SOPHIA COLLEGE (AUTONOMOUS)

Affiliated to the University of Mumbai

Programme: SCIENCE

Programme code: SMCHE

Syllabus for the Academic Year 2022-2023

based on the National Education Policy 2020

(Choice Based Credit System with effect from 2023-2024)

Preamble

Programme: MSc-Analytical Chemistry

The M.Sc. Programme in Analytical chemistry was started under the affiliation of Mumbai University and is now brought under Autonomy. Although the same syllabus has been retained with minor modifications structural changes are incorporated to suit the credit system under autonomy.

The objective of the M.Sc. Analytical Chemistry programme is to provide a comprehensive and in-depth understanding of the fascinating world of Analytical Chemistry. The M.Sc. Programme in Analytical Chemistry combines core and elective theory courses as well as practical courses and independent research guided by an experienced researcher from the department/industry or a national institute. Through a rigorous academic curriculum, industry training and hands-on research experience, we aim to nurture the intellectual curiosity and scientific acumen of our students, preparing them for successful careers in various sectors of the chemical sciences. On completing the programme, the students will be able to analyze and provide practical solutions to the problems within the broad/specialized field of analytical chemistry.

Our esteemed faculty members with expertise in their respective fields and with a passion for both teaching and research are committed to providing a learning environment, encouraging open discussions, and fostering collaborative research endeavors. Through their mentorship, students will have the opportunity to engage in cutting-edge research projects, pushing the boundaries of scientific knowledge and contributing to the advancement of the chemical sciences. We envision our M.Sc. (Analytical Chemistry) postgraduates act as catalysts for positive change, equipped to drive innovation, shape industries, and address societal challenges through their expertise in chemistry.

PROGRAMME OBJECTIVES	
PO 1	To provide students with theoretical and applied knowledge in the interdisciplinary branches of chemistry with emphasis on qualitative and quantitative analysis.
PO 2	To expose the students to the advanced instrumental analysis through hands on training, internships and research to make them job ready.
PO 3	To train students to address the environmental and societal issues and face the real life challenges more effectively.

PROGRAMME SPECIFIC OUTCOMES	
PSO 1	**Critical thinking:** A student with a Master's degree in Analytical chemistry will have an in- depth theoretical and practical knowledge of the subject which will foster their critical thinking.
PSO 2	**Skills in research and industrial field:** Students will build a scientific temper through research, develop entrepreneurial skill and will get an exposure to work in an industrial set up.
PSO 3	**Personality Development:** The students will be able to handle personal, social, environmental issues and will be responsible citizens.

COURSE: M.Sc.
SEMESTER III

Course Code	Unit	Topic	Credits
SMSCHE301		**QUALITY IN ANALYTICAL CHEMISTRY**	
	I	Quality in Analytical Chemistry – I	4
	II	Quality in Analytical Chemistry – II	
	III	Chromatographic Techniques - I	
	IV	Chromatographic Techniques - I	
SMSCHE302		**ADVANCED INSTRUMENTAL TECHNIQUES**	
	I	Spectral Methods – I	4
	II	Spectral Methods - II	
	III	Electroanalytical Techniques	
	IV	Miscellaneous Techniques	
SMSCHE303		**BIOANALYTICAL CHEMISTRY AND FOOD ANALYSIS**	
	I	Bioanalytical Chemistry	4
	II	Immunological methods	
	III	Food Analysis – I	
	IV	Food Analysis – II	
		ENVIRONMENTAL & PHARMACEUTICAL CHEMISTRY AND INDUSTRIALLY IMPORTANT	

SMSCHE304		**MATERIALS**	
	I	Environmental Chemistry	4
	II	Water Quality Standards	
	III	Industrial material	
	IV	Pharmaceutical Chemistry	
		PRACTICALS	
SMSCHEP301	I	QUALITY IN ANALYTICAL CHEMISTRY (GROUP A)	8 (2 credits for each practical)
SMSCHEP302	II	ADVANCED INSTRUMENTAL TECHNIQUES (GROUP B)	
SMSCHEP303	III	BIOANALYTICAL CHEMISTRY AND FOOD ANALYSIS (GROUP C)	
SMSCHEP304	IV	ENVIRONMENTAL & PHARMACEUTICAL CHEMISTRY AND INDUSTRIALLY IMPORTANT MATERIALS (GROUP D)	

FACULTY: SCIENCE
COURSE: M.Sc.
SEMESTER IV

COURSE CODE	UNIT	TOPIC	CREDITS
SMSCHE401		**QUALITY IN ANALYTICAL CHEMISTRY**	
	I	Separation Science	4
	II	Separation, Analysis and Standardization of Herbal Products	
	III	Green Chemistry	
	IV	Chromatographic Techniques – III and Nanotechnology	
		ADVANCED INSTRUMENTAL TECHNIQUES	

SMSCHE402	I	Spectral Methods – III	4
	II	Spectral Methods – IV	
	III	Radiochemical and Thermal methods	
	IV	Hyphenated Techniques	
SMSCHE403		**SELECTED TOPICS IN ANALYTICAL CHEMISTRY**	
	I	Effluent treatment & Solid Waste Management	4
	II	Forensic Chemistry	
	III	Polymers, Paints and Pigments	
	IV	Metallurgy	
SMSCHE404		**INTELLECTUAL PROPERTY RIGHTS AND CHEMINFORMATICS**	
	I	Intellectual Property Rights – I	4
	II	Intellectual Property Rights – II	
	III	Introduction to Cheminformatics	
	IV	Applications of Cheminformatics	
		PRACTICAL	
SMSCHEP401	I	Quality In Analytical Chemistry(Group A)	8 (2 credits for each practical)
SMSCHEP402	II	Advanced Instrumental Techniques (GROUP B)	
SMSCHEP403	III	Selected Topics in Analytical Chemistry (GROUP C)	
SMSCHEP404	IV	PROJECT WORK (GROUP D)	

SEMESTER III

SMSCHE301: QUALITY IN ANALYTICAL CHEMISTRY

NAME OF THE COURSE	Quality in AnalyticalChemistry	
CLASS	M.Sc Part II	
COURSE CODE	SMSCHE301	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

Course Objectives

CO1	To understand various methods of sampling and criteria for method validation.
CO2	To understand the principle, instrumentation and applications of different chromatographic techniques.
CO3	To understand the different methods used to reduce signal to noise ratio
CO4	To introduce the concept of regulatory affairs in drug pharmaceuticals and laboratory maintenance.

Course Outcomes:Learner will be able to

CLO1	Explain dissolution technology and methods of sampling and storage.
CLO2	Interpret the results and improve the quality of results
CLO3	Describe methods used to reduce signal to noise ratio
CLO4	Explain supercritical fluid chromatography, affinity chromatography and ion-exchange in detail with applications.

UNIT NO.	TOPIC	NO. OF LECTURES
I	**Quality In Analytical Chemistry – I**	**15**
	1.1 Sampling: Definition, types of sample, sampling plan, quality of sample, subsampling, Sampling of raw materials, intermediates and finished products. Sample preparations – dissolution technology and decomposition, storage of samples. Pre-treatment of samples:	8L

	soil, food and cosmetics. **1.2 Selection of the Method:** sources of methods, factors to consider when selecting a method, performance criteria for methods used, reasons for incorrect analytical results, method validation, and quality by design (PAT).	7L
II	**Quality In Analytical Chemistry – II**	**15**
	2.1 Measurement of uncertainty: Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results. **2.2 Signal to noise:** Signal to noise ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction, software methods for noise reduction. **2.3 Pharmaceutical Legislation:** introduction to drug acts, drug rules (schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration.	4L 6L 5L
III	**Chromatographic Techniques –I**	**15**
	3.1 Ion exchange chromatography: Ion exchange equilibria, breakthrough capacity, inorganic ion exchangers, synthetic ion exchangers, chelating resins and their applications for separation of inorganic and organic compounds. **3.2 Ion chromatography:** Principle, instrumentation with special reference to separation and suppressor columns, applications. **3.3 Exclusion chromatography :** Theory, instrumentation and applications of gel permeation chromatography, retention behavior, inorganic molecular sieves, determination of molecular weight of polymers	8L 2L 5L
IV	**Chromatographic Techniques –II**	**15**
	4.1 Supercritical fluid Chromatography: Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis. **4.2 Affinity Chromatography:** principle, instrumentation and applications **4.3TLC:** 2D TLC, Silver ion TLC, Preparative TLC, HPLC and GC	8L 4L 3L

References:

1. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997.
2. Quality assurance in analytical Chemistry, W Funk, V Dammann, G. Donnevert VCH Weinheim1995.

3. Amit S. Patil *et. al.*,Quality by Design (QbD) : A new concept for development of Quality pharmaceuticals, International Journal of Pharmaceutical Quality Assurance; 4(2); 13-19.
4. Lalit Singh and Vijay Sharma, Quality by Design (QbD) Approach in Pharmaceuticals: Status, Challenges and Next Steps, Drug Delivery Letters, 2015,
5. 2-8. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997
6. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West, Saonders, College publication.
7. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
8. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
9. Analytical Chemistry, G. D. Christain, Wiley
10. Extraction Chromatography T. Braun, G. Ghersene, Elsevier Publications 1978.
11. Supercritical Fluid Extraction, Larry Taylor Wiley publishers N.Y. 1996

SMSCHE302: ADVANCED INSTRUMENTAL TECHNIQUES

NAME OF THE COURSE	Advanced Instrumental Techniques	
CLASS	M.Sc Part II	
COURSE CODE	**SMSCHE302**	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS PASSING MARK	50 20	50 20

Course Objectives

CO1	To understand the principles and instrumentation of the spectral methods
CO2	To understand the applications of the techniques discussed
CO3	To understand the concepts of the different techniques i.e. spectroscopic/electro-analytical.

Course Objectives:Learner will be able to

CLO1	Differentiate and identify the appropriate technique of analysis for a sample.
CLO2	Interpret the esr/ mossbauer spectrum.
CLO3	Solve numericals based on the topics covered

UNIT NO.	TOPIC	NO. OF LECTURES
I	**Spectral Methods I**	**15**
	1.1 Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis.	1L
	1.2 Principle, instrumentation and applications of the following:	4L
	A) Secondary Ion mass spectroscopy.	5L
	B) Particle-Induced X-Ray Emission	5L
c	C) Low-Energy Ion Scattering and Rutherford Backscattering	
II	**Spectral Methods II**	**15**
	Principle, Instrumentation, and Applications of: A) Electron Spin Resonance Spectroscopy (ESR) B) Mossbauer's Spectroscopy C) Atomic Emission Spectroscopy- based on plasma and electrical discharge sources	 5L 5L 5L
III	**Electroanalytical Methods**	**15**
	Advanced Electroanalytical Techniques: A) Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography	3L
	B) Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry.	3L 2L
	C) Potential Step method- Chronoamperometry	2L
	D) Controlled potential technique- Chronopotentiometry	2L
	E) Stripping Voltammetry- anodic, cathodic, and adsorption	3L
	F) Chemically and electrolytically modified electrodes and ultra-micro electrodes in voltammetry	
IV	**Miscellaneous Techniques**	**15**
	Principle, Instrumentation and Applications: A) Chemiluminescence techniques B) Chiroptical Methods: ORD, CD	 3L 5L
	C) Photoacoustic spectroscopy	3L
	D) Spectroelectrochemistry	4L

References:

1. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
2. 2. Fundamentals of Analytical Chemistry, D.A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)

3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 5th Edition (1998)
4. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)
5. Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987)
6. Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker, New York, 1980.
7. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (A series of volumes)
8. Techniques and mechanism of electrochemistry, P. A. Christian and A. Hamnett Blachie Academic and Professional (1994)
9. Wilson and Wilson's Comprehensive Analytical Chemistry, Ed. G. Svehla. (A series of volumes)
10. Treatise on Analytical Chemistry, Eds. I. M. Kolthoff and Others, Interscience Pub. (A series of volumes).
11. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, (A series of volumes)
12. Polarographic Methods in Analytical Chemistry, M. G. Arora, Anmol Publications Pvt Ltd
13. Surface Analysis –The Principal Techniques, 2nd Edition Edited by John C. Vickerman and Ian S. Gilmore 2009 John Wiley & Sons, Ltd. ISBN: 978-0-470-01763-0
14. NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry *R. V. Parish*. Ellis Horwood, Chichester.

SMSCHE303: BIOANALYTICAL CHEMISTRY AND FOOD ANALYSIS

NAME OF THE COURSE	Bioanalytical Chemistry and food analysis	
CLASS	M.Sc Part II	
COURSE CODE	SMSCHE303	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

Course Objectives:

CO1	To understand the application of analytical chemistry in the chemical and biological fields
CO2	To understand immunological methods and food analysis using a variety of experimental techniques
CO3	To introduce quality assessment of dairy products and species

Course Outcomes:Learner will be able to

CLO1	Apply the knowledge for estimating dairy products
CLO2	Differentiate and identify the techniques of analysis
CLO3	Explain the principle of methods used for the analysis of biological sample, food and food additives.

UNIT NO.	TOPIC	NO. OF LECTURES
I	**Bioanalytical Chemistry**	**15**
	Body Fluids 1.1 Composition of body fluids and detection of abnormal levels of glucose, creatinine, uric acid in blood, protein, ketone bodies and bilirubin in urine leading to diagnosis of diseases. (5L) 1.2 Physiological and nutritional significance of vitamins (water soluble and fat soluble) and minerals. (5L) 1.3 Analytical techniques (including microbiological techniques) for vitamins. (5L)	
II	**Immunological Methods**	**15**
	2.1 General processes of immune response, antigen antibody reactions, precipitation reactions, radio, enzyme and fluoro-immuno assays. (8L) 2.2 Human Nutrition: Biological values and estimation of enzymes, carbohydrates, proteins, essential amino acids and lipids.(7L)	
III	**Food Analysis – I**	**15**
	3.1 Food Legislation and Public health (1L) 3.2 Fuel value of food and importance of food nutrients (2L) 3.3 Food Additives – General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colors, artificial sweeteners, enzymes. Analysis of food products for flavoring agents and colour. (5L) 3.4 Food Contaminants– Trace metals and pesticide residues, contaminants from industrial wastes (polychlorinated polyphenols, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants. (7L)	
IV	**Food Analysis - II**	**15**
	4.1 Food packaging – Introduction, types of packing materials, properties and industrial requirements. (2L)	

	4.2 Processing and Quality requirements of Milk and milk products (cheese, butter and ice cream), vegetables and fruits, meat and meat products. (6L) 4.3 Analysis of Milk – Fat content, proteins, acidity, bacteriological quality and milk adulterants. (2L) 4.4 Analysis of Oils and Fats – acid value, sap value, iodine value, determination of rancidity and antioxidants. (2L) 4.5 Analysis of spices (cloves, cinnamon, pepper, mustard), determination of volatile oils and fixed oils.(3L)	

References:

1. General, organic and biological chemistry, H. Stephen Stoker, Cengage Learning.
2. Advance dairy chemistry, vol 3, P. F. Fox, P. L. H. McSweeney Springer.
3. Physiological fluid dynamics vol 3, Nanjanagud Venkatanarayanasastry Chandrasekhara Swamy Narosa Pub. House, 1992
4. Molecular Biological and Immunological Techniques and Applications for food, edited by Bert Popping, Carmen Diaz-Amigo, Katrin Hoenicke, John Wiley & sons.
5. Food Analysis: Theory and practice, Yeshajahu Pomeranz, Clifton E. Meloan, Springer.
6. Principles of package development, Gribbin et al
7. Modern packaging Encyclopedia and planning guide, Macgra Wreyco.
8. Food Analysis, Edited by S. Suzanne Nielsen, Springer
9. Analytical Biochemistry, D, J. Homes and H. Peck, Longman (1983)
10. Bioanalytical Chemistry, S. R. Mikkelesen and E. Corton, John Wiley and sons 2004

SMSCHE304: ENVIRONMENTAL & PHARMACEUTICAL CHEMISTRY AND INDUSTRIALLY IMPORTANT MATERIALS

NAME OF THE COURSE	Environmental & Pharmaceutical Chemistry and Industrial Important Material	
CLASS	M.Sc Part II	
COURSE CODE	SMSCHE304	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS PASSING MARK	50 20	50 20

Course Objectives:

CO1	To introduce learners to different types of pollution, analysis of pollutants and environmental laws and regulations.

CO2	To provide them with a scientific background for understanding environmental problems, monitoring and controlling the pollution
CO3	To understand the application of analytical chemistry from the perspective of pharma

Course Outcomes:

CLO1	Interpret quality parameters, Environmental regulations with reference to air, soil and water.
CLO2	Apply Sampling techniques and analyses of various environmental material
CLO3	Analyse various industrial and pharmaceutical materials

UNIT NO.	TOPIC	NO. OF LECTURES
I	**Environmental Chemistry**	**15**
	1.1 Sampling and analysis of air pollutants: Particulate matter, aerosols, ammonia and organic vapors. 1.2 Soil pollution and Soil Analysis: sources of soil pollution and their control, sampling of soil, determination of water holding capacity, determination total nitrogen, ammonia and nitrates, fertility of soil and effect of pollution on it, synthetic fertilizers and their long term effect on soil quality. 1.3 Carbon credit and global issues related to air pollution. 1.4 Environmental Legislation: role of pollution control boards, article 48A and 51A, Motor Vehicle Act and method of analysis with respect to PUC. 1.5 Environmental Audits: concept of audit, authorities, evaluation methodology, benefits and certification	3L 5L 3L 2L 2L
II	**Water Quality Standards**	**15**
	2.1 Water: quality and requirements of potable water, direct and indirect pollutants in potable water reservoirs, quality of potable water from natural sources. 2.2 Bore well water quality and analytical parameters. Quality of bottled mineral water 2.3 Process of purification of bore well water to bottled mineral water. 2.4 Regulatory requirements for packaged drinking water	6L 3L 2L 4L
III	**Industrial Materials**	**15**
	4.1 Insecticides, Pesticides: definition, classification and biodegradation	5L

	4.2 Soaps and Detergents: classification and composition, qualitative and quantitative analysis of detergents - alkalinity, active ingredients and oxygen releasing capacity. Biodegradable detergents 4.3 Petrochemical products: crude oils, fuels, and calorific values, fractional distillation process and fractions, properties of fuel, composition of fuel, flashpoint, fire point, corrosion test, carbon residue and impact on environment.	5L 5L
IV	**Pharmaceutical Chemistry**	**15**
	1.1 General idea regarding the Pharmaceutical Industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries. 1.2 Sources of impurities in pharmaceutical products and raw materials. 1.3 Standardization of finished products and their characteristics, official methods of quality control.	7L 4L 4L

References:

1. Environmental Pollution Analysis, S. M. Khopkar, John Wiely (1993).
2. Air Pollution Sampling and Analysis, Sharad Gokhale, IIT Guwahati, May 2009.
3. Environmental Pollution Analysis, S. M. Khopkar, New Age International publication (2011).
4. Water pollution, Arvind Kumar, APH publishing (2004)
5. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paperback publication.
6. Guidelines for drinking-water quality, third edition, (incorporating first and second addenda). WHO report.
7. Soil pollution, S.G. Misra and Dinesh Mani, APH Publishing Corporation, (2009).
8. Soil Pollution: origin, monitoring and remediation, Abrahim Mirsal, Springer (2010).
9. Environmental law in India, Mohammad Naseem, Wolters Kluwer.
10. Environmental Protection, Law and Policy in *India* Kailash Thakur google books (1997).
11. Green chemistry an Introductory text, Mzike Lancaster, Royal Society of Chemistry (2002)
12. Analytical, Agricultural Chemistry S. L Chpra J.S Kanwar Kalyani publication.

NAME OF THE COURSE	**Practical**
CLASS	M.Sc Part II
COURSE CODE	**SMSCHEP301** **SMSCHEP302** **SMSCHEP303** **SMSCHEP304**
NUMBER OF CREDITS	2 (Each paper)
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER	60

SEMESTER		
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS		50
PASSING MARK	----	20

Semester III Practical

Course Objectives

CO1	To acquaint learners with chromatographic and spectroscopic techniques
CO2	To learn quantitative analysis of various food, cosmetic and drug samples
CO3	To be acquainted with separation techniques
CO4	To learn how to check the purity of various samples
CO5	To familiarize students with the SOPs and train them in handling

Course Learning Outcomes: -Learner will be able to

CLO1	Analyse commercial samples of food, cosmetics and drugs
CLO2	Apply the knowledge to decide the most appropriate method of analysis based on requirements.
CLO3	Use technical skills to work with various instruments

SMSCHEP301- Quality in Analytical Chemistry	SMSCHEP302- Advanced Instrumental Techniques	SMSCHEP303 - Bioanalytical Chemistry and Food Analysis	SMSCHEP304 - Environmental & Pharmaceutical Chemistry and Industrially Important Materials
Group A	Group B	Group C	Group D
1. Isolation and identification of Caffeine in tea by HPTLC 2. Separation and estimation of Mg and Zn on an anion exchanger. 3. Determination of	1. Determination of the pK value of an indicator. 2. Determination of copper and bismuth in mixture by photometric titration. 3. Estimation of strong acid, weak acid and salt in	1. Total reducing sugars before and after inversion in honey using: (a)Cole's Ferricyanide (b) Lane - Eynon method. 2. Analysis of lactose in milk	1.Estimation of drugs by non-aqueous titration: Glycine, Sodium Benzoate Pyridoxine hydrochloride, Mebendazole. 2. Estimation of Ca in Ca-pentathonate/calcium lactate

percentage purity of methylene blue indicator. 4. Estimation of fluoride in a tooth paste. 5. Determination of silica by molybdenum blue method.	the given mixture conductometrically 4. Analysis of mixture of carbonate and bicarbonate (present in ppm range) using pHmetry.	3. Estimation of Vitamin C in lemon Juice/squash by Dichlorophenol-indophenol method 4. Iodine value of oil / fat-Wij's Solution 5. Analysis of Calcium, Iron and phosphorous in milk.	tablets

SEMESTER IV

SMSCHE401: QUALITY IN ANALYTICAL CHEMISTRY

NAME OF THE COURSE	Quality in Analytical Chemistry	
CLASS	M.Sc Part II	
COURSE CODE	**SMSCHE401**	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARK	20	20

Course Objectives:

CO1	To understand various methods of separation used in pre-treatment of samples.
CO2	To introduce analysis of herbal based products and their standardizations
CO3	To emphasize the importance of Green Chemistry.
CO4	To understand the principle, instrumentation and applications of selective chromatographic techniques

Course Learning Outcomes: Learner will be able to

CLO1	Explain in detail the application of solvent extraction in analytical chemistry
CLO2	Describe qualitative and quantitative estimations of herbal based formulations and interpret the results.
CLO3	Identify and use green reactions/synthesis in future.
CLO4	Discuss analytical techniques in nanotechnology and selective chromatographic

	techniques

UNIT NO.	TOPIC	NO. OF LECTURES
I	**Separation Science**	**15**
	1.1 Membrane separation processes: operating principles and applications of microfiltration, ultrafiltration, reverse osmosis, dialysis and electro-dialysis. 1.2 Recapitulation of solvent extraction, applications of solvent extraction in Analytical Chemistry, roles of solvent extraction in analytical chemistry, solvent extraction in sample preparation and pre-treatment steps, solvent extraction as a means of analytical determination.	8L 7L
II	**Separation, Analysis and Standardization of Herbal based products**	**15**
	2.1 Herbs as a raw material: Definition of herb, herbal medicine, herbal medicinal products, herbal drug preparation, sources of herbs, selection, identification and authentication of herbal materials, drying and processing of herbal raw materials. 2.2 Extraction of herbal materials: Choice of solvent for extraction, methods used for extraction and principles involved in extraction. 2.3. Standardization of herbal formulation and herbal extracts: Standardization of herbal extracts as per WHO cGMP guidelines, Physical, Chemical, Spectral and toxicological standardization, qualitative and quantitative estimations.	6L 3L 6L
III	**Green Chemistry**	**15**
	3.1 Principle and concepts of green chemistry: sustainable development and green chemistry, atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity 3.2 Organic solvents: environmentally benign solutions, solvent free systems, supercritical fluids (only introduction) Ionic liquids as catalysts and solvents 3.3 Emerging Green Technologies: photochemical reactions (advantages and challenges), examples. Chemistry using microwaves, sonochemistry and electrochemical synthesis. 3.4 Designing Greener Processes: Inherently Safer Designs (ISD), Process intensification (PI) in-process monitoring.	4L 4L 4L 3L
IV	**Chromatographic Techniques –III and Nanotechnology**	**15**
	4.1 Electrophoresis: introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephadex and thin layers) 4.2 Techniques of Electrophoresis: low and high voltage, sds-page, continuous electrophoresis, capillary electrophoresis, zone, gel, isoelectric	2L 8L

	focusing, isotachophoresis and micellar electrokinetic capillary chromatography, instrumentation, detection and applications. 4.3 Introduction to Nanotechnology: Recapitulation, consequences of the nanoscale, (nanoparticles morphology, electronic structure, optical properties) one dimensional nanomaterials (nanofilms, nanolayers), two dimensional nanomaterials (nanotubes, nanowires), three dimensional nanomaterials (nanoparticles and quantum dots).	5L

References:

1. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
2. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
3. Extraction Chromatography, T. Braun, G. Ghersene, Elsevier Publications 1978.
4. Ion exchange chromatography, Ed H.F Walton Howden, Hutchenson and Rossing 1976
5. Chromatographic and electrophoresis techniques, I Smith Menemann Interscience 1960
6. Green chemistry and catalyst, R. A. Sheldon, Isabella Arends, Ulf Hanefeld Wiley VCH verlag GmBH & co.
7. https://psiberg.com/thin-layer-chromatography/
8. https://www.sciencedirect.com/science/article/abs/pii/S0021967308022607
9. https://core.ac.uk/download/pdf/54199265.pdf
10. https://lipidlibrary.aocs.org/lipid-analysis/silver-ion-chromatography-of-lipids/introduction-to-silver-ion-chromatography
11. https://www.tandfonline.com/doi/abs/10.1081/JLC-100103922?journalCode=ljlc20

SMSCHE402: ADVANCED INSTRUMENTAL TECHNIQUES

NAME OF THE COURSE	Advanced Instrumental Techniques	
CLASS	M.Sc Part II	
COURSE CODE	**SMSCHE40**2	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARK	20	20

Course Objectives:

CO1	Understand the principles and instrumentation of the spectral, radiochemical and thermal methods of analysis
CO2	Understand the importance of various hyphenated techniques
CO3	Understand the applications of the different techniques discussed in the paper.

Course Outcomes:

CLO1	Differentiate between different techniques of analysis and understand its applications in various fields
CLO2	Interpret the mass spectrum, thermogram and solve numericals based on this topic.
CLO3	Justify the benefits of hyphenated techniques

UNIT NO.	TOPIC	NO. OF LECTURES
I	**Spectral Methods III**	**15**
	NMR Spectroscopy 1.1 Theory and Instrumentation- recapitulation, FTNMR, 2D NMR, - FID signal generation mechanism, Techniques in 2D NMR- homo nuclear correlation spectroscopy (COSY), total correlation spectroscopy (TOCSY), heteronuclear correlation (HETCOR) 1.2 Radio waves in imaging- principle instrumentation and applications of MRI 1.3 Application of NMR to other nuclei C^{13}, $P^{31}$and F^{19}spectroscopy	9L 3L 3L
II	**Spectral Methods IV**	**15**
	2.1 Mass spectroscopy: recapitulation, correlation of mass spectra with molecular structure- interpretation of mass spectra, analytical information derived from mass spectra- molecular identification, metastable peaks, Fragmentation Reactions 2.2 Raman spectroscopy: Principle Theory Instrumentation , techniques(SERS and Resonance Raman) and Applications of Raman spectroscopy	9L 6L
III	**Radiochemical and Thermal Methods**	**15**
	3.1 Activation analysis- NAA, radiometric titrations and radio-release methods 3.2 Thermal analysis- Principle, Interfacing, instrumentation and Applications of (a) Simultaneous Thermal Analysis- TG-DTA and TG-DSC (b) Evolved gas analysis- TG-MS and TG-FTIR	7L 8L
IV	**Hyphenated Techniques**	**15**
	4.1 Concept of hyphenation, need for hyphenation, possible hyphenations. 4.2 Interfacing devices and applications of GC – MS, ICP -MS, GC - IR, Tandem Mass Spectrometry, LC – MS: HPLC-MS, CE MS.	2L 13L

References:

1. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West and F. J Holler Holt- Saunders 6th Edition (1998)
2. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Ed.
3. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A.
4. Thermal methods of Analysis, P. J. Haines, Blackie Academic & Professional, London (1995)
5. Thermal Analysis, 3rd Edition W. W. Wendlandt, John Wiley, N.Y. (1986) nd
6. Nuclear Analytical Chemistry, D. Bane, B. Forkman, B. Persson, Chartwell - Bratt Ltd (1984)
7. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, A series of volumes
8. A Complete Introduction to Modern NMR Spectroscopy 1st Edition by Roger S. Macomber
9. Spectrometric Identification of Organic Compounds Hardcover – by Robert M.Silverstein Wiley
10. Tandem Techniques (Separation Science Series) 1st Edition by Raymond P. W. Scott John Wiley & Sons Ltd, 1997
11. Encyclopedia of Analytical Science, Editors-in-Chief: Paul Worsfold, Alan Townshend, and Colin Poole ISBN: 978-0-12-369397-6
12. Encyclopedia of Analytical Chemistry: Applications, Theory, and Instrumentation. Meyers Robert A Meyers
13. Introduction to Thermal Analysis Techniques and Applications Edited by Michael E. Brown
14. Principles and Applications of Thermal Analysis Edited by Paul Gabbott

SMSCHE403: SELECTED TOPICS IN ANALYTICAL CHEMISTRY

NAME OF THE COURSE	Selected topics in Analytical Chemistry	
CLASS	M.Sc Part II	
COURSE CODE	**SMSCHE40**3	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARK	20	20

Course Objectives:

CO1	To impart knowledge of effluent treatments and recovery of metals from effluents, recycling and reuse of effluent water.
CO2	To impart knowledge of solid waste management, analysis of polymers, paints

	and pigments
CO3	To understand the applications of analytical techniques in Forensic Chemistry and metallurgy

Course Outcomes

CLO1	Apply the concepts of waste management in day to day life
CLO2	Analyze and apply the appropriate methods of analysis for polymers, paints, ores and alloys.
CLO3	Apply the knowledge in the field of forensic chemistry

UNIT NO.	TOPIC	NO. OF LECTURES
I	**Effluent Treatment & Solid Waste Management**	**15**
	1.1 Effluent treatment plant general construction and process flow charts. Treatment and disposal of Sewage.	3L
	1.2 Effluent parameters for the metallurgical industry. Permissible limits for metal (Cr, As, Pb, Cd) traces in the effluent.	2L
	1.3 Recovery of metals from effluent, modern methods – Electrodialysis, Electrodeposition and Ion Exchange	3L
	1.4 Solid waste management: objectives, concept of 4 R's	1L
	1.5 Methods of solid waste disposal.	1L
	1.6 Treatment and disposal of sludge / dry cake Managing non-decomposable solid wastes	3L
	1.7 Bio- medical waste : Introduction , Classification and methods of disposal	2L
II	**Forensic Chemistry**	**15**
	2.1 Analytical Chemistry in Forensics: General idea.	1L
	2.2 Forensic Analysis: Blood, DNA profiling, Hair analysis, Alcohol in body fluids, systematic drug identification.	4L
	2.3 Analytical Toxicology: Isolation, identification and determination of:	6L
	2.3.1 Narcotics: Heroin, morphine and cocaine.	
	2.3.2 Stimulants: Amphetamines and caffeine.	

	2.3.3 Depressants: Benzodiazepines, Barbiturates and Mandrax. 2.3.4 Hallucinogens: LSD and Cannabis. 2.3.5 Metabolites of drugs in blood and urine of addicts. 2.3.6 Viscera, stomach wash, vomit and postmortem blood for poisons like – cyanide, arsenic, mercury, insecticides and pesticides. 2.4 Analytical Chemistry: Qualitative and Quantitative analysis of forensic evidence from Fire and Explosive scenes 2.5 Analytical Chemistry: Qualitative analysis for identification of adulterants in food materials	3L 1L
III	**Polymers, Paints and Pigments**	**15**
	3.1 Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride, ethylene, acrylic and cellulosic plastics. 3.2 Metallic impurities in plastic and their determination, 3.3 Impact of plastic on environment as pollutant. 3.4 Paints and pigments: Types of paints pigments, determination of volatile and non - volatile components, Flash point (significance and method of determination), separation and analysis of pigments, binders and thinners. 3.5 Role of organosilicones in paints and their impact on environment.	5L 2L 2L 3L 3L
IV	**Metallurgy**	**15**
	4.1 Ores and minerals: Dressing of ores, pollution due to metallurgical processes (ore dressing, calcination, smelting) 4.2 Chemical analysis of ores for principal constituents: Galena, Pyrolusite, Bauxite, Hematite, Monazite 4.3 Alloys: definition, analysis of Cupronickel, Magnelium, Steel and Stainless Steel, Bronze, Gun metal. 4.4 Techniques of purification: Zone refining, analysis of high purity materials like silicon, vacuum fusion and extraction techniques.	3L 4L 4L 4L

References:

1. Environmental Pollution Analysis, S. M. khopkar, New Age International publication (2011).
2. Water pollution, Arvind kumar, APH publishing (2004)
3. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paperback publication.

4. Solid waste management, K Sasikumar and Sanoop Gopi Krishna PHI publication (2009)
5. Solid waste management, Surendrakumar Northen Book Center (2009) rd
6. Handbook of chemical technology and pollution control 3 Edn Martin Hocking AP Publication (2005).
7. Fundamental Concepts of Environmental Chemistry, Second Edition G. S. Sodhi, Alpha Science, 2005
8. Forensic Chemistry, Suzanne Bell, Pearson Prentice Hall Publication, 2006.
9. Forensic Chemistry, David E Newton, Infobase Publishing, 2007.
10. Criminalistics - an Introduction to Forensic Science, Richard Saferstein, Prentice Hall Publication, 2011
11. Chemical analysis of metals; Sampling and analysis of metal bearing ores: American Society for Testing and Materials 1980 - Technology & Engineering
12. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).

SMSCHE404 INTELLECTUAL PROPERTY RIGHTS AND CHEMINFORMATICS

NAME OF THE COURSE	Intellectual Property Rights & Cheminformatics	
CLASS	M.Sc Part II	
COURSE CODE	SMSCHE404	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARK	20	20

Course Objectives

CO1	To achieve a common understanding of IPR laws in India and its economic value.
CO2	To encourage innovation at the college level and encourage the filing of patents
CO3	To provide a basic introduction to fundamentals and applications of cheminformatics
CO4	Introduce students to python, RPi, IoT to understand working of IoT controlled sensors

Course Learning Outcomes:

CLO1	It will bridge the gap between industry and academia and facilitate technology transfer.
CLO2	Understanding IP issues around knowledge transfer can help get discoveries

	from the lab to the marketplace.
CLO3	Explain basic concepts of cheminformatics and will be able to implement computation of molecular descriptors and chemical similarity.
CLO4	Use Python for understanding cheminformatics software, IoT, Design various application based experiments using sensors

UNIT NO.	TOPIC	NO. OF LECTURES
I	**IPR-I**	**15L**
	1.1 Introduction to Intellectual Property: Historical Perspective, Different types of IP, Importance of protecting IP. 1.2 Patents: Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India. 1.3 Drafting of Chemistry patents (Product and Process); Novelty Check. Understanding the importance of patents from a chemistry point of view and its future scope. Drug discovery, development and patents. 1.4 Industrial Designs: Definition, how to obtain, features, International design registration. 1.5 Copyrights: Introduction, how to obtain, Differences from Patents. 1.6 Trade Marks: Introduction, how to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc. 1.7 Geographical Indications: Definition, rules for registration, prevention of illegal exploitation, importance to India.	2L 3L 2L 2L 2L 2L 2L
II	**IPR-II**	

	2.1 Trade Secrets: Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection. 2.2 Integrated Circuit Layout Design Act 2.3 IP Infringement issue and enforcement: Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. 2.4 Economic Value of Intellectual Property: Intangible assets and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. 2.5 Different International agreements: 2.5.1 World Trade Organization (WTO): (i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade Related Services (GATS) Madrid Protocol. (iii) Berne Convention (iv) Budapest Treaty 2.5.2 Paris Convention, WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity. Hague Agreement, Lisbon Agreement WIPO performances and Phonogram Treaty 2.6 Indian IP Regime: Overview of IP laws in India, Major IP Laws in India, International treaties signed by India. Introduction to python	2L 2L 2L 5L 6L
III	**Cheminformatics**	**15**
	3.1 Introduction to Cheminformatics: History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation. 3.2 Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sd Files, Libraries and toolkits, Different electronic effects, Reaction classification. 3.3 Searching Chemical Structures: Full structure search, substructure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	5L 5L 5L
IV	**Tools for understanding applications of cheminformatics**	**15 L**

	4.1 Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Monte Carlo and molecular dynamics methods for molecular models, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, 4.2 Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand based and Structure based Drug design, 4.3 Application of Cheminformatics in Drug Design.	

References:

1. https://www.wipo.int/portal/en/index.html
2. Andrew R. Leach & Valerie J. Gillet (2007) *An Introduction to Cheminformatics.* Springer: The Netherlands.
3. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley– VCH
4. Gupta, S. P. *QSAR and Molecular Modeling.* Springer-Anamaya Pub.: New Delhi.
5. https://jakevdp.github.io/PythonDataScienceHandbook/
6. http://pgg1610.github.io/blog_fastpages/exploratory-data-analysis/machine-learning/resources/2021/06/25/ML_resources.html

Semester IV-Practicals

NAME OF THE COURSE	Practical
CLASS	M.Sc Part II
COURSE CODE	**SMSCHEP40**1 SMSCHEP402 SMSCHEP403 SMSCHEP404
NUMBER OF	2 (credit for each)

CREDITS		
NUMBER OF LECTURES PER WEEK	4 (for each)	
TOTAL NUMBER OF LECTURES PER SEMESTER	60 (for each)	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	---	50
PASSING MARK		20

Course Objective

CO1	To learn analysis of various food, water and forensic samples qualitatively and quantitatively
CO2	To learn treatment ore/alloy samples and determine its constituent metals quantitatively
CO3	To familiarize students with the SOPs and train them in handling various instruments.

CO4	To acquaint them with the recent advances in the field of computational chemistry

Course Learning Outcomes

CLO1	To enable learners to analyse commercial samples .
CLO2	To enable to apply the knowledge and choose an appropriate method for analysis based on requirements
CLO3	Learners will be equipped with technical skills to work with various instruments.
CLO4	To enable learners to apply skills and knowledge in the field of research and industry

SMSCHEP401- Quality in Analytical Chemistry	SMSCHEP402- Advanced Instrumental Techniques	SMSCHEP403- Selected Topics in Analytical Chemistry	SMSCHEP404 - Intellectual Property Rights And Cheminformatics
Group A	Group B	Group C	Group D
1. Determination of copper by extractive photometry using diethyldithiocarbamate. 2. Determination and identification of given oil using SAP value. 3. Estimation of Aldehyde in lemon grass oil / Cinnamon oil 4. Estimation of Glucose by Folin-Wu method 5. Determination of Ursolic acid in herbal cough syrups by HPTLC	1.Estimation of Na+ in dairy whitener by flame photometry 2. Spectrophotometric determination of pH of buffer solution. 3. Simultaneous determination of Ti^{3+} and V^{5+} spectrophotometrically by H_2O_2 method 4.Analysis of water sample: Mn^{2+} by colorimetric method	1. To analyze Pyrolusite for: Fe by colorimetry and / or Mn by volumetry. 2. To analyze Magnelium for Mg by complexometry. 3. Analysis of Bauxite for Ti by colorimetry / Al by gravimetry / Fe (volumetry 4.To analyze Brass for Zn by complexometric method 5. Serology: blood evidence screening tests 6. Toxicology: drug	1.)Python Basics • Python 3 basics • Important difference between python 2.x and python 3.x with example • Keywords in Python • Namespaces and Scope in Python • Statement, Indentation and Comment in Python • Structuring Python Programs • How to assign values to variables in Python and other languages • Decision making • Taking input in Python • Taking input from console in Python • Taking multiple inputs from user in Python • Output using print() function and Output Formatting • File handling in python 2) Introduction to Nodemcu and Raspberry pi and Various IoT controllers 3) Installation, and Input output basics of in Rasberry pi and nodemcu

		screening tests	Project Work: 1) Sms and mailing service by IoT 2) Various interface like Gps, Bluetooth in IOT Research Project on selected topic.

PAPER PATTERN FOR CHEMISTRY SEMESTER END EXAM MSc PART II (Semester III and IV)

Theory Examination

Theory examination of each paper is of 100 marks
Theory written paper is of 50 marks for two and half hours.
Internal in the form of presentations for 50 marks.

Internal Assessment:
50 Marks
Two tests of 25 Marks each and one activity(Assignment, test, Infographic) of 25M

Best of two marks to be considered

Semester End Exam: Subjective

Q.1. Unit 1 : Attempt any two of the following. (2 out of 4) [10marks]
Q.2. Unit 2 : Attempt any two of the following. (2 out of 4) [10marks]
Q.3. Unit 3 : Attempt any two of the following. (2 out of 4) [10marks]
Q.4. Unit 4 : Attempt any two of the following. (2 out of 4) [10marks]
Q.5. Attempt any two of the following (2 out of 4) [10 marks]
(1 question from each unit)

Practical Examination

Practical examination of each paper for 50 marks will be held for three and half hours. (Semester III)

Practical examination of Paper I, II, III for 50 marks will be held for three and half hours and Paper IV would be project and research evaluation of 50 marks. (Semester IV)

Practical 40M

Journal 5M

Viva-voce 5M

Total 50M