_4 (Phosphoric Acid) in the given sample.	**4**
16	Determine the amount of Ca^{2+} using EDTA complexometrically.	**4**
17	Determine the Percent Purity of given Aspirin Sample.	**4**
18	Separation of Chloride and Bromide by Ion Exchange Chromatography.	**4**
19	Determine the Amount of Calcium in an Eggshell.	**4**
20	Quantification of Iron Content in Iron Supplements by Redox Titration.	**4**

References:

- Vogel A.I.(2012), A TextBookof QualitativeInorganic Analysis(3rdEdition). Pearson education India.
- WelcherF.J.(2006), Standard Methods of Chemical Analysis (A Seriesof Volumes) - Krieger publishing company
- Willard H. H. & Merritt L.L. (1984), Instrumental Methods of Analysis, CBS-6thedition.
- Pharmacopoeia of India,British & United States.
- Mahindru S. N. (2003),Hand Book of Food Analysis, Metropolitan book company pvt ltd.
- Homes D.J.and Peck H.(1983), Analytical Biochemistry,PrenticeHall.
- Patel, Gadre & Turkhia (1997), Post Graduate Chemistry Practical Part–I.
- De Anil.K.(2011), EnvironmentalChemistry, 3rd edition, WileyEasternLtd.
- Jahagirdar D.V.(2003), Experiments in Chemistry, Himalaya Publication.

M.Sc. II (Chemistry)
Semester IV
CHA-DSC-625: Non Instrumental Analytical Techniques

Hours: 60 **Credits:2**

Per for many 15 experiments out of the following:

Course Objectives	● To understand the principles and procedures of Volhard's method for assaying sodium chloride injection. ● To grasp the technique of determining the number of nitro groups in a compound using $TiCl_3$. ● To understand the procedure for determining the amount of Cu(II) in a solution containing a mixture of Cu(II) and Fe(II).	
Course Outcomes	By the end of the course students will be able • To ability to accurately assay the sodium chloride injection using Volhard's method, ensuring its quality and potency. • To quantify the number of nitro groups in a compound, aiding in its characterization and analysis. • To accurately determine the concentration of Cu(II) in a mixed solution, demonstrating analytical skills in complex sample analysis.	
Sr. No.	**Contents (Any 15)**	**Hours**
1	To carry out assay of the sodium chloride injection by Volhard's method.	**4**
2	To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.	**4**
3	To determine the amount of Cr (III) in a mixture of Cr (III) and Fe (II) by titration with EDTA.	**4**
4	To determine number of nitro groups in the given compound using $TiCl_3$.	**4**
5	To determine the amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).	**4**
6	An analysis of a mixture of Na2CO3 and NaOH using two indicators.	**4**
7	Standardization of sodium thiosulphate solution withstandard K2Cr2O7.	**4**
8	Determination of the weight percent of iron by redox titration.	**4**
9	Standardization of potassium permanganate using oxalic acid (Reduction-Oxidation Titration).	**4**
10	Determination of aluminium as the 8-hydroxyquinolate, $Al(C_9H_6ON)_3$, with precipitation from homogeneous solution.	**4**
11	Determination of copper in crystallised copper sulphate.	**4**

12	Determination of Water Hardness with EDTA.	**4**
13	Determination of Aspirin Using Back Titration.	**4**
14	Determination of Ascorbic Acid in Orange Juice.	**4**
15	Determination of Chloride in a Soluble Chloride: Fajans' Method.	**4**
16	Quantification of Protein Concentration in Serum by Kjeldahl Method.	**4**
17	Determination of Sulfur Dioxide (SO_2) in Wine by iodometric Titration.	**4**
18	Complexometric Titration for Calcium Content in Milk.	**4**
19	Titrimetric Determination of Vitamin C in Fruit Juice.	**4**
20	Determine the Calcium Carbonate Content of Antacid Tablets.	**4**

References:

- A TextBookof QualitativeInorganic Analysis (3rdEdition)Vogel A.I.(2012).. Pearson education India
- Quantitative Inorganic Analysis including Elementary Instrumental Analysis by ; A. I. Vogels, 3rdEd. ELBS (1964)
- Standard methods of chemical analysis; F. J. Welcher, 1975
- Standard methods of chemical analysis: Instrumental methods of Analysis ; F. J. Welcher , vol. 3, 1966
- Standard methods of Chemical Analysis; W. W. Scott, Vol. I, Van Nostrand Company, Inc.,1939
- Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch.
- Analytical Chemistry: An Introduction" by Douglas A. Skoog and Donald M. West.
- Quantitative Chemical Analysis" by Daniel C. Harris.
- Modern Analytical Chemistry" by David Harvey.
- Analytical Chemistry: Principles and Techniques" by Robert A. Day and Underwood.

M.Sc. II (Chemistry)
Semester IV
CHA-DSE-626(A): Modern Analytical Techniques

Hours: 60 **Credits:2**

Perform any 15 experiments out of the following:

Course Objectives	● To understand the principles and techniques of flame photometry for the determination of calcium in eggshells. ● To gain practical experience in Olesen's colorimetric method for determining available phosphorus in soil samples. ● To learn the pH metric method for estimating phosphoric acid content in beverages. ● To study the polarimetric influence of added impurities on the rotation of solutes. ● To understand the principles and procedures of conductometric analysis for estimating impurities in commercial vinegar samples.	
Course Outcomes	By the end of the course students will be able ● To determine the calcium content in eggshells using flame photometry, ensuring precision and reliability in analysis. ● To determine the available phosphorus content in soil samples using Olesen's colorimetric method, providing valuable information for agricultural purposes. ● To estimate the phosphoric acid content in beverages pH metrically, ensuring product quality and compliance with standards. ● To analyse the influence of added impurities on the polarimetric rotation of solutes, demonstrating an understanding of optical activity in solutions. • To estimate impurities in commercial vinegar samples using conductometric analysis, ensuring product purity and safety.	
Sr. No.	**Contents (Any 15)**	**Hours**
1	Determination of Na/Ca/K in a given sample by Flame photometry method.	**4**
2	Estimation of salicylic acid by colorimetry.	**4**
3	To estimate phosphoric acid in beverages pHmetrically.	**4**
4	Determination of λ_{max} of $KMnO_4$ by colorimetry.	**4**
5	To estimate the impurity of mineral acid in commercial sample of vineger conductometrically.	**4**
6	Determination of Commercial washing soda by potentiometric titration method.	**4**
7	Determination of composition of complex by Job's continuous variation method.	**4**

8	Caffeine serial dilution and analysis using (UV-vis) spectroscopy.	**4**
9	Determination of absorption maxima and effect of solvents on absorption maxima of organic compounds.	**4**
10	Estimation of dextrose by colorimetry.	**4**
11	Estimation of sulfanilamide by colorimetry.	**4**
12	Estimation of ibuprofen by UV spectroscopy.	**4**
13	Assay of paracetamol by UV- Spectrophotometry.	**4**
14	Separation of sugars by thin layer chromatography.	**4**
15	To determine the mean ionic activity coefficient of an electrolyte by emf measurement.	**4**
16	Demonstration experiment on AAS.	**4**
17	Demonstration experiment on Gas Chromatography.	**4**
18	To study the effect of substituent on the dissociation constant of acetic acid conductometrically.	**4**
19	pHmetric estimation of dibasic acid.	**4**
20	Determination of pKa of acetic acid pHmetrically.	**4**

References:

- Instrumental Methods of Chemical Analysis by B.K Sharma
- Organic spectroscopy by Y.R Sharma
- Text book of Pharmaceutical Analysis by Kenneth A. Connors
- Vogel's Text book of Quantitative Chemical Analysis by A.I. Vogel
- Practical Pharmaceutical Chemistry by A.H. Beckett and J.B. Stenlake
- Organic Chemistry by I. L. Finar
- Organic spectroscopy by William Kemp
- Quantitative Analysis of Drugs by D. C. Garrett
- Quantitative Analysis of Drugs in Pharmaceutical Formulations by P. D. Sethi
- Spectrophotometric identification of Organic Compounds by Silverstein

M.Sc. II (Chemistry)
Semester IV
CHA-DSE-626(B): Environmental Analytical Techniques

Hours: 60 **Credits:2**

Perform any 15 experiments out of the following.

Course Objectives	● To understand the principles and techniques of fluoride analysis in groundwater and potable water samples. ● To gain practical experience in conducting ammonia estimation in water samples using the Kjeldahl method. ● To learn the procedures and principles of HPLC analysis for determining organophosphate pesticides in soil samples. ● To understand the methods and principles of calcium estimation in soils and groundwater samples. ● To grasp the techniques and procedures involved in estimating metals in sediment samples using atomic absorption spectrometry (AAS).
Course Outcomes	By the end of the course students will be able to ● Acurately analyze fluoride levels in groundwater and potable water samples, ensuring compliance with safety standards. ● Perform ammonia estimation in water samples using the Kjeldahl method, providing valuable information for water quality assessment. ● Competence in HPLC analysis for the determination of organophosphate pesticides in soil samples, aiding in environmental monitoring and management. ● Estimate calcium levels in soils and groundwater, contributing to soil fertility and agricultural practices. • Determine metal concentrations in sediment samples using AAS, providing insights into environmental contamination and sediment quality.

Sr. No.	**Contents (Any 15)**	**Hours**
1	Analysis of Fluoride in Ground Water and Potable Water.	**4**
2	Estimation of Ammonia in Water using Kjeldahl Method.	**4**
3	Determination of Pesticides (Organophosphate) in Soil Sample using HPLC.	**4**
4	Estimation of Calcium in Soils and Groundwater.	**4**
5	Estimation of Metals in Sediment by AAS.	**4**
6	Estimation of Fluoride Ion in Groundwater and Toothpaste.	**4**
7	Determination of Turbidity of water by Nephelometer.	**4**
8	Determination of Specific Gravity, Bulk Density and Moisture Content of a given soil sample.	**4**
9	Determination of Organic Carbon, NPK and CEC of a given soil sample.	**4**

10	Determination of Bioavailable and Total Heavy Metals in soil.	**4**
11	Gram staining techniques for detection of gram positive and gram-negative bacteria in given soil sample.	**4**
12	Spectrophotometric Determination of Fe in Water Sample using Standard Addition Method.	**4**
13	Determination of Nitrate Nitrogen in Water.	**4**
14	Spectrophotometric Determination of Lead on Leaves Using Solvent Extraction.	**4**
15	Potentiometric Determination of Fluoride in Drinking Water Using a Fluoride Ion-Selective Electrode.	**4**
16	Estimation of Total Dissolved Solids (TDS) in Water	**4**
17	Assessment of Chlorophyll Concentration in Water.	**4**
18	Assessment of Heavy Metal Contamination in Soil.	**4**
19	Evaluation of Microbial Contamination in Water.	**4**
20	Estimation of Total Organic Carbon (TOC) in Water.	**4**

References:

- Environmental Analysis by J. H. Duffus.
- Analytical Techniques for Environmental Chemistry by John R. Dean.
- Environmental Analytical Chemistry by W. T. Frankenberger Jr. and Gene E. Fogg.
- Principles of Environmental Analysis by R. M. Harrison and R. E. Hester.
- Environmental Chemistry: Fundamentals by Stanley E. Manahan.
- Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes edited by PradyotPatnaik.
- Environmental Sampling and Analysis for Technicians by Maria Csuros and Stephen R. Hanna.
- Practical Environmental Analysis by M. Radojevic and V.N. Bashkin.
- Environmental Analytical Chemistry: Theory and Practice by Sven Erik Jorgensen and Lena H. Sorensen.
- Methods in Environmental Analysis: Water, Soil, and Air by Michael R. Hoffmann, Daniel M. Mark, and David W. Tedder.

M.Sc. II (Chemistry)
Semester IV
CHA-RM-627 Research Project II

Hours: 180 **Credits: 6**

Course Objectives

1. To give exposure to the students to research culture and technology
2. To introduce students to how to select a research topic, plan, perform experiments, collect data and analyze the data
3. To foster self-confidence and self-reliance in the students as they learn to work and think independently

Course outcomes

After successful completion of this course, students are expected to:

1. Conceive a problem based on published research and conduct a comprehensive literature survey.
2. Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.
3. Learn handling of instruments, use of chemicals and how to conduct the experiments
4. Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.

The systematic approach towards the execution of the project should be as follows: (Wherever applicable)

1. The complete tenure of the research project should be one academic year. It should be allotted during the third semester and completed in the fourth semester.
2. Weekly 12 hours should be allotted to the research project in a regular timetable.
3. In the fourth semester, students should perform further experimental work, analyze the data and compile the results.
4. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.
5. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
6. Each research group should have a different research topic with some possible level of novelty.
7. The student should select the topic relevant to priority areas of concern or allied subjects.
8. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
9. Students are expected to work in line with the research outline and literature review,which was submittedin the third semester.
10. Students are expected to learn how to execute the research work systematically and overcome the hurdles. Students will get the opportunity to learn about practical aspects of many characterization techniques or models and further how to effectively employ them in the research work. Students should be able to critically evaluate the literature on the topic, identify the research gaps, plan and perform the experiments, interpret the results, understand the limitations of the work and draw conclusions.
11. At the end of the semester, each student should submit a detailed ResearchReport.

12. The format of the final research report shall be as per the guidelines of respective department. (**Example**:Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim and objective, Materials and Methods, Result, Data analysis and Discussions, conclusion, limitations, suggestion, future scope,Bibliography, Appendix etc.)
13. An appropriate and essential conclusive statement must be drawn at the end of the study.
14. Students should maintain lab notebooks, and the supervisor may ask them to submit the mid-semester progress report.
15. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
16. Three copies of the dissertation should be prepared (one copy for each department, guide, and student).
17. At the end of the semester, the candidate should prepare and present research using a PowerPoint presentation using modern ICT tools during the Internal and External Examination.
18. Besides writing a dissertation, students are encouraged to write a manuscript/patent if the results obtained are worthy of publication.
19. Students may present their research work in Avishkar/Webinars/Conferences.
20. Students should note that plagiarism is strictly prohibited.

Internal examination (60 marks): Components of continuous internal assessment:

- Literature collected, methodological planning, analysis of data, design and work, progress reports etc(30 marks)
- Presentation in Webinars/Conferences/publication and departmental presentationetc(20 marks)
- Oral examination (10 marks)

External examination (90 marks)and Components of external assessment:

- Evaluation of dissertation submitted in bound form at the time of examination **(60 marks)**
- Presentation (PPT format) **(15 marks)**
- Overall presentation reflecting the contribution of work, Response to questions **(15 marks)**