RAMAIAH UNIVERSITY OF APPLIED SCIENCES

M. S. Ramaiah University of Applied Sciences

Programme structure and Course details of M.Sc. (Analytical Chemistry)

Postgraduate Degree Programme

Programme Code: 82

2022 onwards

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M.S.Ramaiah University of Applied Sciences
Bangalore - 560 054

Department of Chemistry
Faculty of Mathematical and Physical Sciences
M. S. Ramaiah University of Applied Sciences
University House, New BEL Road, MSR Nagar, Bengaluru – 560 054
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Approved by Academic Council at its 26th meeting held on 14th July 2022

Dean - Academics
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University's Vision, Mission and Objectives

The M. S. Ramaiah University of Applied Sciences (MSRUAS) will focus on student-centric professional education and motivates its staff and students to contribute significantly to the growth of technology, science, economy and society through their imaginative, creative and innovative pursuits. Hence, the University has articulated the following vision and objectives.

Vision

MSRUAS aspires to be the premier university of choice in Asia for student centric professional education and services with a strong focus on applied research whilst maintaining the highest academic and ethical standards in a creative and innovative environment

Mission

Our purpose is the creation and dissemination of knowledge. We are committed to creativity, innovation and excellence in our teaching and research. We value integrity, quality and teamwork in all our endeavors. We inspire critical thinking, personal development and a passion for lifelong learning. We serve the technical, scientific and economic needs of our Society.

Objectives

1. To disseminate knowledge and skills through instructions, teaching, training, seminars, workshops and symposia in Engineering and Technology, Art and Design, Management and Commerce, Health and Allied Sciences, Physical and Life Sciences, Arts, Humanities and Social Sciences to equip students and scholars to meet the needs of industries, business and society
2. To generate knowledge through research in Engineering and Technology, Art and Design, Management and Commerce, Health and Allied Sciences, Physical and Life Sciences, Arts, Humanities and Social Sciences to meet the challenges that arise in industry, business and society
3. To promote health, human well-being and provide holistic healthcare
4. To provide technical and scientific solutions to real life problems posed by industry, business and society in Engineering and Technology, Art and Design, Management and Commerce, Health and Allied Sciences, Physical and Life Sciences, Arts, Humanities and Social Sciences
5. To instill the spirit of entrepreneurship in our youth to help create more career opportunities in the society by incubating and nurturing technology product ideas and supporting technology backed business
6. To identify and nurture leadership skills in students and help in the development of our future leaders to enrich the society we live in
7. To develop partnership with universities, industries, businesses, research establishments, NGOs, international organizations, governmental organizations in India and abroad to enrich the experiences of faculties and students through research and developmental programmes

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Programme Specifications: M. Sc. (Analytical Chemistry)

Faculty	Mathematical & Physical Sciences
Department	Chemistry
Programme Code	082
Programme Name	M.Sc. (Analytical Chemistry)
Dean of the Faculty	Prof. Dilip Kumar Mahanty
Head of the Department	Dr. T. Niranjana Prabhu

1. **Title of the Award:** M.Sc. (Analytical Chemistry)
2. **Mode of Study:** Full-Time
3. **Awarding Institution /Body:** M. S. Ramaiah University of Applied Sciences, Bengaluru
4. **Joint Award:** Not Applicable
5. **Teaching Institution:** Faculty of Mathematical & Physical Sciences, M. S. Ramaiah University of Applied Sciences, Bengaluru
6. **Date of Programme Specifications: 14 July 2022**
7. **Date of Programme Approval by the Academic Council of MSRUAS: 14 July 2022**
8. **Next Review Date:** July 2024
9. **Programme Approving Regulating Body and Date of Approval: University Grants Commission, New Delhi, 21st July 2016**
10. **Programme Accredited Body and Date of Accreditation: NA**
11. **Grade Awarded by the Accreditation Body: NA**
12. **Programme Accreditation Validity: NA**
13. **Programme Benchmark:** NA
14. **Rationale for the Programme:**

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Chemistry is the scientific tool that used to harness natural resources to enhance our lives in different ways. Chemistry started as the chemistry of life, later it became chemistry of compounds and today it is the study of structure, properties, composition, reactions and preparation of carbon containing including other elements such as nitrogen, oxygen, halogens, phosphorus, silicon, and sulphur. As the society is progressing, it requires various materials such as monomers to produce various polymers and drug molecules that cater to the human needs in curing enormous number of diseases. The demand for oils, fats, surfactants and synthesis of these types of molecules in greener routes is ever increasing with the increasing population. Chemistry is also used in making of agrochemicals, dyestuff, clothes, food stuffs, perfumes, metals for various applications, explosives, etc. It has become an interdisciplinary subject for the synthesis of various materials with wide applications among which sustainable energy source is one, where many organic compounds are synthesised for photovoltaic cells, light emitting diodes etc. as alternative high energy sources.

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Paper, pulp, adhesives, personal care, paints and coatings are some of the other areas where organic

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chemists will contribute in providing new materials and improving existing materials. Prominent players operating in the global specialty monomer market include NOF America Corporation, BASF SE, Arkema Group, Evonik Industries AG, Solvay S.A., Isle Chem LLC, Deltech Corporation, Bimax Chemicals Ltd., and so on. India is the 3rd largest producer of chemicals in Asia by volume and 6th largest producer in the world, which is highly diversified covering more than 80,000 commercial products. It is broadly classified into Basic chemicals, Specialty chemicals, and Agrochemicals. India's proximity to the Middle East, the world's source of petrochemicals feedstock, makes for economies of scale. Mistubishi Chemicals, BASF, ADEKA, AkzoNobel, Dupont, Biocon Syngene International Ltd., Merck Ltd, Syngeta, Dyestar, Henkel, Rhodia, Wacker, Croda and SABIC are some of the major chemical industries investing in India.

Analytical chemistry is the study of separation, identification, and quantification of chemical components of natural and artificial materials. Qualitative analysis gives an indication of the identity of the chemical species in the sample and quantitative analysis determines the amount of one or more of these components. Modern analytical chemistry is dominated by instrumental analysis e.g. spectroscopy and chromatography. Analytical chemistry has applications in forensics, bio analysis, clinical analysis, environmental analysis, and materials analysis. Analytical chemistry plays an increasingly important role in the pharmaceutical industry where it is used in discovery of new drug candidates and in clinical applications where understanding the interactions between the drug and the patient are critical. There are a lot of career opportunities analytical chemists in pharmaceutical and other industries mentioned above, in government laboratories and Industries involved in manufacturing/processing of food/beverage products.

The Faculty of Mathematical and Physical Sciences of RUAS offers the M.Sc. (Analytical Chemistry) programme with an outcome based curriculum emphasizing the Critical, Analytical and Problem Solving skills to equip the students to pursue their scientific and research career with better preparedness and a mature professional outlook. The presence of other allied Faculties of the University provides for a multi-disciplinary approach which is emerging as a key differentiator in the success of modern scientific and engineering endeavors. In the coming years, the government intends to boost up funds for basic sciences. There is an acute shortage of qualified teaching staff. The job prospects for candidates with M.Sc. (Analytical Chemistry) look good in academia, R&D sector and industry.

15. Programme Mission

The purpose of the programme is to create innovative problem solvers in multi-disciplinary settings, entrepreneurs and leaders that apply their knowledge, understanding, cognitive abilities, practical skills and transferable skills gained through systematic, flexible and rigorous learning in the chosen academic domain.

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16. Gradate Attributes (GAs)

GA-1. Ability to apply fundamental knowledge of Mathematical and Physical Sciences to solve real life problems in their chosen domain

GA-2. Ability to teach in schools, colleges and universities with relevant training and perform administrative duties in government, semi-government, private and public sector organizations

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GA-3. Ability to understand and solve scientific problems by conducting experimental investigations

GA-4. Ability to apply appropriate tools, techniques and understand utilization of resources appropriately in various laboratories

GA-5. Ability to conduct scientific research and disseminate the knowledge in the chosen domain

GA-6. Ability to understand the effect of scientific solutions on legal, cultural, social, public health and safety aspects, and apply ethical principles to scientific practices and professional responsibilities

GA-7. Ability to develop sustainable solutions and understand their effect on society and environment

GA-8. Ability to Ability to work as a member of a team, to plan and to integrate knowledge of various disciplines and to lead teams in multidisciplinary settings

GA-9. Ability to make effective oral presentations and communicate technical ideas to a broad audience using written and oral means

GA-10. Ability to adapt to the changes and advancements in science and engage in independent and life-long learning

17. Programme Outcomes (POs)

M.Sc. graduates will be able to:

PO-1. Scientific Knowledge: Apply fundamental knowledge of chemical Sciences to solve real life problems in their chosen domain

PO-2. Knowledge, Dissemination and Administration: Teach in schools, colleges and universities with relevant training and perform administrative duties in government, semi-government, private and public sector organizations

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PO-3. Problem Solving: Understand and solve scientific problems by conducting experimental investigations

PO-4. Modern Tool Usage: Apply appropriate tools, techniques and understand utilization of resources appropriately in various laboratories

PO-5. Research: Conduct scientific research and disseminate the knowledge in the chosen domain

PO-6. The Science, Society and Ethics: Understand the effect of scientific solutions on legal, cultural, social, public health and safety aspects, and apply ethical principles to scientific practices and professional responsibilities

PO-7. Environment and sustainability: Develop sustainable solutions and understand their effect on society and environment

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PO-8. Individual and teamwork: Work as a member of a team, to plan and to integrate knowledge of various disciplines and to lead teams in multidisciplinary settings

PO-9. Communication: Make effective oral presentations and communicate technical ideas to a broad audience using written and oral means

PO-10. Life-long learning: Adapt to the changes and advancements in science and engage in independent and life-long learning

18.Programme Goal

The programme goal is to train students with advanced knowledge and understanding of Analytical Chemistry with higher order critical, analytical, problem solving and research skills; ability to think rigorously and independently to meet higher level expectations of academia and research with sufficient transferrable skills, and to pursue a career in academia with further relevant training, business and industry.

19. Program Educational Objectives (PEOs)

The objectives of the M.Sc. (Analytical Chemistry) Programme are to:

PEO-1. To provide students the fundamental knowledge of chemistry to enable them to deliver efficient solutions for complex scientific problems using analytical and cognitive skills in their chosen domain.

PEO-2. To enable students to apply appropriate tools, techniques, methods and understand utilization of resources in laboratories and computational skills in their chosen domain and work as an individual as well as lead team in multidisciplinary settings.

PEO-3. To inculcate ethics, environmental sustainability, communication, soft, managerial and entrepreneurial skills for a successful career in industries and to engage in lifelong learning and also work towards developing sustainable society.

20. Programme Specific Outcomes (PSOs)

At the end of the M.Sc. (Analytical Chemistry) programme, the graduate will be able to:

PSO-1. Apply the knowledge of Chemistry to identify and explain basic laws and principles governing physical and chemical systems, use mathematical, statistical and computational methods to analyze industrially important materials, explain their properties, adopt suitable analytical techniques to obtain the required outcomes.

PSO-2. Model and explore alternative materials and processes in an industry, develop strategies for commercial viability of a processes and products, solve and interpret results obtained through experimentation, adopt safe handling practices and perform duties as per scientific protocols, demonstrate to work as an individual, and as a leader.

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PSO-3. Demonstrate ethics, leadership qualities, communication, managerial, entrepreneurial skills and involvement in lifelong learning for the betterment of organization, environment and society.

21. Programme Structure:

Semester 1

Sl. No.	Course Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Max. Marks	Total Credits
1	CYC511A	Physical Chemistry 1	4			100	4
2	CYC512A	Inorganic Chemistry 1	4			100	4
3	CYC513A	Organic Chemistry 1	4			100	4
4	CYC514A	Instrumental Methods of Analysis	4			100	4
5	CYL515A	Physical Chemistry Laboratory			4	50	2
6	CYL516A	Qualitative & Quantitative Analysis of Inorganic Compounds			4	50	2
7	CYS517A	Seminar 1			2	50	1
Total			**16**		**10**	**550**	**21**

Registrar
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Semester 2

Sl. No.	Course Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Max. Marks	Total Credits
1	CYC521A	Physical Chemistry 2	4			100	4
2	CYC522A	Inorganic Chemistry 2	4			100	4
3	CYC523A	Organic Chemistry 2	4			100	4
4	CYC524A	Computational Chemistry	4			100	4
5	CYL525A	Computational Techniques in Chemistry			4	50	2
6	CYL526A	Qualitative & Quantitative Analysis of Organic Compounds			4	50	2
7	CYS527A	Seminar 2			2	50	1
Total			**16**		**10**	**550**	**21**

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Semester 3

Sl. No.	Course Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Max. Marks	Total Credits
1	CYC631A	Data Analysis and Statistical Inference	3			100	3
2	CYC632A	Advanced Analytical Chemistry Techniques	3			100	3
3	CYC633A	Analysis of Biopharmaceuticals and Foods	3			100	3
4	CYC634A	Environmental Analytical Chemistry	3			100	3
5	MPF615A	Research Methodology	2			50	2
6	CYL636A	Analytical Chemistry Laboratory 1			4	50	2
7	CYL637A	Analytical Chemistry Laboratory 2			4	50	2
8	CYS638A	Seminar 3			2	50	1
Total			**14**		**10**	**600**	**19**

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Semester 4

Sl. No.	Course Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Max. Marks	Total Credits
1	CYI641A	Internship*			8	100	4
	CYS641A	Seminar**					
2	CYP642A	Dissertation Work ***			30	300	15
Total					**38**	**400**	**19**

* Internship can be done during the vacation period for a maximum period of 8 weeks, where the student needs to submit a report along with the presentation.

**A student can opt for seminar instead of internship, where a student in consultation with his/her project supervisor is expected to conduct review of literature related to their project work, write a review article and submit along with a presentation on the same topic.

*** A student in consultation with allotted supervisor is required to conduct research on a topic, submit a dissertation report along with an article in a prescribed journal format. Dissertation can be conducted within the department or in the other department within the university in consultation with Head of the Department. A student can also conduct dissertation work in any of the reputed R & D institute / organization or in an Industry in consultation with Head of the Department. In such cases, an internal supervisor from the department will facilitate and monitor the work along with the external supervisor.

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22. Course Delivery: As per the Timetable

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23. Teaching and Learning Methods

1. Face to Face Lectures using Audio-Visuals
2. Workshops, Group Discussions, Debates, Presentations
3. Demonstrations
4. Guest Lectures
5. Laboratory work/Field work/Workshop
6. Industry Visit
7. Seminars
8. Group Exercises
9. Project Work
10. Project
11. Exhibitions
12. Technical Festivals

24. Assessment and Grading

24.1. Components of Grading

There shall be **two components** of grading in the assessment of each course:

Component 1, Continuous Evaluation (CE): This component involves multiple subcomponents (LSC1, LSC2, etc.) of learning assessment. The assessment of the subcomponents of CE is conducted during the semester at regular intervals. This subcomponent represents the formative assessment of students' learning.

Component 2, Semester-end Examination (SEE): This component represents the summative assessment carried out in the form an examination conducted at the end of the semester.

Marks obtained CE and SEE components have equal weightage (CE: 50% and SEE: 50%) in determining the final marks obtained by a student in a Course.

The complete details of Grading are given in the Academic Regulations.

24.2. Continuous Evaluation and Semester-End Examination Policies

Continuous evaluation and Semester-End Examination depends on the type of the course as discussed below:

24.2.1 Theory Courses

Theory Course			
CE (Weightage: 50 %)			SEE (Weightage: 50 %)
TSC1 Midterm exam / Term Test	TSC2 Assignment	TSC3 Innovative	SEE Written exam
50 Marks	25 Marks	25 Marks	100 Marks

There shall be three subcomponents, first one is midterm exam carrying 50 marks and others carrying 25 marks each.

The innovative TSC3 can be of any of the following types:

a) Online Test
b) Problem Solving

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c) Field Assignment
d) Open Book Test
e) Portfolio
f) Reports
g) Case Study
h) Group Task
i) Quiz
j) Any other

After the three subcomponents are evaluated, the CE component marks are determined as:
CE Component Marks = (Total of the marks obtained in all the three subcomponents) ÷ 2

24.2.2 Laboratory Course

For a laboratory course, the scheme for determining the CE marks is as under:

Laboratory Course		
CE (Weightage: 50 %)		SEE (Weightage: 50 %)
LSC1	LSC2	Lab SEE
25 Marks	25 Marks	50 Marks

The subcomponents can be of any of the following types:

a) Laboratory / Clinical Work Record
b) Experiments
c) Computer Simulations
d) Creative Submission
e) Virtual Labs
f) Viva / Oral Exam
g) Lab Manual Report
h) Any other (e.g. combinations)

After the subcomponents of CE are evaluated, the CE component Marks are determined as:
CE Component Marks = (Total of the best two subcomponent marks out of the three) ÷ 2

25. Student Support for Learning

1. Course Notes
2. Reference Books in the Library
3. Magazines and Journals
4. Internet Facility
5. Computing Facility
6. Laboratory Facility
7. Workshop Facility
8. Staff Support
9. Lounges for Discussions
10. Any other support that enhances their learning

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26. Quality Control Measures

1. Review of Course Notes
2. Review of Question Papers and Assignment Questions
3. Student Feedback
4. Moderation of Assessed Work
5. Opportunities for students to see their assessed work
6. Review by external examiners and external examiners reports
7. Staff Student Consultative Committee meetings
8. Student exit feedback
9. Subject Assessment Board (SAB)
10. Programme Assessment Board (PAB)

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27. Programme Map (Course-PO-PSO Map)

Sem.	Course Title	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
1	Physical Chemistry 1	3		2								3	2	
1	Inorganic Chemistry 1	3		2								3	2	
1	Organic Chemistry 1	3		3								3	3	
1	Instrumental Methods of Analysis	3		2								3	3	
1	Chemistry Laboratory 1				3					3		3	3	3
1	Chemistry Laboratory 2				3					3		3	3	3
1	Seminar 1		2							3				3
2	Physical Chemistry 2	3		3								3	2	
2	Inorganic Chemistry 2	3		2								3	2	
2	Organic Chemistry 2	3		3							2	3	3	
2	Computational Chemistry	3		3	3							3	3	
2	Chemistry Laboratory 3				3					3		3	3	
2	Chemistry Laboratory 4				3					3		3	3	3
2	Seminar 2		2							3				3
3	Data Analysis and Statistical Inference	3		3								3	2	
3	Advanced Analytical Chemistry Techniques	3						1			2	3	2	
3	Analysis of Biopharmaceuticals and Foods	3		3				2				3	2	2
3	Environmental Analytical Chemistry	3		3								3	2	
3	Research Methodology	3		3	3	3				3	3	3	3	3
3	Analytical Chemistry Laboratory 1				3					3			3	3
3	Analytical Chemistry Laboratory 2				3					3			3	3
3	Seminar 3		2							3				3
4	Internship									3				3
4	Seminar		2							3			3	3
4	Dissertation Work	3		3	3	3	3		3	3	2	3	3	3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution														

28. Co-curricular Activities

Students are encouraged to take part in co-curricular activities like seminars, conferences, symposia, paper writing, attending industry exhibitions, project competitions and related activities for enhancing their knowledge and networking.

29. Cultural and Literary Activities

Annual cultural festivals are held to showcase the creative talents in students. They are involved in planning and organizing the activities.

30. Sports and Athletics

Students are encouraged to take part in sports and athletic events regularly. Annual sports meet will be held to demonstrate sportsmanship and competitive spirit.

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Detailed Course Curriculum

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Semester 1

Course Specifications: Physical Chemistry 1

Course Title	Physical Chemistry 1
Course Code	CYC511A
Course Type	Core Theory
Department	Chemistry
Faculty	Faculty of Mathematical and Physical Sciences

1. Course Summary

The aim of this Course is to introduce students to fundamentals and applications of certain aspects of Physical Chemistry.
In this Course the students are taught the laws of thermodynamics and their application to phase transformations, principles of photochemistry, electrochemistry and kinetics. They are also taught about phase equilibria, colloids, micelles and colligative properties. Emphasis is given on quantum mechanics and the occurrence of various types of molecular energy levels.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

- **CO-1.** Explain the laws of thermodynamics, concepts in photochemistry, JT effect, Raoult's law, and Henry's law to the physical transformation of substances
- **CO-2.** Discuss the theories of kinetics, concepts in quantum mechanics, phase diagram construction and electrochemistry
- **CO-3.** Illustrate quantum mechanical systems such as particle in a box, hydrogen atom, orbitals, electron systems, kinetics of complex & fast reactions
- **CO-4.** Apply the principles of chemical & enzyme kinetics to determine the energetics of chemical reactions and assess the effect of catalyst on the outcome of reaction kinetics, laws of electrochemistry to estimate chemical compounds, applications of Schrodinger wave equation and thermodynamic processes
- **CO-5.** Solve problems based on quantum mechanics and chemical/enzyme kinetics, electrochemistry, colloids, colligative properties, Phase equilibria and thermodynamics

4. Course Contents

Quantum Chemistry I:

Postulates of quantum mechanics, Schrödinger equation (time dependent & independent); Eigen

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values and Eigen functions, Numerical. Physical interpretation of wave function. Concepts of operators (Laplacian, Hamiltonian, Linear and Hermition). Commutation of operators, normalization, orthogonality and orthonormality of wave functions, Numerical. Solution of Schrödinger equation for a free particle, particle in a ring, particle in a 1D and 3D boxes, Numerical. Hamiltonian equation for hydrogen and hydrogen like atoms. Application of Schrödinger equation to harmonic oscillator, rigid rotator. Eigen functions and eigenvalues of angular momentum.

Thermodynamics I:

First law of thermodynamics: State function, Internal energy, enthalpy and heat capacity. Joule – Thomson effect, Numerical. Second law of thermodynamics: Spontaneous and reversible processes, Carnot theorem, concept of entropy, Maxwell relations, Gibb's -Helmholtz equation, Chemical potential, Clapeyron-Clausius equation, concept of activity and activity coefficient, Numerical. Third law of thermodynamics: Determination of absolute entropies, Boltzmann entropy equation, entropies of real gases.

Concepts of partial molar properties – partial molar free energy, chemical potential, partial molar volume and its significance. Gibbs-Duhem equation, Gibbs-Duhem-Margulus equation. Determination of partial molar volume: Graphical method, intercept method and Apparent molar volume method. Activity and activity coefficient: Determination of activity coefficient by EMF and solubility method, Numerical.

Chemical Kinetics:

Rate of reaction, rate law, rate constant, molecularity, order & numerical problems based on kinetic data. Rate expression of first, second and third order reactions. Methods of determining order of a reaction, half-life time of a reaction, effect of temperature and catalyst on reaction rates, mechanisms of complex reactions, collision theory of bimolecular reaction, Arrhenius equation, ACT theory, Lindeman theory, kinetics of complex reactions, chain reactions and branched chain reactions.

Kinetics of fast reactions- flow method (Plug flow method and Stopped flow method), Flash photolysis and Shock tube method.

Photochemistry:

Jablonski diagram, Fluorescence, phosphorescence, Photosensitization, and quenching and luminescence. Laws of photochemistry (Beer-Lambert's law, Grotthus-Draper law, Stark-Einstein law) and numerical. Quantum yield and numerical, photochemical processes with examples. Quantum yield of photochemical combination of (i) H_2 and Cl_2 (ii) H_2 and Br_2 (iii) dissociation of HI (iv) dimerization of anthracene.

Electrochemistry 1:

Nernst equation, redox systems, electrochemical cells; electrolytic conductance – Kohlrausch's law and its applications; transport number, ionic mobility, ionic equilibria; conductometric and potentiometric titrations, Oswald's dilution law.

Electrochemistry of solutions: Ionic atmosphere, Debye-Huckel theory for the problem of activity coefficient, Debye-Huckel limiting Law, Debye-Huckel equation for appreciable concentration, Debye-Huckel Onsagar conductance equation and its extension to ion solvent interations, Debye-Huckel Bjerrum mode, Ion association, triple ions, triple ions and conductance minima. Thermodynamics of electrified interface, derivation of electro capillary Lipmann's equation, surface excess, thermodynamic aspects of surface excess.

Phase Equilibrium:

Derivation of phase rule from the concept of chemical potential. Calculation of Phases, components and degree of freedom. Reduced phase rule. Application of Phase Rule to one (water and Sulphur), two (Pb-Ag and KI-water) and three component (CH_3COOH-$CHCl_3$-Water and (Salt A-Salt B-Water) system. High pressure systems (water and carbon). Reduced phase

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rule. Principle of triangular diagram, plots for a mixture of three liquids consisting of one, two and three pairs of partially miscible liquids.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3		2								3		
CO-2	3										3		
CO-3	3										3		
CO-4	3		2								3	2	
CO-5	3		2								3		
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		50
Demonstrations		02
1.Demonstration using Videos	02	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		08
1. Solving Numerical Problems	08	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

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The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Term Test	Assignment	Innovative	
Maximum Marks▶	50	25	25	
CO-1	X		X	X
CO-2	X		X	X
CO-3	X		X	X
CO-4		X	X	X
CO-5		X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

7. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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8. Course Resources

a. Essential Reading

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1. Class Notes
2. P. Atkins, P. J. De (2006), Atkin's Physical chemistry, 6th Edn. Oxford University Press, Noida-UP.
3. Ira Levine (2011), Physical Chemistry, 6th Edn. McGraw Hill Education (India) Pvt. Ltd., Bangalore.
4. Puri, Sharma and Pathania (2012), Principles of Physical Chemistry, 46th Edition, Vishal Publishing & Co. Jalandhar
5. Keith J. Laidler, John H. Meiser and Bryan C. Sanctuary (2002), Physical Chemistry, 4th Revised edition, Houghton Mifflin.
6. Samuel Glastone, Text book of physical chemistry, 2nd edition, Mac Millan India Ltd (1991).

b. Recommended Reading

1. K. J. Laidler, Chemical Kinetics, McGraw Hill. Inc. New York (1988).
2. McQuarie and Simon, Physical Chemistry: A Molecular Approach, Viva, New Delhi, (2001).
3. R. K. Prasad, Quantum Chemistry, New Age International, 2nd edition, (2000).
4. J. J. Bikerman, Surface Chemistry: Theory and Applications, Academic Press. New York (1972).
5. D. R. Crow, Principles and applications of Electrochemistry- 3rd edition Chapmanhall London (1988).
6. S. Glasstone, Thermodynamics for Chemists, , East-West Press, New Delhi, (1960).

c. Magazines and Journals

1. Chemistry for everyone Letters; Springer ISSN: 1610-3653 Jo. No. 10311
2. Journal of Chemical Sciences; Springer ISSN:0973-7103

d. Websites

1. http://nptel.ac.in/

e. Other Electronic Resources

1. Electronic resources on the subject area are available on MSRUAS library

9. Course Organization

Course Code	CYC511A		
Course Title	Physical Chemistry 1		
Course Leader's Name	As per Timetable		
Course Leader's Contact Details	**Phone:**	+91-804-906-5555	
	E-mail:	hod.cy.mp@msruas.ac.in	
Course Specifications Approval Date	14th July 2022		
Next Course Specifications Review Date	July 2024		

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Course Specifications: Inorganic Chemistry 1

Course Title	Inorganic Chemistry 1
Course Code	CYC512A
Course Type	Core Theory
Department	Chemistry
Faculty	Faculty of Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to introduce students to the basic and advanced concepts of Inorganic Chemistry.

The student will be introduced to the concept of atomic structure and chemical bonding. The basic chemistry of main group elements and d and f block elements would be focused on magnetic, electronic and spectral properties. Acid-Base chemistry and non-aqueous system will be elaborated. The solid state chemistry and structure of inorganic ionic compounds such as NaCl, ZnS, CsCl, CaF_2 and $CaCl_2$ will be emphasized.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Outline the principles of electron filling in the atomic orbitals, VSEPR theory, molecular orbital theory, wades rule, polymorphism, magnetic property d and f-block elements and acid-base concepts and non-aqueous solutions.

CO 2. Differentiate between VSEPR and MO theory/CFT, closo/nido/arachno boranes, structure of silicates and phosphates, electronic configuration in d and f-block elements and its consequences

CO 3. Explain with examples the industrially important compounds, inorganic molecules by VSEPR theory, structure of ionic crystals, defects in crystals, acid- base concepts, closo/nido/ arachno boranes, structure of silicates and phosphates, super heavy elements

CO 4. Discuss the structure and bonding in solids, borazines, metallocarboranes, oxyacids of nitrogen, phosphorous sulfur halogens, intercalated compounds, silicates, concepts of non-aqueous solvents, polarizability and partial covalent character

CO 5. Illustrate the potential applications of main group compounds, d and f block elements, boranes carboranes silicates phosphates, metallo carboranes and non aqueous solvents

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Dean - Academics, M.S. Ramaiah University of Applied Sciences

Dean, Faculty of Mathematical and Physical Sciences, M.S. Ramaiah University of Applied Sciences, Bangalore-560058

4. Course Contents

Atomic Structure and Chemical Bonding:
Aufbau energy diagram, Pauli's exclusion principle and Hund's rule of maximum multiplicity, Valence bond theory, Hybridization and Valence shell electron pair repulsion theory (VSEPR): crystal field theory, shapes of molecules; Molecular orbital theory: bond order, stability and magnetic properties of diatomic molecules.
Ionic Bond: Lattice energy: Born Lande equation, Born-Haber cycle, uses of Born-Haber type of calculations.
Kapustinskii equation; polarizability and partial covalent character.

Industrial important compounds of alkali and alkaline earth metals:
Hydroxides, plastaer of paris, bicarbonates, bicarbonates and metals oxides, halides, boranes, carboranes- application of Wades rule, metallocarboranes borazines; Compounds of phosphorus, sulphur and nitrogen - oxyacids of nitrogen, phosphorus, sulfur and halogens (including the ligation properties of their anions); noble gas compounds; carbon and sulphur. Silicates: classification and structures of ortho, pyro, chain, cyclic, sheet and three dimensional silicates, silica gel, alumino-silicates. Graphitic compounds – intercalation compounds with heavier alkali metals, halides, oxides, oxygen and fluorine.

d and f – Block elements - Transition elements:
Basic concepts of d-block elements electronic configuration, oxidation state, color, magnetic, catalytic properties. 3d , 4d and 5d series.
Lanthanides: Elements and their electronic configurations; oxidation states; lanthanide contraction and its consequences; magnetic properties; electronic spectral properties and colour; complex formation; isolation of lanthanides from monazite sand; separation of lanthanides using ion-exchange method.

Actinides: Elements and their electronic configuration, comparison of actinides with lanthanides – with respect to the oxidation states, electronic spectral properties and complex formation. Comparative study of f-block elements with d-block elements – with respect to oxidation states; magnetic properties and electronic spectral properties. Trans-uranium elements, further extension of periodic table, super heavy elements (SHE).

Acids, Bases and Solvents:
Review of acid- base concepts– Bronsted, Lewis and solvent system definitions of acids and bases, Strengths of hydracids, oxoacids and Lewis acids, Drago -Wayland equation for Lewis acid- Lewis base interactions, HSAB concept, Bronsted acid-base strength verses hardness and softness, symbiosis, applications of HSAB concept. Non-aqueous media – Classification of solvents, leveling effect, reactions in HF, BrF_3, N_2O_4 and molten salts, super acids. Liquid ammonia, chemical reactions of ammonia, anhydrous H2SO4, liquid dinitrogen tetroxide and Sulphur dioxide.

Solid-State Chemistry:
Basic concepts of symmetry in crystals, Bravais Lattices, miller indices, radius ratio rule Structure of ionic crystals, NaCl, ZnS, CsCl, CaF_2, $CdCl_2$.Defects and ion transport, schottky defect, Frenkel Defects, metal excess defects, metal deficiency defects, thermal defects, semiconductor chemistry.

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5. Course Map (CO-PO-PSO Map)

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	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2	3										3		
CO-3	3										3		
CO-4	3										3		
CO-5	3		2								3	2	
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		56
Demonstrations		02
1. Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	02	
3. Demonstration on a Computer	00	
Numeracy		02
1. Solving Numerical Problems	02	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

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7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

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The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent ▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks ▶	50	25	25	
CO-1	×	×	×	×
CO-2	×		×	×
CO-3	×	×	×	×
CO-4			×	×
CO-5		×	×	×
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

1. Class Notes

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2. HUHEEY, J.E. (2008) Inorganic Chemistry: Principles of Structure and Reactivity. Dorling Kindersley Pvt Ltd., Noida
3. J.D. Lee (2008) Concise Inorganic Chemistry, 5th Edn, Oxford University Press, New Delhi.
4. Shriver and Atkins, (2006) Inorganic Chemistry, WH Freeman and Company, New York.

b. Recommended Reading

1. F.A. Cotton, G. Wilkinson and P. L. Gaus, (1995) Basic Inorganic Chemistry III edition, John-Wiley and Sons, USA.
2. N.N. Greenwood and A.E. Earnshaw, (1997) Chemistry of Elements, Butterworth Heinemann, UK.
3. Jack Barrett and Mounir A. Malati, Harwood, Fundamentals of Inorganic Chemistry, (1998).
4. Catherine E. Housecroft and Alan G. Sharpe, (2001) Inorganic Chemistry, IV edition, Pearson Education Asia Pvt. Ltd. Bengaluru.

c. Websites

1. http://www-jmg.ch.cam.ac.uk/data/c2k/ci/inorganic.html
2. https://www.nature.com/subjects/inorganic-chemistry

d. Other Electronic Resources

1. http://www.freebookcentre.net/chemistry-books-download/Inorganic-Chemistry-(PDF-194p).html
2. https://ocw.mit.edu/index.htm (MIT free open Course materials)

e. http://nptel.ac.in/

10. Course Organization

Course Code	CYC512A	
Course Title	Inorganic Chemistry 1	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Organic Chemistry 1

Course Title	Organic Chemistry 1
Course Code	CYC513A
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to introduce students to various concepts of organic chemistry. Students will be able to discuss and select starting material, reactive intermediates, stereochemistry required in synthesis of organic molecules. Course focuses on carbohydrates, vitamins and heterocyclic chemistry. Emphasis is given on organic reaction mechanisms and reactive intermediates.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Discuss the principles of structure and bonding, acid base concepts, reactive intermediates, stereochemistry, vitamins and carbohydrates

CO 2. Illustrate the reaction mechanism and stereochemistry of the molecules and structural elucidation of natural products

CO 3. Identify the reagents, reactive intermediates, reaction mechanism, stereochemistry of heterocyclic compounds, carbohydrates and other molecules

CO 4. Apply the basic concepts of synthesis of heterocyclic molecules, carbohydrates, reactive intermediates for the synthesis of new molecules

CO 5. Recommend reagents, reactive intermediates, reaction mechanism, stereochemistry for synthesis of small organic molecules

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4. Course Contents

Structure and Bonding in Organic Molecules:

Review of basic principles of structure and bonding, application of acid base concepts, Aromaticity and antiaromaticity, Hückel's rule, n-annulenes, heteroannulene, fullerenes, C-60, cryptates, Bonds weaker than covalent; addition compounds, inclusion compounds, crown ethers, cyclodextrins, catenanes and rotaxanes

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Reactive intermediates:

Reactive intermediates: Generation, stability , structure, and reactivity of (1) Carbocations (2) Carbanions- (3) Carbenes (4) Free radicals and (5) Nitrene, Types of mechanism reactions, Classification of reactions.

Reactions:

Addition, Elimination and Condensation reactions: Electrophilic, Nucleophilic and Free-radical reactions of aliphatic, alkenes, alkynes, aromatics, carbonyl compounds; Various mechanisms involved; Reactivity control

Classification of reactions and mechanisms. Thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates.

Methods of determining mechanisms: Based on the structure of products, determination of the presence of intermediates, isotopic labeling, isotope effects, from stereochemical evidence.

Acids and bases: Hard and soft acids and bases. Effect of structure on the strengths of acids and bases

Stereochemistry:

Fischer, Newman, Sawhorse and flying wedge projections and their interconversions. Optical isomerism: Elements of symmetry and chirality. D-L conventions. CIP rules, R-S and M-P conventions. Cram's and Prelog's rules.

Conformational analysis: Conformational analysis of cycloalkanes: cyclobutane, cyclopentane, cychexanes (monosubstituted e.g., methyl, iso-propyl, tert-butyl and di-substituted cyclohexanes e.g., dialkyl, dihalo, diols), and cycloheptane. Nomenclature and conformations of fused rings and bridged ring systems.

Carbohydrates – I:

Introduction to carbohydrates. Classification of monosaccharides: aldoses and ketoses. Structural formulae of sugars- aldotetroses, aldopentoses and aldohexoses. Mutarotation, Configuration of aldoses and ketoses: d- and l-sugars. Cyclic structures of monosaccharides. Cyclization of hydroxyaldehydes, pyranose and furanose forms of monosaccharides. 12 Reactions of monosaccharides: esters and ether formations, formation of cyclic ketals, and acetals. Glycoside formation, enolisation, tautomerisation, epimerization and reduction. Reaction of monosaccharides with phenyl hydrazine: formation of osazones. Oxidation of monosaacharides. Reducing and non-reducing sugars. Reaction with bromine water, nitric acid and periodate. Synthesis of aldonic, uronic, aldaric acids and alditols.

Heterocyclic compounds:

Nomenclature of heterocyclic compounds. Synthesis and reactivity of five-, six- and seven-membered heterocycles containing one or more hetero atoms of nitrogen, oxygen and sulfur; Fused-ring heterocycles

Vitamins:

Biological importance and synthesis of Vitamins A, Vitamin B1 (thiamine), Vitamin B6 (pyridoxine), folic acid, pantothenic acid, riboflavin, Vitamin C, Vitamin E (α-tocopherol), Vitamin H (biotin), Vitamins K1 and K2

General biogenetic studies: classification, structural elucidation, chemistry and applications of Alkaloids, and Terpenes

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2			2								3		
CO-3			3								3		
CO-4			3								3		
CO-5	3											3	

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		55
Demonstrations		05
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	05	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

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The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent ▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks ▶	50	25	25	
CO-1	×		×	×
CO-2	×		×	×
CO-3	×	×	×	×
CO-4	×	×	×	×
CO-5		×	×	×
The details of SC1, SC2, SC3 or SC4 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

f. Essential Reading

1. Course and class notes
2. Carey and Sundberg (1990), Advanced Organic Chemistry – Part A & B, 3rd Edition, Plenum Press, New York.
3. Jerry March (2008) Advanced Organic Chemistry – Reactions, Mechanism and Structure, USA, John Wiley
4. Advanced Organic Chemistry (1990), F A Carey and R J Sundberg, New York, Plenum Press.
5. A Guide Book to Mechanism in Organic Chemistry (2000) Peter Sykes, USA, Longman.

b. Recommended Reading

1. Smith, M. B. (2013), March Advanced Organic Chemistry: Reactions, Mechanism, and Structure. 7th Edn. Wiley, New Jersey, USA.
2. R O C Norman and J M Coxon (1996) Principles of Organic Synthesis, London, Blackie Academic and Professional.
3. D Nasipuri (1999), Stereochemistry of Organic Compounds, New Delhi, New-Age International

c. Other Electronic Resources

http://nptel.ac.in/

10. Course Organization

Course Code	CYC513A	
Course Title	Organic Chemistry 1	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Instrumental Methods of Analysis

Course Title	Instrumental Methods of Analysis
Course Code	CYC514A
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to introduce students to modern instrumental methods of analysis in the field of chemistry. Students are taught the overview of modern instrumental methods for determining the structure, composition and properties of materials. Techniques which are included in the module are spectroscopic techniques such as optical, mass, electron and x-ray photoelectron spectroscopic methods, separation techniques such as chromatography including the detection techniques, microscopic techniques such as optical spectroscopy, electron spectroscopy and probe based microscopy. This module also deals with thermal characterization techniques, voltammetry techniques, radio analytical techniques and x-ray diffraction technique.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Outline the working principle and instrumentation of mass, optical, electron and X-ray and NMR spectroscopic techniques, chromatography, microscopy, thermal, X-ray diffraction, electrochemical and radio analytical techniques

CO 2. Analyze the morphology of materials using optical, electron and probe type microscopy techniques

CO 3. Interpret thermal properties of materials using TGA, DTA and DSC techniques

CO 4. Identify and analyze the appropriate chromatographic techniques for separation and analysis of chemical compounds

CO 5. Interpret the structure and/or determine concentration of chemical compounds using UV-Visible, Infrared, Raman, NMR, mass spectroscopy and voltammetry techniques.

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4. Course Contents

Spectrometric methods:

Theory, working principles and applications of Optical atomic spectroscopy (AAS and AES), UV/visible spectrometry, Molecular fluorescence/Luminescence spectrometry, Infrared Spectroscopy, Raman Spectroscopy, X-Ray Photoelectron Spectroscopy, NMR Mass spectrometry: Basic theory, instrument types including quadrupoles, ion traps, and chromatography coupling with examples of recent applications, Interpretation of mass spectrometric data

Separation techniques:
Theory, working principles, instrumentation and applications of Gas & liquid chromatography, HPLC, separation based on volatility, solubility, interactions with stationary phase, size and electrical field Detection: simple vs. specific (gas and liquid), detection as a means of further analysis (use of tags and coupling to IR and MS), electrophoresis (plates and capillary)

Microscopy:
Theory, working principles and applications of Light Microscopy: Polarizing Microscope, Reflected Light Microscopy, Electron Microscopy: Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Probe Microscopy: Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM) & Atomic Force Microscope (AFM)

Thermometric methods:
Thermogravimetric analysis, differential scanning calorimetry, differential thermal analysis

Electroanalytical Techniques:
Principles, instrumentations and applications of conductometry, potentiometry. Principles, Instrumentation and applications of voltammetric techniques such as hydrodynamic voltammetry, polarography, cyclic voltammetry, pulse voltammetry and stripping voltammetry

Radio analytical techniques- Radiometric Analysis, Isotopic dilution techniques, neutron activation analysis X-ray-diffraction analysis: Principle, instrumentation and applications

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2	3		2								2	3	
CO-3	3		2								2	3	
CO-4	3		2								2	3	
CO-5	3		2								2	3	
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		60
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

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Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks▶	50	25	25	
CO-1	×		×	×
CO-2	×		×	×
CO-3		×	×	×
CO-4	×	×	×	×
CO-5	×	×	×	×
The details of SC1, SC2, SC3 or SC4 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

1. Class Notes
2. D.A. Skoog, D.M. West, F.J. Holler, S.R. Couch (2013) Fundamentals of analytical chemistry, Cengage Learning, USA.
3. D.A. Skoog, F.J. Holler, S.R. Couch (2017) Principles of Instrumental Analysis, 7th edn, Cengage Learning, USA
4. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas (2006) Vogel's textbook of quantitative chemical analysis 6th edn, Pearson education, New Delhi.

b. Recommended Reading

1. P.S. Kalsi (2004) Spectroscopy of Organic Compounds 6th edn, New Age International Publishers, New Delhi
2. G. Svehla (2009) Vogel's Qualitative Inorganic Analysis 7th edn, Person Education Ltd, New Delhi

c. Other Electronic Resources

a. http://nptel.ac.in/

10. Course Organization

Course Code	CYC514A	
Course Title	Instrumental Methods of Analysis	
Course Leader's Name	As per Time Tables	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Physical Chemistry Laboratory

Course Title	Physical Chemistry Laboratory
Course Code	CYL515A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

This course intends to train the students to perform quantitative analysis related to physical chemistry and instrumentation.
Students are trained to determine physical and chemical properties of given samples. They are trained to analyze the results and infer appropriate conclusions based on concepts of physical and inorganic chemistry.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Setup the experimental apparatus required to achieve the stated aim
CO 2. Conduct experiments as per the standard procedures and tabulate the measured values
CO 3. Calculate the required parameters and plot the results
CO 4. Interpret and draw conclusions
CO 5.Write laboratory report as per the prescribed format.

4. Course Contents

1. Determination of pKa values of orthophosphoric acid using pH Meter.
2. Conductometric estimation of Lithium sulphate against Barium Chloride.
3. Potentiometric estimation of KI solution using standard KMnO4 solution.
4. Determine the creatinine content in the given sample using spectrophotometry.
5. Construction of phase diagram for three-component system (ethanol/ toluene/water).
6. Estimation of first order rate constant of hydrolysis of ethyl acetate by volumetry.
7. Determination of Critical Solution Temperature (CST) of phenol-water system
8. Determination of molecular weight of a polymer by viscosity method.
9. Conductometric estimation of a mixture of strong and weak acids by using a standard alkaline solution.

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10. Potentiometric estimation of acid mixture versus NaOH.
11. Kinetics of autocatalytic reaction between potassium permanganate and oxalic acid.
12. Determination of intrinsic viscosity of a given polymer using Ubbelohde viscometer.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1				3							3		
CO-2				3							3		
CO-3				3							3		
CO-4				3							3		
CO-5									3			3	3

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		60
1. Course Laboratory	60	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

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7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1, LSC2), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation			
	Component 1: CE (50% Weightage)		Component 2: SEE (50% Weightage)
Subcomponent ▶	LSC1	LSC2	50 Marks
Subcomponent Type ▶	Lab Report	Term Test	
Maximum Marks ▶	25	25	
CO-1	×	×	×
CO-2	×	×	×
CO-3	×	×	×
CO-4	×	×	×
CO-5	×	×	
The details of LSC1, LSC2 are presented in the Programme Specifications Document.			

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

1. Laboratory Manual
2. B. Vishwanathan and P.S. Raghavan (2005) Practical Physical Chemistry, VIVA Books, New Delhi

b. Recommended Reading

1. Arthur Israel Vogel, G. H. Jeffery (1989) Vogel's text book of quantitative chemical analysis, Longman Scientific & Technical, London, UK

10. Course Organization

Course Code	CYL515A	
Course Title	Physical Chemistry Laboratory	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Qualitative and Quantitative Analysis of Inorganic Compounds

Course Title	Qualitative & Quantitative Analysis of Inorganic Compounds
Course Code	CYL516A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

This course intends to train the students to perform qualitative and quantitative analysis of Inorganic compounds.

Students are trained to do the semi micro qualitative analysis of inorganic mixture containing four cations; out of which two will be rare metal ions such as W, Mo, Se, Ti, Zr, Ce, Th and V. Students will also be trained to perform quantitative analysis of inorganic compounds using volumetric and gravimetric analysis. They are trained to analyze the results and infer appropriate conclusions based on concepts of inorganic chemistry.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Setup the experimental apparatus required to achieve the stated aim
CO 2. Conduct experiments as per the standard procedures and tabulate the measured values
CO 3. Calculate the required parameters and plot the results
CO 4. Interpret and draw conclusions
CO 5.Write laboratory report as per the prescribed format.

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4. Course Contents

1. Semi micro qualitative analysis of inorganic mixture containing four cations; out of which two will be rare metal ions such as W, Mo, Se, Ti, Zr, Ce, Th and V.
   (A minimum of 4-5 salt mixture needs to be performed)
2. Preparation and quantitative analysis of hexamine cobalt (III) chloride
3. Preparation of cis and trans-dichloro bis (ethylenediamine) cobalt (III) chloride.
4. Preparation of potassium trisoxalato ferrate (III).
5. Simultaneous determination of chromium and manganese in a solution by visible spectroscopy
6. Quantitative estimation of iron and aluminum from an inorganic mixture by volumetric method followed by gravimetric method.

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7. Quantitative estimation of copper and nickel from an inorganic mixture by volumetric method followed by gravimetric method.
8. Quantitative estimation of copper and iron (as Fe_2O_3) from an inorganic mixture by volumetric method followed by gravimetric method.
9. Quantitative estimation of zinc and calcium form an inorganic mixture by volumetric method followed by gravimetric method.
10. Quantitative estimation of zinc and magnesium form an inorganic mixture by volumetric method followed by gravimetric method.

5. Course Map (CO-PO-PSO Map)

	Programme Specific Outcomes (PSOs)												
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1				3							3		
CO-2				3							3		
CO-3				3								3	
CO-4				3								3	
CO-5									3				3

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		60
1. Course Laboratory	60	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
	Total Duration in Hours	**68**

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7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1, LSC2), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation			
	Component 1: CE (50% Weightage)		Component 2: SEE (50% Weightage)
Subcomponent ▶	LSC1	LSC2	50 Marks
Subcomponent Type ▶	Lab Report	Term Test	
Maximum Marks ▶	25	25	
CO-1	×	×	×
CO-2	×	×	×
CO-3	×	×	×
CO-4	×	×	×
CO-5	×	×	
The details of LSC1, LSC2 are presented in the Programme Specifications Document.			

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

Essential Reading

1. G. Svehla (1989) Vogel's – A Text Book of Macro and Semimicro Qualitative Inorganic Analysis, 5th Edition, Longman Group Limited, London, UK

b. Recommended Reading

1. G.H. Jeffery et. al. (1989) Vogel's Text book of quantitative chemical analysis, Longman Scientific & Technical, NY, USA

10. Course Organization

Course Code	CYL516A	
Course Title	Qualitative & Quantitative Analysis of Inorganic Compounds	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
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Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Seminar 1

Course Title	Seminar 1
Course Code	CYS517A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Conduct a thorough literature review and submit a review article / scientific report
CO-2. Make a presentation to a panel of examiners

4. Course Contents

Choose the relevant research topic

Study the literature and give a seminar

Prepare a review article/ scientific report and give a presentation on the same topic

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1		2							3				3
CO-2		2							3				3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		60
1. Case Study and Presentation	60	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Industrial Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (SC1,), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation		
	Component 1: CE (50% Weightage) (Report)	**Component 2: SEE (50% Weightage)**
Subcomponent ▶	**LSC1**	
Subcomponent Type ▶	**Report**	**Presentation**
Maximum Marks ▶	**50**	**50 Marks**
CO-1	X	
CO-2		X
The details of LSC1 are presented in the Programme Specifications Document.		

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The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Literature reading
2.	Understanding	Literature reading
3.	Critical Skills	Literature reading
4.	Analytical Skills	Literature reading
5.	Problem Solving Skills	Drawing conclusions from the literature
6.	Practical Skills	Literature reading, preparation of report
7.	Group Work	
8.	Self-Learning	Literature reading, preparation of report
9.	Written Communication Skills	Preparation of report
10.	Verbal Communication Skills	Presentation of report
11.	Presentation Skills	Presentation of report
12.	Behavioral Skills	Course work
13.	Information Management	Presentation of report
14.	Personal Management	Course work
15.	Leadership Skills	---

9. Course Resources

b. Essential Reading

1. Books / Research Articles

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10. Course Organization

Course Code	CYS517A	
Course Title	**Seminar 1**	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Semester 2

Course Specifications: Physical Chemistry 2

Course Title	Physical Chemistry 2
Course Code	CYC521A
Course Type	Core Theory
Department	Chemistry
Faculty	Faculty of Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to introduce students to fundamentals and applications of certain aspects of Physical Chemistry.
In this course the students are taught the laws of thermodynamics and their applications, principles of spectroscopy, electrochemistry, and kinetics. They are also taught about macromolecules and surface chemistry. Emphasis is given on Approximate methods of quantum mechanics and numerical.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Classify the polymers, mechanisms of enzyme, chemical kinetics, adsorption isotherms, wave functions and thermodynamic functions

CO-2. Outline the chemistry & properties of polymers, mechanism & kinetics of polymerization, term symbols, perturbation theory, factors affecting surface activity and overpotential, RS and JJ-coupling. Spin-orbital interaction and term multiplicities, Zeeman effect

CO-3. Discuss the principles of quantum mechanics approximate methods, rotational, vibrational, Raman and electronic spectra, theories & kinetics of electrochemistry, corrosion of metals, polarography, amperometry, effect of various parameters on activity of catalysts/enzymes, theories of unimoleuclar reactions, radial and angular distribution function and their significance

CO-4. Apply the spectroscopic information to determine structure & properties of compounds, thermodynamic concepts & laws to determine nature of chemical interactions, various parameters which can influence catalysis to predict the surface activity/chemical reactions, electrochemical theories and properties to understand

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various electrochemical systems and quantum mechanical concepts in real life problems

CO-5. Solve numerical based on electrochemistry, polymers, quantum chemistry, spectroscopy, kinetics, thermodynamics and surface chemistry

4. Course Contents

Quantum Chemistry II:

Schrödinger equation to hydrogen atom in spherical polar co-ordinates. Solution of ϕ, θ, equation and statements of solution of R equation. Total wave functions of hydrogen atom. Quantum numbers and their characteristics. List of wave functions for few initial states of hydrogen like atoms. Diagrams of radial and angular wave functions. Radial and angular distribution function and their significance. Electron - spin, spin-orbital, anti-symmetry and Pauli-exclusion principle, Slater determinants. Numerical on effective nuclear charge. Coupling of Angular momenta. Russell-Saunders and JJ-coupling, Term symbols (both atomic and molecular). Spin-orbital interaction and explanation of term symbols. Zeeman effect. Approximate methods: Need for approximate methods. Perturbation method. Rayleigh Schrödinger perturbation theory for time-independent non-degenerate system

Spectroscopy:

Rotational spectra of diatomic and polyatomic molecules. Applications of microwave spectra, Numerical. Vibrational spectra of diatomic and polyatomic molecules. Rotation-vibration spectra of diatomic and polyatomic molecules. Raman spectroscopy, Scattering phenomena, rotational Raman spectrum of diatomic molecules, rotation-vibration Raman spectrum. Electronic spectra, Frank-Condon principle. Explanation on spectral line intensity based on Frank-Condon principle.

Chemical Kinetics II:

Enzyme kinetics – Mechanism and kinetic of enzyme catalyzed reactions, host guest interactions, derivation Michaelis-Menton equation and interpretation, Significance of Michaelis-Menten constant, Numerical. Lineweaver-Burk plots, autocatalysis and oscillatory reactions. Effects of enzyme concentration, pH, Temperature, Activators and Inhibitors on enzyme activity. Theories of unimoleuclar reactions- Perrin theory, Lindemann theory.

Surface chemistry- Types of adsorption isotherms, Effect of temperature on adsorption, Mechanical adsorption, Estimation of surface area using BET equation, Gibbs adsorption isotherm and its significance, Surface tension and surface energy, Pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Surface film on liquids (electro-kinetic phenomena), Catalytic activity of surfaces.

Electrochemistry II:

Structure of electrified interface: Electrical capacitance, Helmholtz theory, Guoy- Chapman theory, Stern model. Electrocatalysis, Valcano plots and Kinetics of electrode reactions. Overpotential: Concentration overpotential and activation overpotential, Derivation of Butler-volmer equation. Electrochemical Corrosion of metals. Polarography: Ilkovic equation, half wave potential and its significance, Amperometric titrations, types and applications.

Macromolecules:

Introduction, classification, polymerization reactions, Kinetics of addition and condensation polymerization. Molar mass of polymers, determination of molar mass of polymers – Number-average, mass-average and viscosity-average methods. Numerical problems. Conducting polymers and mechanism.

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2	3		2								3		
CO-3	3		2								3		
CO-4	3										3	2	
CO-5	2		3								3	2	
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		50
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		10
1. Solving Numerical Problems	10	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

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The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks▶	50	25	25	
CO-1	X		X	X
CO-2	X		X	X
CO-3	X		X	X
CO-4	X	X	X	X
CO-5	X	X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document..				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

1. Class Notes
2. P. Atkins, P. J. De (2006), Atkin's Physical chemistry, 6th Edn. Oxford University Press, Noida-UP.
3. Ira Levine (2011), Physical Chemistry, 6th Edn. McGraw Hill Education (India) Pvt. Ltd., Bangalore.
4. Puri, Sharma and Pathania (2012), Principles of Physical Chemistry, 46th Edition, Vishal Publishing & Co. Jalandhar
5. Keith J. Laidler, John H. Meiser and Bryan C. Sanctuary (2002), Physical Chemistry, 4th Revised edition, Houghton Mifflin.
6. Samuel Glastone (1991), Text book of physical chemistry, 2nd edition, Mac Millan India Ltd.
7. C. N. Banwell (1994), Introduction to Molecular Spectroscopy, TMH Edition.

b. Recommended Reading

1.K. J. Laidler, Chemical Kinetics, McGraw Hill. Inc. New York (1988).
2.McQuarie and Simon, Physical Chemistry: A Molecular Approach, Viva, New Delhi, (2001).
3.R. K. Prasad, Quantum Chemistry, New Age International, 2nd edition, (2000).
4.J. J. Bikerman, Surface Chemistry: Theory and Applications, Academic Press. New York (1972).
5.D. R. Crow, Principles and applications of Electrochemistry- 3rd edition Chapmanhall London (1988).
6.S. Glasstone, Thermodynamics for Chemists, , East-West Press, New Delhi, (1960).

c. Magazines and Journals

1. Chemistry for everyone Letters; Springer ISSN: 1610-3653 Jo. No. 10311
2. Journal of Chemical Sciences; Springer ISSN:0973-7103

d. Websites

1. http://nptel.ac.in/

e. Other Electronic Resources

1. Electronic resources on the subject area are available on MSRUAS library

10. Course Organization

Course Code	CYC521A	
Course Title	Physical Chemistry 2	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Inorganic Chemistry 2

Course Title	Inorganic Chemistry 2
Course Code	CYC522A
Course Type	Core Theory
Department	Chemistry
Faculty	Faculty of Mathematical and Physical Sciences

1. Course Summary

The aim of this Course is to introduce students to the basic and advanced concepts of Inorganic Chemistry. The student will be introduced to the application of group theory to understand the structure and spectroscopic properties of molecules. The coordination chemistry and reaction mechanisms therein will be elaborated. The molecular orbital theory and its importance in the chemistry of coordination complexes will be highlighted. The chemistry of several important categories of inorganic compounds such as metallocenes, metal carbonyls and compounds containing metal-metal bonds will be covered. The student will learn the principles of bio-inorganic chemistry.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Outline the principles of the character table construction, Orgel diagrams and molecular orbital theory and correlate to the crystal structures, spectroscopic and magnetic properties of coordination complexes, stereochemistry of the co-ordination numbers from 2 to 6

CO-2. Differentiate between closo/nido/arachno boranes, ligand substitution mechanism in square planar and octahedral complexes, d-d transition and charge transfer spectra

CO-3. Predict the properties of a coordination complexes from the molecular orbital theory and LFT, and explain Metal ion storage and transport properties of biological systems, Factors affecting stability constant in solution

CO-4. Discuss the concepts of group theory, chemistry of solid state materials, bonding and structures in organometallic compounds, the relevance of Orgel diagrams and transport and storage of dioxygen; haemoglobin, myoglobin and phenomenon of cooperativity, stability constants

CO-5. Illustrate the potential applications of organometallic compounds and metal complexes; gold complexes and platinum complexes in medicine; Photosynthesis; chlorophyll, PS I, PS II, Biochemical importance of NO, Role of Ca in signal transduction, porphyrins, nitrogen fixation

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4. Course Contents

Coordination Compounds and Reaction Mechanisms:
Metal – Ligand Bonding: Review of basic concepts of co-ordination chemistry. Stereochemistry of complexes with coordination Nos. 2 to 12, types of Ligands, crystal field splitting in various ligand fields, structural and thermodynamic effects of crystal field splitting- octahedral ionic radii, Jahn – Teller distortion in metal complexes and metal chelates, hydration and lattice energies, Iriving-William stability order; spectrochemical series, limitations of crystal field theory, Evidences for metal – ligand orbital overlap, LFT (ACFT), nephelauxetic series, MO theory and diagrams of octahedral complexes (including π-bonding),
Factors affecting stability constant in solution – Methods of determination of stability constant, Mechanism of substitution reactions in square planar and octahedral complexes and trans effects, Mechanisms of Redox reactions.
Determination of binary formation of stability constant by pH measurements, spectrophotometry, polarography and ion exchange methods

Spectroscopic and Magnetic properties of Transition Metal Complexes:
Spectroscopic ground states, selection rules, term symbols for dn ions, Racah parameters, Orgel, correlation and Tanabe-Sugano diagrams, spectra of 3d metal aqua complexes of trivalent V, Cr, divalent Mn, Co and Ni, $[CoCl_4]^{2-}$, calculation of Dq, B and β parameters, charge transfer spectra.
Origin and types of magnetic behaviour- diamagnetism, paramagnetism, ferro and antiferromagnetism, magnetic susceptibility and its measurement by the Guoy method, temperature dependence of magnetism – Curie and Curie-Weiss laws, types of paramagnetic behaviour – spin-orbit coupling.

Organometallic Chemistry: Classification of Organometallic compounds based on the nature of metal-carbon bond, Bonding in pi-metal complexes, Metallocenes; Metal carbonyls; Compounds containing metal-metal bonds.
Synthesis Bonding in pi-metal complexes, Metallocenes; Metal carbonyls; Compounds containing metal-metal bonds, Industrial Applications of organometallic compounds.

Symmetry and Group Theory:
Symmetry elements and symmetry operations, Definition of groups and subgroups, and group multiplication tables. Conjugate relationships, classes of operations, representation of symmetry operations as matrices, reducible and irreducible representations, characters of representations, great orthogonality theorem (without proof) and its corollaries, properties of irreducible representations. Mulliken's symbols for irreducible representations. Character tables of Cnv, Cnh, Dnh and Cn point groups (derivation of character table only for Cnv point group). Applications of character tables in vibrational, electronic spectroscopy, crystal field splitting.

Bioinorganic Chemistry:
Essential and trace elements in biological systems, metal complexes in medicine; Metal ion storage and transport; Ferritin, transferrin, oxygen transport, phenomenon of cooperativity, model systems (picket fence porphyrins), hemocyanin and hemerythrin, electron-transfer reactions; Rubredoxin, ferredoxins, cytochromes. photosystems PS I, PS II. Nitrogen fixation: bacterial nitrogenase system. Biochemical importance of NO, Role of Ca in signal transduction, porphyrins, nitrogen fixation.

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2	3										3		
CO-3	3		2								3	2	
CO-4	3										3		
CO-5	3		2								3		
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		58
Demonstrations		02
1. Demonstration using Videos	0	
2. Demonstration using Physical Models / Systems	02	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	02	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

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The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent ▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks ▶	50	25	25	
CO-1	X		X	X
CO-2	X		X	X
CO-3		X	X	X
CO-4	X	X	X	X
CO-5	X	X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

1. Class Notes
2. F. Albert Cotton (2008) Chemical Applications of Group Theory, Wiley Interscience, USA
3. HUHEEY, J.E. (2008) Inorganic Chemistry: Principles of Structure and Reactivity. Dorling Kindersley Pvt Ltd., Noida
4. J.D. Lee (2008) Concise Inorganic Chemistry, 5th Edn. Oxford University Press, New Delhi.
5. Carey and Sundberg, 1990, Advanced Organic Chemistry – Part A & B, 3rd Edn, Plenum Press, New York.
6. Shriver and Atkins, 2006, Inorganic Chemistry, WH Freeman and Company, New York.

b. Recommended Reading

1. C. E. Housecroft and Alan G. Sharpe (2008), Inorganic Chemistry, Prentice Hall, NJ, USA
2. BANNERJEE,D.(1993), Coordination Chemistry, Tata Mc Graw Hill Publishing Co., New Delhi.

c. Websites

1. http://www-jmg.ch.cam.ac.uk/data/c2k/cj/inorganic.html
2. https://www.nature.com/subjects/inorganic-chemistry

d. Other Electronic Resources

1. http://www.freebookcentre.net/chemistry-books-download/Inorganic-Chemistry-(PDF-194p).html
2. https://ocw.mit.edu/index.htm (MIT free open Course materials)

10. Course Organization

Course Code	CYC522A	
Course Title	Inorganic Chemistry 2	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Organic Chemistry 2

Course Title	Organic Chemistry 2
Course Code	CYC523A
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to introduce students to various named reactions, oxidation reduction reagents, molecular arrangements, nucleic acids and proteins.
Students will be able to analyses and select appropriate reagents, reaction conditions and synthons for synthesis of various organic molecules. Emphasis is given on natural products and their applications in various industries.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

- **CO 1.** Discuss the reactive intermediates, stereochemistry, oxidation and reduction, molecular rearrangements reaction mechanisms, pericyclic reactions, sigmatropic reactions, heterocyclic compound synthesis, named reaction, natural products, nucleic acids, protein structure and reagents in organic synthesis
- **CO 2.** Illustrate nucleophilic, electrophilic, radical reactions, specific reagents for oxidation and reduction, heterocyclic reactions and organometallic reagents
- **CO 3.** Identify heterocyclic motifs, reagents, named reaction, molecular rearrangements, stereochemistry in natural products and drug molecules
- **CO 4.** Apply named reaction, heterocyclic synthesis, and organic reagents for synthesis of natural and pharmaceutically important products
- **CO 5.** Design small organic molecules considering factors such as stereochemistry and reagents for various applications

4. Course Contents

Oxidizing and Reducing agents in Organic Chemistry:

Oxidizing Agents: Oxidation with chromium and manganese reagents (CrO_3, $K_2Cr_2O_7$, PCC, PDC, Jones reagent, MnO_2, $KMnO_4$), Pb (OAC)4, NBS, SeO_2, $KMnO_4$, OsO_4, Sommelet oxidation, Oppenauer oxidation, Fenton's reagent, Sharpless epoxidation.

Reducing Agent: Catalytic hydrogenation (homogeneous and heterogeneous, reduction by dissolving metals (Na, Pd, Mg). reduction by hydride transfer (NABH4, LiAlH4, Al-t- BuO, DIBAL-H, NaCNBH4), selectivity in, diborane as reducing agent, tributyl tinhydride, stannous chloride, Bakers yeast, Organoboron compounds.

Named Reactions: Mechanism of Named Reactions:

Arndt-eistert reaction, Baylis–Hillman Reaction, Curtius Reaction, Gabriel Synthesis, Haloform Reaction, Heck Reaction, Hell–Volhard–Zelinskii Reaction, Knoevenagel Reaction, Kolbe–Schmitt Reaction, Lossen Reaction, Mannich Reaction, McMurry Reaction, Michael Reaction, Mitsunobu Reaction, Nef Reaction, Paterno–Buchi Reaction, Robinson Annulation, Sakurai Reaction, Schmidt Reaction, Stork Enamine Reaction, Strecker Synthesis, Vilsmeier Reaction, Weiss Reaction, Wittig Reaction and its application in organic synthesis.

Molecular Rearrangements:

General mechanistic considerations, Rearrangement to electron deficient carbon; Pincol –Pinacolone, Wagner –Meerwein, Dinenone-phenol, Allylic, Rearrangement to electron deficient nitrogen; Hofmann, Curtius, Schmidt, Lossen, Beckmann, rearrangement to

electron deficient oxygen atom; Bayer-Villiger, Dakin, Rearrangement to electron rich atom; Favorskii, Wittig, Stevens, Intramolecular rearrangement; Claisen, Benzidine, Fries rearrangement.

Reagents in Organic Synthesis:

Complex Metal Hydrides, Gilman's Reagent, Lithium Dimethylcuprate, Lithium Disopropylamide (LDA), N,N'-Dicyclohexylcarbodimide (DCC), 1,3-Dithiane (Reactivity Umpolung), DDQ, Green chemistry (Phase Transfer Catalysts, Crown Ethers, Merrifield Resin), Peterson's Synthesis, Wilkinson's Catalyst, Baker Yeast.

Amino Acids and Peptides:

Synthesis and reactions of amino acids. Classification and nomenclature of peptides. Sanger and Edman methods of sequencing. Cleavage of peptide bond by chemical and enzymatic methods. Peptide synthesis- Protection of amino group (Boc-, Z- and Fmoc-) and carboxyl group as alkyl and aryl esters. Use of DCC, EEDQ, HOBt and active esters, acid halides, anhydrides in peptide bond formation reactions. Deprotection and racemization in peptide synthesis. Solution and solid phase techniques. Introduction to peptidomimetics.

Protein Structure:

Primary and secondary structure of proteins: alpha helix, beta-pleated sheet, tertiary structure of proteins: Covalent bonds, Ionic bonds, hydrogen bonds, Van der Waals bonds, repulsive forces, Relative importance of binding forces, the quaternary structure of proteins

Nucleic acids: Structure of DNA: Primary, secondary and tertiary structure of DNA, Interaction of drugs on DNA

Chemistry of Natural Products:

Carotenoids, Flavanones, Plant Pigments, Porphyrins: Prostaglandins: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule.

Pericyclic reactions:

Introduction, molecular orbital symmetry, frontier orbitals of ethylene, 1, 3-butadiene, thermal and photochemical reactions, classification of pericyclic reactions: Electrocyclic reactions, Sigmatropic reactions and Cycloaddition reactions

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (Pos)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2			2								3		
CO-3	2										3		
CO-4			3									3	
CO-5										2		3	

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		60
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

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7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

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The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks▶	50	25	25	
CO-1	X		X	X
CO-2	X		X	X
CO-3	X	X	X	X
CO-4	X	X	X	
CO-5		X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.
Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

2. Course and class notes
2. J. March (1992) Advanced Organic Chemistry, USA, John Wiley & Sons.
3. E. J. Eliel (2009) Stereochemistry of Carbon Compounds, USA, McGraw Hill.
4. Brian S. Furniss (1996) Vogel's Text Book of Practical Organic Chemistry, 5th edition, ELBS Longman.
5. Frank Settle (1997) Instrumental techniques for Analytical Chemistry, London, Prentice Hall.

b. Recommended Reading

1. S. H. Pine (1987) Organic Chemistry, USA, McGraw Hill.
2. D. Nasipuri (1994) Stereochemistry of Organic Compounds, USA, Wiley.

c. Other Electronic Resources

1. http://nptel.ac.in/

10. Course Organization

Course Code	CYC523A	
Course Title	Organic Chemistry 2	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Computational Methods in Chemistry

Course Title	Computational Methods in Chemistry
Course Code	CYC524A
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this Course is to introduce students to the concept of computational chemistry

Computational chemistry helps chemists to make predictions before running the actual experiments and to be better prepared for making observations. Students are taught the basic mathematics that are relevant to chemists. Emphasis is given on concepts of computer modeling and simulation including ab initio approaches based on quantum chemistry and empirical approaches to study the structures and properties of molecules and materials.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	4:0:0
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

- **CO-1.** Differentiate theoretical approaches such as HF(Hartree-Fock), DFT(Density Functional Theory) and force field methods
- **CO-2.** Identify various methods for simulating/modeling various scientific problems and discuss their advantages/disadvantages
- **CO-3.** Illustrate the principles of differentiation, integration and data modeling
- **CO-4.** Assess and recommend suitable computational chemistry tool for theoretical predictions
- **CO-5.** Apply semi-empirical and computational modeling to make theoretical predictions of outcome of a reaction, suitable methods for calculating electronic properties of simple molecules and crystals

4. Course Contents

Vectors and Matrices: Linear algebra, linear system, eigen values and eigen vectors, applications of matrices

Differentiation and Integration: Differential calculus with functions of single variable, different methods of evaluating integrals, Numerical integration by trapezoidal and Simpson's rule

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Data Modelling: Interpolation, curve fitting by least square method.

Hartree Self-Consistent Field method. Spin orbitals for many electron atoms symmetric and antisymmetric wave functions. Pauli's exclusion principle. Slater determinants. Qualitative treatment of Hartree-Fock Self-Consistent Field (HFSCF) method. Roothan's concept of basis functions, Slater type orbitals (STO) and Gaussian type orbitals (GTO), sketches of STO and GTO

Computational chemistry as a tool and its scope: Potential energy surface: stationary points, concept of transition state with examples, local and global minima, Hessian Matrix.
Molecular mechanics methods: force fields-bond stretching, angle bending, torsional terms, non-bonded interactions, electrostatic interactions. Mathematical expressions. Radial distribution, functions, Important features of commonly used force fields like MM3, MMFF, AMBER, OPLS and CHARMM

Ab initio methods: Hartree Self-Consistent Field method. Spin orbitals for multi electron systems symmetric and antisymmetric wave functions. Pauli's exclusion principle. Slater determinants. Qualitative treatment of Hartree-Fock Self-Consistent Field (HFSCF) method. Roothan's concept of basis functions, Slater type orbitals (STO) and Gaussian type orbitals (GTO), sketches of STO and GTO. Basis set approximation, Classification of basis sets - minimal, double zeta, triple zeta, split valence, polarization and diffuse basis sets, contracted basis sets, Pople style basis sets and their nomenclature, correlation consistent basis sets, Hartree-Fock limit. Electron correlation. Qualitative ideas on post Hartree-Fock methods-variational method, basic principles of Configuration Interaction (CI). Perturbational methods-basic principles of Møller Plesset Perturbation Theory.

General introduction to semi-empirical methods: Huckel MOT with suitable examples: ethane, propenyl and other systems, Calculation of properties- energy, delocalization energies, bond order. Introduction to Density Functional Theory (DFT) methods: Hohenberg-Kohn theorems. Kohn-Sham orbitals. Exchange correlation functional. Local density approximation. Generalized gradient approximation. Hybrid functionals (basic principles and terms). Comparison of molecular mechanics, ab-initio, and DFT methods. .

Computational Chemistry Calculations: Molecular geometry input-Cartesian coordinates and internal coordinates, Z-matrix. Z-matrix of single atom, diatomic molecule, non-linear triatomic molecule, linear triatomic molecule, polyatomic molecules. General format of GAMESS / ORCA input files. GAMESS / ORCA key word for: basis set selection, method selection, charge, multiplicity, single point energy calculation, geometry optimization, constrained optimization and frequency calculation.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)												Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3												3		
CO-2	3		2										3		
CO-3	3		2											3	
CO-4				3										3	
CO-5			3	2										3	
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution															

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		50
Demonstrations		05
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	05	
Numeracy		05
1. Solving Numerical Problems	05	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**70**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

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Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks▶	50	25	25	
CO-1	X		X	X
CO-2	X		X	X
CO-3	X		X	X
CO-4		X	X	
CO-5		X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

1. Class Notes
2. Christopher J Cramer (2004) "Essentials of computational chemistry", 2nd edition, England, John Wiley & Sons
3. Jan Jensen (2010) "Molecular modeling basics", 1st edition, Boca Raton, CRS press, Taylor & Francis Group.
4. Alan Hinchliffe (2003) "Molecular modeling for beginners", 2nd edition, England, John Wiley & Sons

b. Recommended Reading

1. Szabo & Ostlund (1996) "Modern quantum chemistry", 1st edition revised, New York, McGraw-Hill
2. Wolfeam Koch (2001) "A chemist's guide to DFT" 2nd edition, New York, Wiley-VCH

c. Magazines and Journals

1. Journal of computational chemistry
2. Journal of chemical theory and computation

d. Websites

http:// www.wag.caltech.edu/home/ch121/

10. Course Organization

Course Code	CYC524A	
Course Title	Computational Methods in Chemistry	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Computational Techniques in Chemistry

Course Title	Computational Techniques in Chemistry
Course Code	CYL525A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Faculty of Mathematical and Physical Sciences

1. Course Summary

This course intends to train the students to perform quantitative analysis related to physical and computational chemistry.

Students are trained to determine physical and chemical properties of given samples. They are trained to analyze the results and infer appropriate conclusions based on concepts of physical and inorganic chemistry.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

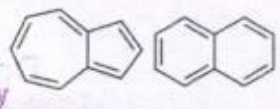
After the successful completion of this course, the student will be able to:

- **CO-1.** Plan the experimental setup to achieve the stated aim
- **CO-2.** Conduct experiments as per the standard procedures and tabulate the measured values
- **CO-3.** Calculate the required parameters and plot the results
- **CO-4.** Interpret, compare with standard results and draw conclusions
- **CO-5.** Write laboratory report as per the prescribed format

4. Course Contents

List of Experiments:

1. Draw and perform the geometry optimization of the given structures using semi-empirical method.



Azulene Naphthalene

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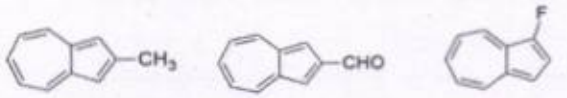
2. Calculate the HOMO-LUMO energy gaps in conjugated systems.
3. Determine the UV-Vis spectra of unsubstituted and substituted azulene structures using suitable computational methods.



2-methylazulene azulene-2-carbaldehyde 1-fluoroazulene

4. Optimize the di-atomic and tri-atomic molecules using DFT and determine the bond length, bond angle and dipole moment.
5. Perform geometry optimization and energy calculation on the following molecules. Visualize the frontier molecular orbitals and interpret the results for bonding in following molecules. Benzene, Naphthalene, and Azulene.
6. Perform the frequency analysis of given set of molecules and determine IR spectra.
7. Plot electrostatic potential map (ESP) surface of given molecule and predicts the electron rich and electron deficient sites.
8. Study the mechanism of SN2 reaction.
9. Calculate the ionization potential (IP) and electron affinity (EA) of a given set of molecules using fundamentals of conceptual DFT.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1				3							3		
CO-2				3							3		
CO-3				3								3	
CO-4				3								3	
CO-5									3				3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		60
1. Course Laboratory	60	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	

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Others		
1. Case Study Presentation	00	00
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1, LSC2) COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation			
	Component 1: CE (50% Weightage)		Component 2: SEE (50% Weightage)
Subcomponent▶	SC1	SC2	
Subcomponent Type ▶	Lab Report	Term Test	50 Marks
Maximum Marks▶	25	25	
CO-1	X	X	X
CO-2	X	X	X
CO-3	X	X	X
CO-4	X	X	X
CO-5	X		
The details of LSC1, LSC2 are presented in the Programme Specifications Document.			

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Laboratory instruction
2.	Understanding	Laboratory instructions and experiments
3.	Critical Skills	Laboratory work
4.	Analytical Skills	Laboratory work
5.	Problem Solving Skills	Laboratory work
6.	Practical Skills	Laboratory work
7.	Group Work	Laboratory work

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8.	Self-Learning	Laboratory work
9.	Written Communication Skills	Laboratory work, examination
10.	Verbal Communication Skills	Laboratory examination
11.	Presentation Skills	---
12.	Behavioral Skills	Course work
13.	Information Management	Laboratory work
14.	Personal Management	Course work
15.	Leadership Skills	---

9. Course Resources

a. Essential Reading

1. Laboratory Manual
2. Christopher J Cramer (2004) "Essentials of computational chemistry", 2nd edition, England, John Wiley & Sons
3. Jan Jensen (2010) "Molecular modelling basics", 1st edition, Boca Raton, CRS press, Taylor & Francis Group.
4. Alan Hinchliffe (2003) "Molecular modelling for beginners", 2nd edition, England, John Wiley & Sons

b. Recommended Reading

1. Szabo & Ostlund (1996) "Modern quantum chemistry", 1st edition revised, New York, McGraw-Hill
2. Wolfeam Koch (2001) "A chemist's guide to DFT" 2nd edition, New York, Wiley-VCH

c. Magazines and Journals

1. Journal of Chemical Education; ACS, ISSN: 0021-958

d. Websites

1. https://nptel.ac.in/

e. Other Electronic Resources

1. Electronic resources on the subject area are available on MSRUAS library

10. Course Organization

Course Code	CYL525A	
Course Title	Computational Techniques in Chemistry	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Qualitative and Quantitative Analysis of Organic Compounds

Course Title	Qualitative and Quantitative Analysis of Organic Compounds
Course Code	CYL526A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

This course intends to train the students to perform qualitative and quantitative analysis of organic compounds.
Students are trained to prepare some of the organic compounds and carry out the qualitative and quantitative analysis of organic compounds. They are trained to analyze the results and infer appropriate conclusions based on concepts of organic chemistry.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Setup the experimental apparatus required to achieve the stated aim
CO 2. Conduct experiments as per the standard procedures and tabulate the measured values
CO 3. Calculate the required parameters and plot the results
CO 4. Interpret and draw conclusions
CO 5.Write laboratory report as per the prescribed format.

4. Course Contents

I. Qualitative analysis of organic compounds (Any four types):

a. The Systematic analysis of a two component/three component mixture involves the following:
1. Nature of the mixture
2. Type of the mixture
3. Separation of the mixture into two/three components.

II. Systematic analysis of each component involves the following:
1. Preliminary Tests.
2. Detection of elements.
3. Detection of the functional group.
4. Physical constants. (M.P. or B.P.)
5. Conformation with preparation of derivatives.

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6. Result

II. Qualitative Analysis of organic compounds (Any two):

1. Estimation of sugar
2. Estimation of amines
3. Estimation of amine salts
4. Estimation of carboxylic acid
5. Estimation of salts of carboxylic acid

III. One pot synthesis (Any two):

1. Preparation of aspirin from salicylic acid
2. Preparation of paracetamol from p-aminophenol
3. Preparation of m-dinitrobenzene from nitrobenzene

5. Course Map (CO-PO-PSO Map)

											Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1				3							3		
CO-2				3							3		
CO-3				3								3	
CO-4				3								3	
CO-5									3				3

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		60
1. Course Laboratory	60	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	

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5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1, LSC2) COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation			
	Component 1: CE (50% Weightage)		**Component 2: SEE (50% Weightage)**
Subcomponent ▶	**SC1**	**SC2**	
Subcomponent Type ▶	**Lab Report**	**Term Test**	**25 Marks**
Maximum Marks ▶	**25**	**25**	
CO-1	X	X	X
CO-2	X	X	X
CO-3	X	X	X
CO-4	X	X	X
CO-5	X		
The details of LSC1, LSC2 are presented in the Programme Specifications Document.			

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--

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12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

9. Course Resources

a. Essential Reading

1. ARTHUR I. VOGEL, 1970, Elementary Practical Organic Chemistry Part III Quantitative Organic Analysis, England, LONGMAN.

b. Recommended Reading

1. Brian S Furniss, et al. (2005) Vogel's Text book of practical organic chemistry, 5th Edition, Pearson Education, UK

10. Course Organization

Course Code	CYC526A	
Course Title	Qualitative and Quantitative Analysis of Organic Compounds	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Seminar 2

Course Title	Seminar 2
Course Code	CYS527A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Conduct a thorough literature review and submit a review article / scientific report
CO-2. Make a presentation to a panel of examiners

4. Course Contents

Choose the relevant research topic

Study the literature and give a seminar

Prepare a review article/ scientific report and give a presentation on the same topic

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1			2						3				3
CO-2			2						3				3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		60
1. Case Study Presentation	60	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Industrial Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1) COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation		
	Component 1: CE (50% Weightage)	**Component 2: SEE (50% Weightage)**
Subcomponent ▶	**LSC1**	
Subcomponent Type ▶	**Report**	**Presentation**
Maximum Marks ▶	**50**	**50 Marks**
CO-1	X	
CO-2		X
The details of LSC1 are presented in the Programme Specifications Document.		

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The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Literature reading
2.	Understanding	Literature reading
3.	Critical Skills	Literature reading
4.	Analytical Skills	Literature reading
5.	Problem Solving Skills	Drawing conclusions from the literature
6.	Practical Skills	Literature reading, preparation of report
7.	Group Work	
8.	Self-Learning	Literature reading, preparation of report
9.	Written Communication Skills	Preparation of report
10.	Verbal Communication Skills	Presentation of report
11.	Presentation Skills	Presentation of report
12.	Behavioral Skills	Course work
13.	Information Management	Presentation of report
14.	Personal Management	Course work
15.	Leadership Skills	---

9. Course Resources

a. **Essential Reading**
1. Books / Research Articles

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10. Course Organization

Course Code	CYC527A	
Course Title	**Seminar 2**	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Semester 3

Course Specifications: Data Analysis and Statistical Inference

Course Title	**Data Analysis and Statistical Inference**
Course Code	CYC631
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

This Course aims at introducing students to data analysis and statistical inference of data obtained from different analytical techniques.
Students are taught the representation of measured data, analysis of errors involved in chemical measurements. The students are also taught the elements of statistics and probability distributions and estimation of uncertainty in analytical methods. Emphasis will be given on chemometrics which deals with the data analysis using computers.

2. Course Size and Credits:

Number of Credits	03
Credit Structure (Lecture: Tutorial: Practical)	3:0:0
Total Hours of Interaction	45
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Discuss the concepts of various types of errors, estimation of uncertainty in analytical techniques and methods for calibration of the analytical techniques
CO-2. Justify the use of data analysis and statistical treatment to analytical data in chemistry
CO-3. Apply various statistical treatment methods for the evaluation of the measured data
CO-4. Identify the sources of uncertainty in the measured data
CO-5. Analyze the analytical data to represent, preprocess, model and classify using chemometric techniques

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4. Course Contents

Introduction to statistics:
Measurements, errors in chemical analysis, precision and accuracy, mean, median, range, standard deviation, variance, central limit theorem, pooling

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Absolute error, relative error, systemic errors. Gaussian distribution, confidence intervals, comparison of means with student's T, F test, T tests with a spreadsheet, Grubbs test for an outlier, method of least squares, calibration curves and non-linear calibration curve

Statistical evaluation of analytical data:
Treatment of data, reliability of data, significant figures, rounding of data, confidence interval, one-way ANOVA, detecting outliers, Q test, p values and power, algebra and logic, hypothesis testing, formal statistical tests, one-sample T test, two-sample T test, paired T test, Fisher's F test, Duncan's multiple range test, detection limits; statistical process control; bioassays.

Evaluating measurement uncertainty for chemical testing laboratories:
Evaluation of uncertainty for chemical test results, method validation and quality control data in uncertainty estimates, confidence levels, comparisons of obtained results at different times and places, statistics for measurement of uncertainty estimation, converting data and combining uncertainties quantifying uncertainty components

Chemometrics:
Overview, methods for modeling multivariate data, chemical calibration - curve fitting multivariate data, classical and inverse analysis, regression analysis techniques include MLR, PCR and PLS, and multiway methods.
Classification methods - discriminants, unsupervised methods,
Self-modeling methods in evolving systems preprocessing and signal correction methods.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3		3	1							2		
CO-2	3		2								3		
CO-3	3		3	3							3	2	
CO-4	3										3		
CO-5	2		3	3							3	3	

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		30
Demonstrations		05
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	05	
Numeracy		10
1. Solving Numerical Problems	10	
Practical Work		00
1. Course Laboratory	00	

2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	00
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**55**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			**Component 2: SEE (50% Weightage)**
Subcomponent▶	**TSC1**	**TSC2**	**TSC3**	**100 Marks**
Subcomponent Type ▶	**Mid Term Test**	**Assignment**	**Innovative**	
Maximum Marks▶	**50**		**25**	
CO-1	X		X	X
CO-2	X		X	X
CO-3		X	X	
CO-4	X	X	X	X
CO-5	X	X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

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8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures

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2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment, Solving Numerical Problems
4.	Analytical Skills	Assignment, Solving Numerical Problems
5.	Problem Solving Skills	Assignment, Examination, Solving Numerical Problems
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

9. Course Resources

a. Essential Reading

1. Class Notes
2. D.A. Skoog, F.J. Holler, S.R. Couch (2018) Principles of Instrumental analysis, 7th edition, Cengage Learning, USA
3. J.N. Miller, J.C. Miller (2005) Statistics and Chemometrics for Analytical Chemistry, New Jersey, Prentice Hall.
4. R.G. Brereton (2018) Chemometrics, Data Driven Extraction for Science, 2nd edition, John Wiley & Sons Ltd, USA

b. Recommended Reading

1. P.C. Meier, R.E. Zünd (2000) Statistical Methods in Analytical Chemistry, 2nd Edition. Wiley, USA
2. D.A. Skoog, D.M. West, F.J. Holler, S.R. Couch (2013) Fundamentals of analytical chemistry, Cengage Learning, USA.
3. S.N. Deming, Y. Michotte, D.L. Massart, L. Kaufman, B.G.M. Vandeginste (1988) Chemometrics: A Textbook, Elsevier, Netherlands

c. Other Electronic Resources

http://nptel.ac.in/

Electronic resources on the subject area are available on MSRUAS library

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10. Course Organization

Course Code	CYC631	
Course Title	**Data Analysis and Statistical Inference**	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Advanced Analytical Chemistry Techniques

Course Title	Advanced Analytical Chemistry Techniques
Course Code	CYC632A
Course Type	Core Theory
Department	Chemistry
Faculty	Faculty of Mathematical and Physical Sciences

1. Course Summary

This Course aims at introducing students to data analysis and statistical inference of data obtained from different analytical techniques.

In this Course the advanced analytical chemistry techniques will be taught. Some of the topics include advance NMR techniques for the determination of molecular structure, qualitative and quantitative analysis of compounds by polorography, coulomery and electrogravimetry analytical techniques and analytical instruments for surface probes and chemosensors.

2. Course Size and Credits:

Number of Credits	03
Credit Structure (Lecture: Tutorial: Practical)	3:0:0
Total Hours of Interaction	45
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Discuss the concepts of NMR, polarography, surface analysis types and techniques in identification / estimation of compounds

CO 2. Elucidate the structure of molecules using UV, IR, NMR (1D and 2D) and mass spectral data

CO 3. Analyze the molecular arrangement on the surfaces of materials using mass spectroscopy by SIMS, dynamic SIMS, low-energy ion scattering and Rutherford back scattering, surface structure from SPM data

CO4. Estimate the chemicals qualitatively and quantitatively by polarography, coulometry and electrogravimetry and interpret the data obtained

CO5. Evaluate the use of chemosensors and biosensors for environmental monitoring and process control

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4. Course Contents

Advanced 1HNMR

Interaction of nuclear spin and magnetic moment, spin-spin splitting, coupling constants, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Carbon-13 NMR spectroscopy, Multiplicity-proton (1H) decoupling-noise decoupling, off resonance decoupling, selective proton decoupling. Chemical shift. DEPT 13C NMR spectra.

Basic principles of two-dimensional (2D) NMR spectroscopy, 2D line shapes, Resolved 2D spectroscopy. Correlated 2D experiments, Homo nuclear and Heteronuclear, COSY, TOCSY, NOESY, ROESY, DOSY, HETCOR, INADEQUATE.

Multinuclear 2D and 3D experiments such as HSQC, HMQC.

Application of UV, IR, NMR (1D and 2D) and Mass Spectrometry in the structural elucidation of organic compounds

Polarography

Theory, apparatus, derivative polarography, modified polarographic techniques, sinusoidal AC polarography, pulse polarography, chronopotentometry and their application in qualitative and quantitative analysis.

Coulometry: Introduction: principles, technique, coulometry at constant current and controlled potential coulometry, applications and stripping analysis. High frequency titration

Introduction: theory and instrumentation, high frequency titrimetry, types of cell. Advantages of high frequency methods, applications.

Electrogravimetry: Introduction, theory, apparatus, cell processes, deposition and separation, electrolytic separation of metals, metals which can be determined.

Surface Analysis

Auger electron spectroscopy, electron spectroscopy for chemical analysis, molecular surface mass spectrometry by SIMS, dynamic SIMS, low-energy ion scattering and Rutherford back scattering, vibrational spectroscopy from surfaces, surface structure determination by interference techniques, scanning probe microscopy, vacuum technology for applied surface science

Chemosensors and biosensors: sensors and transducers, electrochemical sensors, semiconductor devices as chemical sensors, optical chemical sensors, piezoelectric sensors, sensor signal processing, chemistry of biomolecules and their immobilization for biosensors, types of biosensors and their application - environmental monitoring, process control

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2			3									3	
CO-3			3									3	
CO-4			3									3	
CO-5			3				3					3	
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		40
Demonstrations		00
1. Demonstration using Videos	0	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		05
1. Solving Numerical Problems	05	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**55**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme

Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent ▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks ▶	50	25	25	
CO-1	X		X	X
CO-2	X	X	X	X
CO-3	X	X	X	X
CO-4	X		X	X
CO-5	X	X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

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9. Course Resources

a. Essential Reading

1. Class Notes
2. D.A. Skoog, F.J. Holler, S.R. Couch (2018) Principles of Instrumental analysis, 7th edition, Cengage Learning, USA

b. Recommended Reading

1. D.A. Skoog, D.M. West, F.J. Holler, S.R. Couch (2013) Fundamentals of analytical chemistry, Cengage Learning, USA.
2. S.N. Deming, Y. Michotte, D.L. Massart, L. Kaufman, B.G.M. Vandeginste (1988) Chemometrics: A Textbook, Elsevier, Netherlands

c. Websites

1. http://www-jmg.ch.cam.ac.uk/data/c2k/cj/inorganic.html
2. https://www.nature.com/subjects/analytical-chemistry

d. Other Electronic Resources

1. https://ocw.mit.edu/index.htm (MIT free open Course materials

10. Course Organization

Course Code	CYC632A	
Course Title	Advanced Analytical Chemistry Techniques	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Analysis of Biopharmaceuticals and Foods

Course Title	**Analysis of Biopharmaceuticals and Foods**
Course Code	CYC633A
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to introduce students the concepts of biopharmaceutical and food analysis.
The course introduces the student to the principles of chemistry relevant to biopharmaceutical and food analysis. Emphasis will be laid on the drug chemistry. Students will be introduced to the analytical techniques used in post-translational modifications of biopharmaceuticals, their physico-chemical properties and assaying of food products.

2. Course Size and Credits:

Number of Credits	03
Credit Structure (Lecture: Tutorial: Practical)	3:0:0
Total Hours of Interaction	45
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

-

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

CO-1. Discuss the methods for the therapeutic drug monitoring, methods of determining quality and purity of biopharmaceutical & food products
CO-2. Illustrate the techniques used in food analysis and to monitor the quality of biopharmaceutical products
CO-3. Outline various processes involved in biopharmaceuticals, role and methods of pigment analysis in food preservation and degradation, working principles of various instruments used in the analysis of biopharmaceutical and food products
CO-4. Analyze the impurities in biopharmaceuticals and residue of pesticide/ fumigant in diverse foods
CO-5. Identify and justify suitable analytical techniques for the evaluation of biopharmaceuticals and food products

4. Course Contents

Tumour markers for screening, early detection of cancer, diagnostic utility, monitoring response to therapy and the properties of an ideal marker. Methods available for analysis of the analytes.

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Radioactivity and its measurement.

Photometry, fluorometry, turbidimetry, osmometry, electrophoresis and immunochemical techniques.

Therapeutic drug monitoring: introduction, necessity of TDM, criteria for valid TDM, essentials for effective TDM, organization of a TDM service, effectiveness of TDM. Analytical aspects of TDM, uses of HPLC and immunoassays in TDM for measurement of serum drug concentrations. Drugs of abuse: classification, metabolic aspects and identification. Narco analysis and brain finger printing techniques.

Biopharmaceuticals: Introduction, analytical techniques to structurally monitor post translational modifications - enzyme or chemical digestion coupled with LCMS determining deamidation, glycosylation, phosphorylation, acetylation, alkylation, sulfation, glycylation, methylation, oxidation, mis-matched S-S bridges, truncation, N/C-terminal modifications.

Protein analysis and structural characterization. Carbohydrate structure – glycosylation.

Immunochemistry- biomarker assay, cell based neutralization assay, immugenicity assays, quantitative immunoassays, pharmacokinetics and toxicokinetic studies. Secondary and tertiary structure determination using analytical techniques.

Physico-chemical properties: Determination by various analytical techniques

Analysis of impurities: identification of process related impurities using LCMS/MS, GC-MS, NMR and ICP-MS to detect antibiotics, viral particles, pyrogenic substances, DNA, contaminating proteins, etc.

Food analysis: introduction, conventional, genetically modified, organic and processed foods - types of samples, storage, preservation and analysis of samples as per BIS. Analysis of coliforms, yeasts, moulds and pathogens. Analysis of moisture, fat, protein, carbohydrates, fiber and vitamins in foods

Food pigments: importance and occurrence -role of pigment analysis in food preservation and degradation. Methods of detection of various pigments. Methods of detection of permitted and non-permitted synthetic food colors.

Estimation of pesticide and fumigant residues in diverse foods by various analytical techniques

Comparison of BIS with other international standards.

5. Course Map (CO-PO-PSO Map)

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	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2	3			3		2					2	3	
CO-3	3										3		
CO-4	3			3		1					2	3	
CO-5	3			2							3		

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		40

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Demonstrations		2
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	02	
Numeracy		03
1. Solving Numerical Problems	3	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**55**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			**Component 2: SEE (50% Weightage)**
Subcomponent▶	**TSC1**	**TSC2**	**TSC3**	**100 Marks**
Subcomponent Type ▶	**Mid Term Test**	**Assignment**	**Innovative**	
Maximum Marks▶	**50**	**25**	**25**	
CO-1	X		X	X
CO-2	X		X	X
CO-3	X		X	X
CO-4	X	X	X	X
CO-5	X	X	X	X
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

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Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment, Solving Numerical Problems
4.	Analytical Skills	Assignment, Solving Numerical Problems
5.	Problem Solving Skills	Assignment, Examination, Solving Numerical Problems
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

9. Course Resources

a. Essential Reading

1. Class Notes
2. Burtis. C. A. (2008) Fundamentals of clinical chemistry, 6th Edition, Saunders, Philadelphia.
3. C. S. James, (1995) Analytical chemistry of Foods, Blackie Academic and Professional, Glasgow.
4. R. Twyeman, (2004) Principles of Proteomics, BIOS Scientific Publishers, UK
5. D.A. Skoog, D.M. West, F.J. Holler, S.R. Couch (2013) Fundamentals of analytical chemistry, Cengage Learning, USA

b. Recommended Reading

1. SergioCaroli. (2012) Analytical Techniques for Clinical Chemistry: Methods and Applications. Wiley, USA
2. Rui M. S. Cruz. (2014) Methods in Food Analysis, CRC Press, USA
3. Gary Walsh, (2003) Bio-pharmaceuticals, 2nd Edition Ed., Wiley, USA
4. JÖRG KNÄBLEIN. (2005) Modern Biopharmaceuticals. Wiley, USA
5. Sussana Wu-Pong, (2010) Biopharmaceutical and Drug Design, Springer, USA.

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c. Other Electronic Resources

http://nptel.ac.in/

Electronic resources on the subject area are available on MSRUAS library

10. Course Organization

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Course Code	CYC633A	
Course Title	**Analysis of Biopharmaceuticals and Foods**	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Environmental Analytical Chemistry

Course Title	Environmental Analytical Chemistry
Course Code	CYC634A
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to train students on how to carryout analysis of environmental pollutants.

This Course deals with the air, water and soil pollution. The emphasis is on sources, monitoring and control of pollution using modern analytical methods. Radioactive pollution is also discussed in detail. The Course will also cover various national and international environmental standards.

2. Course Size and Credits:

Number of Credits	03
Credit Structure (Lecture: Tutorial: Practical)	3:0:0
Total Hours of Interaction	45
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Identify air, water and soil of pollutants in the environment
CO 2. Apply suitable methods for pollution control
CO 3. Discuss the principles of techniques used for measurement of air, water and soil pollutants
CO 4. Suggest and evaluate the methods to remediate radioactive and other contaminants in soil and water
CO 5.Recommend techniques for measurement of soil and water pollutants in the environment

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4. Course Contents

Analytical methods for environmental monitoring: physicochemical methods for air, water and soil analysis. Evaluation of the presence of organic, inorganic, radioactive contaminants. Mobility, transformation and degradation of contaminants. Environmental impact assessment (EIA)

Air pollution: chemistry in atmosphere, pollutants, sources and classifications, dispersion of pollutants in the atmosphere, pollutant concentration and diffusion of pollutants. Particulate air pollution. Air quality criteria and emission standards. Global warming, stratospheric ozone depletion, acid rain,

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long-range transport, hazardous air pollution, urban smog Air pollution assessment: use of gas sensors in air pollution control systems (APCSS) Air pollution control measures and equipment: control of particulate emission – control of gaseous emission – flue gas treatment methods: stacks gravitational and inertial separation, settling chambers, dynamic separators, cyclones, filtration, liquid scrubbing, spray chambers, packed towers, orifice and ventury scrubbers, electrostatic precipitators, gas/solid adsorption, thermal decomposition. Modern methods & approaches of air pollution control

Water pollution: origin of waste water – types of water pollutants and their effects. Biological pollutants, physical pollutants: thermal waste, chemical pollutants: organic and inorganic – oxygen demanding substances, physiological pollutants: taste affecting pollutants.
Adverse effects on : human health and environment, aquatic life, animal life, plant life — water pollution measurement techniques – water pollution control equipment & instruments – Indian standards for water pollution control. Waste water treatment plants

Soil pollution: liquid and solid wastes – domestic and industrial wastes, pesticides, toxic: inorganic and organic pollutants, soil deterioration – poor fertility, septicity, ground water pollution, concentration of infecting agents in soil. Review of soil testing methods.
Use of non- hazardous resources in the remediation of contaminated soils. Solid waste disposal: domestic and industrial solid wastes: incineration, sanitary land field, management of careful and sanitary disposal of solid wastes.
Study of radioactive contaminants in environmental samples: determination of the distribution coefficients of radionuclides. Secondary silicate-radionuclide reactions of high-activity radioactive waste in storage conditions. Diffusion transport of radionuclides. Analytical methodologies for determining radionuclides by plastic scintillation, minimizing the generation of waste products. Radiochemical sensors use for monitoring radioactive effluents.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3						3			2	3		
CO-2	3						3				3	2	2
CO-3	3										3		
CO-4	3		2				2				3	2	2
CO-5	3		2				2				3	2	2

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		45
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**55**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2, TSC3), COs are assessed as illustrated in the following Table.

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Focus of COs on each Component or Subcomponent of Evaluation				
	Component 1: CE (50% Weightage)			Component 2: SEE (50% Weightage)
Subcomponent ▶	TSC1	TSC2	TSC3	100 Marks
Subcomponent Type ▶	Mid Term Test	Assignment	Innovative	
Maximum Marks ▶	50	25	25	
CO-1	X		X	X
CO-2	X	X	X	X
CO-3	X		X	X
CO-4	X	X	X	
CO-5	X	X	X	x
The details of TSC1, TSC2, TSC3 are presented in the Programme Specifications Document.				

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	--
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

9. Course Resources

a. Essential Reading

1. Class Notes
2. Girard, J. E. (2010) Principles of Environmental Chemistry, Second edition, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA
3. Roger N. Reeve (2002) Introduction to Environmental Analysis. John Wiley & Sons, USA

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4. Pradyot Patnaik (1997) Handbook of Environmental Analysis, CRC Press, Boca Raton, Florida,

b. Recommended Reading

1. Roger N. Reeve and John D. Barnes (1994) Environmental Analysis, John Wiley & Sons, Chichester, UK.
2. Loconto, Paul R (2006) Trace environmental quantitative analysis, Taylor and Francis, UK.
3. Fifield, F.W., and P.J. Hains., (1995) Environmental Analytical Chemistry, 1 st ed., Blackie Academic and Professional, Glasgow, UK.
4. B.S. Yadav. (2006) Recent Advances In Environmental Analysis Water Soil And Air. Adhyayan Publishers and Distributors, New Delhi.

c. Other Electronic Resources

http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm

10. Course Organization

Course Code	CYC634A	
Course Title	Environmental Analytical Chemistry	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Research Methodology

Course Title	Research Methodology
Course Code	MPF615A
Course Type	Core Theory
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of the course is to introduce students to the principles of research, research methodology and significant phases of research.
Students are taught the significant role of Literature Review in a research cycle and the expectations from good literature review as well as procedure for systematic literature review. The essential aspects of technical communication to develop desirable writing skills for the preparation of research document including research paper as well as the skills for an effective presentation are also discussed. The module also emphasizes the desirable close knit relation between innovation and concept of out of the box thinking. Students will get an insight into the privilege, honour and the associated responsibilities of a researcher.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	2:0:0
Total Hours of Interaction	30
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Describe the value, scope, relevance and mandatory steps of research as well as principles of effective research
CO-2. Discuss and demonstrate the application and utility of the Systematic approach and out of box thinking concepts for research to be effective
CO-3. Explain and apply the procedures outlined for a systematic Literature Review
CO-4. Outline the principles to prepare a well-structured research proposal and research paper
CO-5. Identify and apply the essential skills desirable for an effective technical presentation

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4. Course Contents

Foundations of Research:

Definitions of Research, Mandatory Steps in Research, Types of Research, Relevance of Research for Innovation and Technology Development, Effective Research and Self Discipline. Out of the Box Thinking and Systematic approach in Research – Transformation to Impossible Thinking, Convergent and Divergent Thinking, Generation, Evaluation and Selection of Ideas.

Literature Review:

Importance of Literature Review, Constituents of Good Literature Review, Strategies for Literature Search, Referencing, Paraphrasing, and Summarizing Academic Standards and Ethics. Statistical Methods and Data Analysis

Research Proposal:

Structure of a Good Research Proposal, Getting Started, Tips for Compilation of Good Research Proposal. Technical Communication - Research Paper for Publication- Significance of Problem Statement and its scope, Formulation of Hypothesis, Adequacy of Methodology, Significance of Presentation and Discussion of Results, Relevance and Importance of references.

Effective Presentation:

Preparation, Templates, Balance between Good Design and Good Content, Planning and Sequencing, PAMPERS (Projection, Articulation, Modulation, Punctuation, Enunciation, Repetition and Speed) rule, PEOPLE (Position & Gestures, Eye Contact, Orientation, Proximation, Looks & Appearance, and Expressions & Emotion) rule, 4P's Rule (Plan, Prepare, Practice and Present), Essentials of Effectiveness, Effective Pausing and Inclusive Answering.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3										3		
CO-2			3		3				3	3		3	
CO-3			3	3	3				3	3		3	3
CO-4			3		3				3	3		3	3
CO-5				3					3	3		3	3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures35		30
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		05
Total Duration in Hours		**35**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (TSC1, TSC2), COs are assessed as illustrated in the following Table.

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	Focus of COs on each Component or Subcomponent of Evaluation		
	Component 1: CE (50% Weightage)		Component 2: SEE (50% Weightage)
Subcomponent ▶	TSC1	TSC2	50 Marks
Subcomponent Type ▶	Term Test	Assignment	
Maximum Marks ▶	25	25	
CO-1	X		X
CO-2	X	X	X
CO-3	X	X	X
CO-4	X		X
CO-5	X		X
The details of TSC1 and TSC2 are presented in the Programme Specifications Document.			

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Classroom lectures
2.	Understanding	Classroom lectures, Self-study
3.	Critical Skills	Assignment
4.	Analytical Skills	Assignment
5.	Problem Solving Skills	Assignment, Examination
6.	Practical Skills	Assignment
7.	Group Work	Group discussions, assignment
8.	Self-Learning	Self-study
9.	Written Communication Skills	Assignment, Examination
10.	Verbal Communication Skills	--
11.	Presentation Skills	--
12.	Behavioral Skills	--
13.	Information Management	Assignment
14.	Personal Management	--
15.	Leadership Skills	--

9. Course Resources

a. Essential Reading

1. Class Notes
2. Booth, W. C, Colomb and G.G Williams., (2005) The Craft of Research, Chicago University Press, USA

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3. Willium M.K and Trochim. (2003)Research Methods, 2nd Edition, Biztantra Publicshres, New Delhi
4. Jonathan Grix. (2004) The Foundation of Research, Palgrave Macmillan; Study Guide edition, USA

b. Recommended Reading

1. Wisker Gina. (2001) The Post Graduate Research Handbook, , Palgrave Macmillan, USA.
2. Rugg G. and Petre M. (2004) The Unwritten Rules of Ph.D Research, Open University Press, UK

c. Other Electronic Resources

1. http://nptel.ac.in/

10. Course Organization

Course Code	MPF615A	
Course Title	Research Methodology	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Analytical Chemistry Laboratory 1

Course Title	Analytical Chemistry Laboratory 1
Course Code	CYL636A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

This course intends to train the students to estimate error, uncertainty, statistical analysis along with analytical chemistry.
Students are trained to determine physical and chemical properties of given samples. They are trained to analyze the results and infer appropriate conclusions based on concepts of Analytical chemistry.

2. Course Size and Credits:

Number of Credits	2
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Setup the experimental apparatus required to achieve the stated aim
CO-2. Conduct experiments as per the standard procedures and tabulate the measured values
CO-3. Calculate the required parameters and plot the results
CO-4. Interpret and draw conclusions
CO-5.Write laboratory report as per the prescribed format

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4. Course Contents

List of Experiments:

1. To determine the absolute error and relative error associated with the determination of co-efficient of viscosity of the given liquid and to check for any significant variation in the test results if the same experiment is done using two different Ostwald viscometer using t-test.
2. To verify any significant variation in results between volumetric and conductometric titration methods for measuring the concentration of a given HCl solution using standard NaOH solution (0.25 M).
3. Determine of first order reaction rate constant for acid hydrolysis of ethyl acetate. Perform regression analysis and calculate R^2 value.

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4. Estimate the amount of Calcium present in the given six samples of the same aqueous solution using EDTA and test for any outlier using Grubb's test.
5. Determine viscosity of the given liquid using two different Ostwald's viscometer and check whether any significant variation in the measurement of coefficient of viscosity of a given liquid.
6. Perform experiment to determine the concentration of potassium and sodium In the given aqueous solutions using flame photometer, and report the calculations and results. Also perform the t-test.
7. Structural Elucidation of the given compounds using the UV-Visible, FT-IR, Mass, 1D and 2D NMR spectrograms.

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1				3							3		
CO-2				3							3		
CO-3				3								3	
CO-4				3								3	
CO-5									3				3

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems		
Practical Work		60
1. Course Laboratory	56	
2. Computer Laboratory	04	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	

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5. Group Discussions	0	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1, LSC2) COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation			
	Component 1: CE (50% Weightage)		Component 2: SEE (50% Weightage)
Subcomponent▶	LSC1	LSC2	50 Marks
Subcomponent Type ▶	Lab Report	Term Test	
Maximum Marks▶	25	25	
CO-1	X	X	X
CO-2	X	X	X
CO-3	X	X	X
CO-4	X	X	X
CO-5	X		
The details of LSC1, LSC2 are presented in the Programme Specifications Document.			

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

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S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Laboratory instruction
2.	Understanding	Laboratory instructions and experiments
3.	Critical Skills	Laboratory work
4.	Analytical Skills	Laboratory work
5.	Problem Solving Skills	Laboratory work
6.	Practical Skills	Laboratory work
7.	Group Work	Laboratory work
8.	Self-Learning	Laboratory work
9.	Written Communication Skills	Laboratory work, examination
10.	Verbal Communication Skills	Laboratory examination
11.	Presentation Skills	---

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12.	Behavioral Skills	Course work
13.	Information Management	Laboratory work
14.	Personal Management	Course work
15.	Leadership Skills	---

9. Course Resources

a. Essential Reading

1. D.L. Pavia et al., (2015) Introduction to spectroscopy, Cengage LearningIndia Pvt Ltd, Noida
2. Arthur Israel Vogel, G. H. Jeffery (1989) Vogel's text book of quantitative chemical analysis, Longman Scientific & Technical, London, UK
3. J.N. Miller and J.C. Miller (2005) Statistics and Chemometrics for Analytical Chemistry, Pearson/Prentice Hall, UK.

b. Recommended Reading

1. P.S. Kalsi (2004) Spectroscopy of organic compounds, New Age International (P) Ltd, Publishers, New Delhi.

c. Magazines and Journals

1. Analytical Chemistry, ACS Publications

d. Websites

https://freevideolectures.com/course/4648/nptel-analytical-chemistry

e. Other Electronic Resources

a. Electronic resources on the subject area are available on MSRUAS library

10. Course Organization

Course Code	CYL636A	
Course Title	Analytical Chemistry Laboratory 1	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Analytical Chemistry Laboratory 2

Course Title	Analytical Chemistry Laboratory 2
Course Code	CYL637A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

This course intends to train the students to estimate error, uncertainty, statistical analysis along with analytical chemistry.

Students are trained to determine physical and chemical properties of given samples. They are trained to analyze the results and infer appropriate conclusions based on concepts of Analytical chemistry.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO 1. Setup the experimental apparatus required to achieve the stated aim
CO 2. Conduct experiments as per the standard procedures and tabulate the measured values
CO 3. Calculate the required parameters and plot the results to perform computational studies
CO 4. Interpret and draw conclusions
CO 5. Write laboratory report as per the prescribed format.

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4. Course Contents

Experiment List:

1. Estimation of acidity, alcohol and gluten in flour (water and alcohol extract)
2. Estimation of iron in flour
3. Estimation of acidity, lactone, proline, dextrose, hydroxyl methyl ferfural in honey
4. Analysis of keratin from urine sample
5. Column chromatography betacarotene and chlorophyll separation
6. Estimation of Ash and acid insoluble ash
7. Estimation of amount of crude fat in a given food sample
8. Estimation of amount of total carbohydrates in a given food sample
9. Estimation of starches, amino acids
10. Estimation of Crude fibre in foods
11. Determination of minerals-calcium, phosphorus, iron using colorimetry

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12. Estimation of vitamins- ascorbic acid, carotene, thiamine
13. Analysis of lipids- saponification value, acid value, peroxide and iodine value
14. Quantitative Determination of Protein in Foods by the Biuret Method
15. Determination of pH of soils of different locations
16. Determination of ions (potassium, sodium) by flame photometry
17. Determination of Total Hardness of a sample of water using disodium salt of EDTA
18. Determination of Dissolved Oxygen in the given water sample by Winkler's iodometric method
19. Determination of residual chlorine of the given industrialwaste water sample
20. Determination of Chemical Oxygen Demand (COD) of thegiven industrial waste water sample

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1				3								3	
CO-2				3								3	
CO-3				3								3	
CO-4				3								3	
CO-5									3				3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1. Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		60
1. Course Laboratory	60	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		00
1. Case Study Presentation	00	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Analytical Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1, LSC2) COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation			
	Component 1: CE (50% Weightage)		Component 2: SEE (50% Weightage)
Subcomponent	LSC1	LSC2	
Subcomponent Type	Lab Report	Term Test	50 Marks
Maximum Marks	25	25	
CO-1	X	X	X
CO-2	X	X	X
CO-3	X	X	X
CO-4	X	X	X
CO-5	X		
The details of LSC1, LSC2 are presented in the Programme Specifications Document.			

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Laboratory instruction
2.	Understanding	Laboratory instructions and experiments
3.	Critical Skills	Laboratory work
4.	Analytical Skills	Laboratory work
5.	Problem Solving Skills	Laboratory work
6.	Practical Skills	Laboratory work
7.	Group Work	Laboratory work
8.	Self-Learning	Laboratory work
9.	Written Communication Skills	Laboratory work, examination
10.	Verbal Communication Skills	Laboratory examination
11.	Presentation Skills	---
12.	Behavioral Skills	
13.	Information Management	Laboratory work
14.	Personal Management	
15.	Leadership Skills	---

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Head, Department of Chemistry, Ramaiah University of Applied Sciences, Bangalore - 560 058.

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Dean, Faculty of Mathematical and Physical Sciences, M.S. Ramaiah University of Applied Sciences, Bangalore-560058

9. Course Resources

a. Essential Reading

1. Laboratory Manual
2. Rui M. S. Cruz. (2014) Methods in Food Analysis, CRC Press, UK.
3. S. Suzanne Nielsen (2010) Food Analysis, Springer, USA.
4. Arthur Israel Vogel, G. H. Jeffery (1989) Vogel's text book of quantitative chemical analysis, Longman Scientific & Technical, London, UK.

b. Recommended Reading

1. S.S. Nielsen (1998) Introduction to Food Analysis, Aspen Publishers, Netherlands.

c. Magazines and Journals

The Journal of Food Composition and Analysis
Electrophoresis - Wiley Publication

d. Websites

www.iufost.org
www.ift.org

e. Other Electronic Resources

www.ninindia.org
www.cftri.res.in
www.ndb.nal.usda.gov

10.Course Organization

Course Code	CYL637A		
Course Title	Analytical Chemistry Laboratory 2		
Course Leader's Name		As per Timetable	
Course Leader's Contact Details		**Phone:**	+91-804-906-5555
		E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date		14th July 2022	
Next Course Specifications Review Date		July 2024	

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Course Specifications: Seminar 3

Course Title	Seminar 3
Course Code	CYS638A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

2. Course Size and Credits:

Number of Credits	02
Credit Structure (Lecture: Tutorial: Practical)	0:0:2
Total Hours of Interaction	60
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Conduct a thorough literature review and submit a review article / scientific report

CO-2. Make a presentation to a panel of examiners

4. Course Contents

Choose the relevant research topic

Study literature and give seminar

Prepare a review article/ scientific report and give a presentation on the same topic

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Bangalore

5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1		2							3				3
CO-2		2							3				3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		60
1. Case Study Presentation	60	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**68**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. Industrial Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation		
	Component 1: CE (50% Weightage) (Report)	**Component 2: SEE (50% Weightage) (Presentation)**
Subcomponent ▶	**LSC1**	
Subcomponent Type ▶	**Assignment**	
Maximum Marks ▶	**50**	**50 Marks**
CO-1	**X**	
CO-2		**X**
The details of LSC1 are presented in the Programme Specifications Document.		

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The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Literature reading
2.	Understanding	Literature reading
3.	Critical Skills	Literature reading
4.	Analytical Skills	Literature reading
5.	Problem Solving Skills	Drawing conclusions from the literature
6.	Practical Skills	Literature reading, preparation of report
7.	Group Work	
8.	Self-Learning	Literature reading, preparation of report
9.	Written Communication Skills	Preparation of report
10.	Verbal Communication Skills	Presentation of report
11.	Presentation Skills	Presentation of report
12.	Behavioral Skills	Course work
13.	Information Management	Presentation of report
14.	Personal Management	Course work
15.	Leadership Skills	---

9. Course Resources

a. **Essential Reading**
1. Books / Research Articles

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10. Course Organization

Course Code	CYS638A	
Course Title	**Seminar 3**	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Semester 4

Course Specifications: Internship

Course Title	Internship
Course Code	CYI641A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

Aim of The aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	0:0:4
Total Hours of Interaction	120
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	100
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Write a report on experiences during internship
CO-2. Make a presentation to a panel of examiners

4. Course Contents

Choose relevant industry/business organization/research organization/university

Undergo internship

Prepare a scientific report and give a presentation on the same topic

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Head
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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1									3				3
CO-2									3				3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		120
1. Case Study Presentation	120	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**128**

7. Course Assessment and Reassessment

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The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Industrial Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1), COs are assessed as illustrated in the following Table.

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Focus of COs on each Component or Subcomponent of Evaluation		
	Component 1: CE (50% Weightage)	Component 2: SEE (50% Weightage)
Subcomponent ▶	LSC1	
Subcomponent Type ▶	Report	Presentation
Maximum Marks ▶	50 Marks	50 Marks
CO-1	X	
CO-2		X
The details of LSC1 are presented in the Programme Specifications Document.		

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Literature reading
2.	Understanding	Literature reading
3.	Critical Skills	Literature reading
4.	Analytical Skills	Literature reading
5.	Problem Solving Skills	Drawing conclusions from the literature
6.	Practical Skills	Literature reading, preparation of report
7.	Group Work	
8.	Self-Learning	Literature reading, preparation of report
9.	Written Communication Skills	Preparation of report
10.	Verbal Communication Skills	Presentation of report
11.	Presentation Skills	Presentation of report
12.	Behavioral Skills	Course work
13.	Information Management	Presentation of report
14.	Personal Management	Course work
15.	Leadership Skills	---

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9. Course Resources

a. Essential Reading

1. Literature / Discussion with allotted supervisor/s

10. Course Organization

Course Code	CYI661A	
Course Title	Internship	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Seminar

Course Title	Seminar
Course Code	CYS641A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and give a presentation on the chosen topic.

2. Course Size and Credits:

Number of Credits	04
Credit Structure (Lecture: Tutorial: Practical)	0:0:4
Total Hours of Interaction	120
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	50
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

CO-1. Conduct a thorough literature review and submit a review article
CO-2. Make a presentation to a panel of examiners

4. Course Contents

Choose the relevant research topic

Study the literature give a seminar

Prepare a review article and present the same

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1		2										3	
CO-2		2							3				3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

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6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		120
1. Case Study Presentation	120	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		08
Total Duration in Hours		**128**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Industrial Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (SC1,), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation		
	Component 1: CE (50% Weightage)	Component 2: SEE (50% Weightage)
Subcomponent ▶	LSC1	
Subcomponent Type ▶	Report	Presentation
Maximum Marks ▶	50 Marks	50 Marks
CO-1	X	
CO-2		X
The details of LSC1 are presented in the Programme Specifications Document.		

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The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Literature reading
2.	Understanding	Literature reading
3.	Critical Skills	Literature reading
4.	Analytical Skills	Literature reading
5.	Problem Solving Skills	Drawing conclusions from the literature
6.	Practical Skills	Literature reading, preparation of report
7.	Group Work	
8.	Self-Learning	Literature reading, preparation of report
9.	Written Communication Skills	Preparation of report
10.	Verbal Communication Skills	Presentation of report
11.	Presentation Skills	Presentation of report
12.	Behavioral Skills	Course work
13.	Information Management	Presentation of report
14.	Personal Management	Course work
15.	Leadership Skills	---

9. Course Resources

a. **Essential Reading**
   1. Research Articles /Dissertation Reports / Books

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10. Course Organization

Course Code	CYS641A	
Course Title	**Seminar**	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
	E-mail:	hod.cy.mp@msruas.ac.in
Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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Course Specifications: Dissertation

Course Title	Dissertation
Course Code	CYP642A
Course Type	Laboratory Course
Department	Chemistry
Faculty	Mathematical and Physical Sciences

1. Course Summary

The aim of this module is to train a student to carry out research work.

The research work will be carried out at MSRUAS or in any other laboratory of student's choice under the supervision of a senior researcher. The duration of the research work is for six months. The student is expected to submit a dissertation and make a presentation to the examiners in the faculty.

2. Course Size and Credits:

Number of Credits	15
Credit Structure (Lecture: Tutorial: Practical)	0:0:15
Total Hours of Interaction	450
Number of Weeks in a Semester	15
Department Responsible	Chemistry
Total Course Marks	300
Pass Criterion	As per the Academic Regulations
Attendance Requirement	As per the Academic Regulations

3. Course Outcomes (COs)

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

- **CO-1.** Recognize the need for developing a new or improving an existing scientific problem through an organized survey of literature
- **CO-2.** Define scientific problem
- **CO-3.** Design and perform the experiments
- **CO-4.** Analyse the results obtained
- **CO-5.** Write a technical Report and give presentation

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4. Course Contents

Selection of topic for research
Critical review on the chosen topic
Performance of experiments
Collection of relevant data
Interpretation of data
Preparation of dissertation report and presentation of the same

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5. Course Map (CO-PO-PSO Map)

	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3
CO-1	3		3		3						3		
CO-2			3		3			3				3	3
CO-3			3	3	3			3				3	3
CO-4					3			3				3	3
CO-5						3			3	2			3
3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution													

6. Course Teaching and Learning Methods

Teaching and Learning Methods	Duration in hours	Total Duration in Hours
Face to Face Lectures		00
Demonstrations		00
1.Demonstration using Videos	00	
2. Demonstration using Physical Models / Systems	00	
3. Demonstration on a Computer	00	
Numeracy		00
1. Solving Numerical Problems	00	
Practical Work		00
1. Course Laboratory	00	
2. Computer Laboratory	00	
3. Engineering Workshop / Course/Workshop / Kitchen	00	
4. Clinical Laboratory	00	
5. Hospital	00	
6. Model Studio	00	
Others		450
1. Case Study Presentation / Solving Research Problem	450	
2. Guest Lecture	00	
3. Industry / Field Visit	00	
4. Brain Storming Sessions	00	
5. Group Discussions	00	
6. Discussing Possible Innovations	00	
Term Tests, Laboratory Examination/Written Examination, Presentations		10
Total Duration in Hours		**460**

7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. (Industrial Chemistry) Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

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The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (LSC1), COs are assessed as illustrated in the following Table.

Focus of COs on each Component or Subcomponent of Evaluation		
	Component 1: CE (33% Weightage)	Component 2: (67% Weightage)
Subcomponent ▶	SC1	
Subcomponent Type ▶	Pre-project (40 marks) and Mid Term (60 Marks) Presentation	Final Project Presentation (50 Marks), Report (100 Marks) Journal Article (50 Marks)
Maximum Marks ▶	100	200
CO-1	X	X
CO-2	X	X
CO-3	X	X
CO-4	X	X
CO-5		X
The details of LSC1 are presented in the Programme Specifications Document.		

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

S. No	Curriculum and Capabilities Skills	How imparted during the course
1.	Knowledge	Literature reading
2.	Understanding	Literature reading
3.	Critical Skills	Literature reading
4.	Analytical Skills	Literature reading
5.	Problem Solving Skills	Drawing conclusions from the literature
6.	Practical Skills	Literature reading, preparation of report
7.	Group Work	
8.	Self-Learning	Literature reading, preparation of report
9.	Written Communication Skills	Preparation of report
10.	Verbal Communication Skills	Presentation of report
11.	Presentation Skills	Presentation of report
12.	Behavioral Skills	Course work
13.	Information Management	Presentation of report
14.	Personal Management	Course work
15.	Leadership Skills	---

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9. Course Resources

a. Essential Reading

1. Research Articles / Dissertation Reports / Books
2. Lecture Sessions on individual project, Thesis Preparation delivered by the concerned Head of Department.

10. Course Organization

Course Code	CYP642A	
Course Title	Dissertation	
Course Leader's Name	As per Timetable	
Course Leader's Contact Details	**Phone:**	+91-804-906-5555
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Course Specifications Approval Date	14th July 2022	
Next Course Specifications Review Date	July 2024	

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