KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES

Panangad, Kochi- 682506, Kerala

MSc. Marine Chemistry

Syllabus

2024

Regulations, Eligibility, Scheme and Syllabus for

MSc. Marine Chemistry

(Effective from 2024 Admission onwards)

All the general rules and regulations laid down by the Kerala University of Fisheries and Ocean Studies PG Curriculum shall be applicable.

ELIGIBILITY CRITERIA.

Those students who possess B.Sc. Degree in Chemistry (Any branch) are eligible for admission to this Programme.

PROGRAMME AND SCHEME OF EXAMINATIONS

1. M.Sc. Marine Chemistry programme shall have 4 core courses and 2 core practical courses each in first three semesters along with 1 elective course in 1st semester and 2 elective courses each in 2nd semester and 3rd semesters. Of these 4 elective courses, 2 will be offered by the department and 2 open electives shall be opted by the students. During the course, students can opt one MOOC having 3 credits. In 4th semester, evaluation of project work/ dissertation will be conducted at the end of the semester.
2. There shall be external university examination of 3 hour duration for each theory courses at the end of each semester, to be conducted after the completion of 80 working days.
3. Each theory shall have 3- 4 credits and practical course 2 credits.
4. Each theory question paper may contain ten short answer types of weightage 1, four short essays out of 6 questions of weightage 5 and two long essays out of 4 questions of weightage 10.

5. Each practical examination is of 3 hour duration and shall carry 2 credits each. Attendance carries weightage 10, Lab performance weightage 20,Tests weightage 50 and Record weightage 20.
6. Project/dissertation evaluation and viva-voce shall be conducted at the end of the programme only. Project / dissertation, and viva voce shall carry 20 credits in total.
7. Combined field studies and study tours may be carried out at any time during the entire period of the programme.

EVALUATION AND GRADING

The evaluation scheme for each course shall contain two parts (a) Internal/Continuous evaluation and (b) external evaluation. 50% marks shall be given to internal evaluation and the remaining 50% to external evaluation.

Internal evaluation: The internal evaluation shall be based on pre-determined transparent system involving periodic written tests, assignments, seminars and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The weightage assigned to various components for internal evaluation is as follows.

Components of Internal Evaluation

	Component	Weightage
A	Assignment	10
B	Seminar	5
C	Attendance	5
D	Class room participation	5
D	Test	25

To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal grade.

The course teacher shall maintain the academic record of each student registered for the course, which shall be forwarded to the University, through the Director of the School.

External evaluation: The external Examination in theory courses is to be conducted by the University with question papers set by external experts. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external evaluation shall be done immediately after the examination preferably in a Centralized Valuation Camp.

GRIEVANCE CELL

Students' grievances pertaining to the award of internal marks shall be brought to the notice of the teacher concerned. In the case of failure to settle the grievances, the matter shall be placed in a three member departmental committee consisting of School director, HOD and the concerned teacher. School Director/HOD will be the chairman of the committee and the decision of the committee shall be final.

EVALUATION OF PROJECT REPORT/ DISSERTATION

In the fourth semester students need to do project work of 6 month duration, which can be done either at KUFOS or at any other scientific institutions/ university/ research centres. The project has got internal as well as external evaluation. The project will be evaluated by a committee consisting of the head of the department, internal examiner/ guide and an external examiner appointed by university authorities. The mark for internal examination is 150 and external mark is also 150 with total of 300 marks for project. Total credits allocated for the dissertation is 20. Distribution of weightage allotted for dissertation will be as follows

Internals		Externals	
Originality	25%	Project Evaluation	50%
Presentation	50%	Presentation	50%
Report	25%		

LEARNING OUTCOMES- BASED CURRICULUM FRAMEWORK

A high priority task in the context of future education development agenda in India is fostering quality higher education. Further improvement of quality of higher education is considered critical for enabling effective participation of young people in knowledge production and participation in the knowledge economy, improving national competitiveness in a globalized world and for equipping young people with skills relevant for global and national standards and enhancing the opportunities or social mobility. Sustained initiatives are required for institutionalizing an outcome-oriented higher education system and enhancing employability of graduates through curriculum reform based on a learning outcomes-based curriculum framework, improving/upgrading academic resources and learning environment, raising the quality of teaching and research across all higher education institutions; technology use and integration to improve teaching-learning processes and reach a larger body of students through alternative learning modes such as open and distance learning modes and use of MOOCs.

Other priority areas of action for fostering quality higher education include translation of academic research into innovations for practical use in society and economy, promoting efficient and transparent

governance and management of higher education system, enhancing the capacity of the higher education system to govern itself through coordinated regulatory reform and increasing both public and private sector investment in higher education, with special emphasis on targeted and effective equity-related initiatives.

The overall objectives of the learning outcomes-based curriculum framework are to:

- help formulate graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes that are expected to be demonstrated by the holder of a qualification;
- enable prospective students, parents, employers and others to understand the nature and level of learning outcomes (knowledge, skills, attitudes and values) or attributes a graduate of a programme should be capable of demonstrating on successful completion of the programme of study;
- maintain national standards and international comparability of learning outcomes and academic standards to ensure global competitiveness, and to facilitate student/graduate mobility; and
- provide higher education institutions an important point of reference for designing teaching-learning strategies, assessing student learning levels, and periodic review of programmes and academic standards

TEACHING - LEARNING PROCESS

The Learning Outcomes-Based Approach to curriculum planning and transaction requires that the teaching-learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. The outcomebased approach, particularly in the context of undergraduate studies, requires a significant shift from teacher-centric to learner-centric pedagogies, and from passive to active/participatory pedagogies. Planning for teaching therein becomes critical. Every programme of study lends itself to well-structured and sequenced acquisition of knowledge and skills. Practical skills, including an appreciation of the link between theory and experiment, will constitute an important aspect of the teaching-learning process. Teaching methods, guided by such a framework, may include: lectures supported by group tutorial work; practicum and field-based learning; the use of prescribed textbooks and e-learning resources and other self-study

materials; open-ended project work, some of which may be team-based; activities designed to promote the development of generic/transferable and subject-specific skills; and internship and visits to field sites,and industrial or other research facilities etc.

ASSESSMENT METHODS

A variety of assessment methods that are appropriate to a given disciplinary/subject area and a programme of study will be used to assess progress towards the course/programme learning outcomes. Priority will be accorded to formative assessment. Progress towards achievement of learning outcomes will be assessed using the following: time-constrained examinations; closed-book and open-book tests; problem based assignments; practical assignment laboratory reports; observation of practical skills; individual project reports (case-study reports); team project reports; oral presentations, including seminar presentation; viva voce interviews; computerised adaptive testing; peer and self assessment etc. and any other pedagogic approaches as per the context.

AIMS OF THE MASTER'S DEGREE PROGRAMME IN MARINE CHEMISTRY

The overall aims of master's degree programme in Marine Chemistry are:

- provide students with learning experiences that help instill deep interests in learning various disciplines in marine sciences including marine chemistry, biogeochemistry,marine pollution, isotope geochemistry, instrumentation techniques etc.
- develop broad and balanced knowledge and understanding of key chemical concepts, principles, and theories related to chemistry;and equip students with appropriate tools of analysis to tackle issues and problems in the field of marine chemistry
- develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in the area
- provide students with the knowledge and skill base that would enable them to undertake further studies in the subject and related areas or in multidisciplinary areas that involve chemistry and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

PROGRAMME LEARNING OUTCOMES: MSc. MARINE CHEMISTRY

After successful completion of two-year Masters programme in Marine Chemistry, the students should be able to

- Demonstrate (i) in-depth knowledge and understanding about the fundamental concepts, principles and processes underlying the chemistry and its different subfields (analytical, inorganic, organic and physical), and its linkages with related disciplinary areas/subjects (ii) the procedural knowledge that creates different types of professionals in the field of marine chemistry and related fields such as chemical industry, teaching, research, environmental monitoring, etc; (iii) practical skills related to specialisation areas within marine chemistry as well within the subfields of chemistry (analytical, inorganic, organic and physical), and other related fields of study, including broader interdisciplinary subfields (life and environmental sciences);
- Demonstrate skills in seawater analysis; analyse the chemical properties, nutrients cycles and biogeochemical interactions of the ocean.
- Use skills required for the extraction, separation and identification of various organic compounds in the marine environment.
- Understand and use various instruments in the area of marine analytical chemistry such as HPLC, IR, NMR and other spectroscopic techniques in the identification of inorganic and organic compounds.
- Employ chemical techniques relevant to academia, industry and government, and generic skills and global competencies, including relevant disciplinary knowledge and skills that enable students to undertake further studies in the field of Environmental Chemistry or multi-disciplinary areas involving chemistry, and apply standard methodology to the solution of problems in chemistry.
- Handle advanced analytical tools and softwares used in marine sample analysis to explain Marine Chemistry, Marine Pollution, Isotope geochemistry, Sediment chemistry and Diagenesis.
- Undertake hands on lab work and activities that help develop in students practical knowledge and skills, that are required for pursuing career various disciplines related to Oceanography and skills for working safely and competently in the laboratory;

- Recognize and appreciate the importance of the chemical sciences and its application in academic, industrial, economic, environmental and social contexts.

COURSE LEVEL LEARNING OUTCOMES

SEMESTER I: (Core subjects: Theoretical Chemistry, Organic Reaction Mechanism and Stereochemistry, Co-ordination Chemistry and Introduction to Marine Environment)

- Understand the theoretical and fundamental aspects of Quantum mechanics, Group theory chemical bonding and Molecular Spectroscopy.
- Provide the students the basic concepts in organic and physical organic chemistry, stereochemistry and conformational analysis
- Give the students a strong back ground in bonding in coordination compounds, theories in bonding, chemistry of lanthanides and actinides, bioinorganic chemistry and reaction mechanisms in coordination compounds.
- Provide the students a strong foundation regarding the marine Environment – focussing on the general aspects, estuaries, ocean floor and biology of the oceans.

SEMESTER II: (Core subjects: Thermodynamics, Synthetic Organic Chemistry and Chemistry of Natural Products, Molecular Spectroscopy and Marine Chemistry)

- The Course provides a deep insight into various aspects of classical and statistical thermodynamics.
- Demonstrate modern synthetic methods and synthetic strategies to learn the synthesis and bio-synthesis of natural products
- Give an introductive picture of theoretical aspects of spectroscopic techniques by focussing on the fundamentals.
- Provide students a fundamental understanding of the chemistry of the oceans – focussing on dissolved gases, major and minor elements, micro nutrients and organic compounds.

SEMESTER III: (Core subjects: Solution Chemistry, Kinetics and Photochemistry, Marine Natural Products, Instrumental Methods in Marine Chemistry and Marine Pollution)

- Familiarizes the students with various theories and mechanisms of Chemical Kinetics, Solution Chemistry and Photochemistry
- Deliver a fundamental knowledge about marine natural products, sources, classes, isolation and applications.
- Provide an understanding of the instrumental methods used in chemistry – with special focus on techniques applicable to marine analyses.
- Understand the types of pollution, categories of pollutants and monitoring strategies of marine pollution.

SEMESTER IV:

- Design research oriented project on particular context.
- Review the literature on selected topics and identify the recent advances in current research.
- Prepare the students to work as part of teams on multi-disciplinary projects.
- Design and conduct experiments, analyse and interpret data.
- Demonstrate the skill to write disseratation, and communication skill in presentation.

Kerala University of Fisheries & Ocean Studies

MSc. Marine Chemistry - Course Structure, Scheme & Syllabus

(Credit Semester System – 2024 Admission onwards)

I Semester

Course	Course Code	Course Title	L	Tutorial	P	Exam Duration	Internal (%)	External (%)	Credits
Core	MCH 2101	Theoretical Chemistry	4			3 hrs	50	50	**4**
Core	MCH 2102	Organic Reaction Mechanism and Stereochemistry	4			3 hrs	50	50	**4**
Core	MCH 2103	Co-ordination Chemistry	4			3 hrs	50	50	**4**
Core	MCH 2104	Introduction to Marine Environment	3	1		3 hrs	50	50	**3**
Practical	MCH 2105	Practical I - Quantitative Chemical Analyses			4	3 hrs	50	50	**2**
Practical	MCH 2106	Practical II – Separation and Synthetic Methods			4	3 hrs	50	50	**2**
Elective	MCH 2107	Surface Chemistry and Colloids	3			3 hrs	50	50	**3**
	MCH 2108	Analytical Chemistry							
	MCH 2109	Atmospheric Chemistry							
						Total Credits			**22**

II Semester

Course	Course Code	Course Title	L	Tutorial	P	Exam Duration	Internal (%)	External (%)	Credits
Core	MCH 2201	Thermodynamics	4			3 hrs	50	50	**4**
Core	MCH 2202	Synthetic Organic Chemistry and Chemistry of Natural	4			3 hrs	50	50	**4**
Core	MCH 2203	Molecular Spectroscopy	3	1		3 hrs	50	50	**3**
Core	MCH 2204	Marine Chemistry	3	1		3 hrs	50	50	**3**
Practical	MCH 2205	Practical III – Environmental Analyses			4	3 hrs	50	50	**2**
Practical	MCH 2206	Practical IV – Physico-Chemical Methods			4	3 hrs	50	50	**2**
Elective	MCH 2207	Biogeochemistry	4			3 hrs	50	50	**4**
	MCH 2208	Isotope Geochemistry							
	MCH 2209	Environmental Impact Assessment							
	MCH 2210	Paleo Oceanography							
Open Elective OR MOOC	OST 2201	General Oceanography	3						**3**
	OST 2202	Environment and Biodiversity							
	OST 2203	Marine Biotechnology							
	OST 2204	Marine Drugs							
	OST 2204	Climate Change and Polar							
	OST 2206	IPR and GI							
	OST 2207 (Offered by the Department)	Analytical methods in Marine Environment							
							Total Credits		**25**

III Semester

Course	Course Code	Course Title	L	Tutorial	P	Exam Duration	Internal (%)	External (%)	Credits
Core	MCH 2301	Solution Chemistry, Kinetics and	3			3 hrs	50	50	**3**
Core	MCH 2302	Marine Natural Products	4			3 hrs	50	50	**4**
Core	MCH 2303	Instrumental Methods in Marine Chemistry	3	1		3 hrs	50	50	**3**
Core	MCH 2304	Marine Pollution	3	1		3 hrs	50	50	**3**
Practical	MCH 2305	Practical V - Physicochemical			4	3 hrs	50	50	**2**
Practical	MCH 2306	Practical VI - Instrumental Techniques			4	3 hrs	50	50	**2**
Elective	MCH 2307	Marine Geochemistry	3			3 hrs	50	50	**3**
	MCH 2308	Polar Sciences							
	MCH 2309	Coastal Zone Management							
	MCH 2310	Science writing and IPR							
Open Elective	OST 2301	Coastal Oceanography	3			3 hrs	50	50	**3**
	OST 2302	Ornamental Fishes and Aquarium Management							
	OST 2303	Fundamentals of Molecular Biology							
	OST 2304	Instrumentation techniques							
	OST 2305	Marine Geology							
	OST 2306	Food safety and Quality							
						Total Credits			**23**

IV Semester

Course	Course Code	Course Title	L	P	Exam Duration	Internal (%)	External (%)	Credits
Core		Dissertation			3 hrs	50	50	**20**
							Total Credits	**20**
							Total Credits for the whole Programme (22+25+23+20)	**90**

SEMESTER I

MCH 2101: Theoretical Chemistry

Credits: 4

Module I Quantum Mechanics

Introductory Concepts (Failure of Classical mechanics – Uncertainty principle), the postulates of quantum mechanics: Wave function postulate- well behaved functions, orthogonality and orthonormality. Operator postulate- Laplacian and linear operators. Angular momentum operators and commutators. Hamiltonian operator and its properties. Eigen value postulate eigen value equations and eigen functions. Expectation value postulate. Postulate of time dependent Shrodinger equation. Solution of Schrodinger wave equation for a free particle, particle on a ring, particle in1D box, particle in 3D box, separation of variables, degeneracy. One dimensional Harmonic oscillator- Complete solution. Hermite polynomials, recursion formula, features of the wave functions. Hydrogen like systems, wave functions of hydrogen like systems.

Module II Symmetry and Groups

Symmetry and Character table: Symmetry elements and symmetry operation, Point groups, Multiplication of operations, Group multiplication table, Similarity transformation and classification of symmetry operation, Matrix representation of point group. Reducible and Irreducible representations. The Great Orthogonality theorem. Rules derived from GOT (proof not required). Setting up of character table of C_{2v},C_{3v} and C_{2h} groups. Direct product representations.

Module III Chemical Bonding

LCAO-MO theory- MO theory of H_2^+ and H_2.treatment of other homo diatomic molecules Li_2, Be_2, B_2, C_2, N_2, O_2 and F_2. MO treatment of hetero diatomic molecules LiH, CO, NO and HF. Spectroscopic term symbols for homo diatomic molecules. Valance bond theory of H_2. Quantum mechanical treatment of SP, SP^2 and SP^3 Hybridisation.

HMO theory of conjugated π-systems. Bond order and charge density calculations. Free valance. Application of HMO method to ethylene, allyl system, butadiene and benzene.

Module IV Fundamentals of Spectroscopy

Origin of spectra, regions of electromagnetic spectra and origin of spectra, intensity of absorption, influencing factors, Beer lamberts' law, signal to noise ratio, natural line width, Doppler broadening, Born Oppenheimer approximation, Basics of rotational, vibrational and electronic spectroscopy.

Course Outcome	**Cognitive Level**
Understand the inadequacy of classical mechanics and the origin of quantum mechanics.	U
Identify the operator formulation of quantum mechanics.	R
Solve and derive Schrodinger equation.	E
Apply the principles of quantum mechanics to particle in a box, harmonic oscillator and rigid rotor	A
An insight to chemical bonding and group theory	U
Deriving hybridization of molecules using group theory	A
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)	

References

1. P.W. Atkins and J de Paula. Physical Chemistry, 9thedn., Oxford University Press, 2010
2. A.K. Chandra. Introductory Quantum Chemistry, 3rdedn., McGraw Hill, 1989.
3. C.N.Banwell. Fundamentals of Molecular Spectroscopy, 12thedn., Tata McGraw Hill,1992.
4. H.B. Gray. Electrons and Chemical Bonding, Benjamin, 1965.
5. R.S. Drago. Physical Methods in Inorganic Chemistry, Affiliated East West Press, 1965.
6. M.C. Day and J.Selbin. Theoretical Inorganic Chemistry 3rdedn., Van Nostrand – Reinhold, 1976

7. J.E. Huheey, E.A.Keiter, and R.L.Keiter. Inorganic Chemistry – Principles of Structure and Reactivity, Harper Collins College Publ., 1993.

MCH 2102: Organic Reaction Mechanism and Stereochemistry

Credits: 4

Module I Basic Concepts in Organic Chemistry

Review of basic concepts in organic chemistry: bonding, hybridisation, MO picture, inductive effect, electromeric effect, resonance effect, hyper conjugation, steric effect. Concept of aromaticity: delocalization of electrons - Hückel's rule, criteria for aromaticity, examples of neutral and charged aromatic systems - annulenes. Anti- and homo-aromatic systems- Fullerenes, Carbon nanotubes and Graphene. Mechanism of electrophilic and nucleophilic aromatic substitution reactions with examples. Arenium ion intermediates. SN1, SN2 and Benzyne mechanisms.

Module II Physical Organic Chemistry

Energy profiles. Kinetic versus thermodynamic control of product formation, Hammond postulate, kinetic isotope effects with examples, Hammet equation, Taft equation. Catalysis by acids and bases with examples from acetal, cyanhydrin and ester formation and hydrolysis reactions-AAC2, AAC1, AAL1, BAC2 and BAL1 mechanisms. Solvent effect. Bulk and specific solvent effects. Introduction to carbon acids, kinetic and thermodynamic acidity. Hard and soft acids and bases - HSAB principle and its applications. Photoreactions of carbonyl compounds: Norrish reactions of ketones. Paterno- Buchi reaction, Barton, Di-π-methane and photo Fries rearrangements.

Module III Stereochemistry of Organic Compounds

Introduction to molecular symmetry and chirality – examples from common objects to molecules, Centre of chirality – molecules with C, N, S based chiral centres, Absolute configuration, enatiomers, diastereomers, racemic modifications, R and S nomenclature using Cahn -Ingold – Prelog rules.

Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic

compounds, spiranes, exocyclic alkylidenecycloalkanes. Topicity and prostereoisomerism.

Geometrical isomerism: E-Z nomenclature, methods of determination of geometrical isomers, Interconversion of geometrical isomers.

Module IV Conformational Analysis

Conformational descriptors – factors affecting conformational stability of molecules.Conformational analysis of acyclic and cyclic systems – substituted ethanes, cyclohexane and its derivatives, Fused and bridged bicyclic systems – decalins, adamantane, norbornane.

Conformation and reactivity of elimination – dehalogenation, dehydrohalogenation, semipinacolic determination, pyrolytic elimination – Saytzeff and Hoffmann eliminations substitution and oxidation of secondary alcohols; Chemical consequences of conformational equilibrium – Curtin Hammett principle.

No.	**Course Outcome**	**Cognitive Level**
1.	To predict the mechanisms of different molecular Rearrangements	An
2.	Describe reaction mechanisms in terms of energetics, reaction kinetics, and thermodynamics.	U
3.	Evaluate the yield of a particular product in a mixture under a set of condition.	E
4.	Assign R/S and E/Z notation for stereoisomers and to distinguish between enantiomers and diastereomers.	E
5.	Distinguish between various kinds of chirality, and to predict the stereochemistry of cycloaddition reaction.	A
6.	Distinguish between stereoselective and stereospecific Reaction.	S
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. E.L. Eliel, S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley &Sons, 1994.
2. F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th Edn., Springer, 2007.
3. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2004.
4. D. Nasipuri, Stereochemistry of Organic Applications, 3rd Edn., New Age Pub., 2010.
5. P.S.Kalsi: Stereochemistry, Conformation and Mechanism, 7th Edn., New Age Publ., 2008
6. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, Academic Press, 2002.
7. J. March, M.B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edn., Wiley, 2007.
8. P.J, Grratt, Aromaticity, John Wiley & Sons Incorporated, 1986
9. D.G. Morris, Stereochemistry, RSC, 2001.
10. A. Fleming, Frontier Orbitals and Organic Chemical Reactions, Wiley, 1976.
11. S. Sankararaman, Pericyclic Reactions-A Text Book, Wiley VCH, 2005.
12. L. Kuerti, B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press, 2005.

MCH 2103: Coordination Chemistry

Credits: 4

Module I Bonding in coordination compounds

Structure of coordination compounds with coordination number 1 to 8; examples of higher coordination numbers; isomerism in coordination compounds, chelate effect.VSEPR Theory**:** Valence Shell Electron Pair Repulsion Theory-stereochemical rules and explanation of the shapes of molecules and ions of non-transition elements with 2-7 valence shell electron pairs.

Module II Metal-ligand bonding in transition metal complexes

Crystal field splitting diagrams in complexes of low symmetry; ligand field theory, molecular orbital theory of octahedral complexes, Spectrochemical and Nephelauxetic series; thermodynamic and structural effects; site selection in spinels, Jahn-Teller effects and distortions; experimental evidence for metal-ligand orbital overlap; Limitation of crystal field theory, molecular orbital theory.

Module III Lanthanides and Actinides

Spectral and magnetic properties, Term symbols of Lanthanide ions, Use of lanthanide compounds as Shift reagents.Comparative evaluation of co-ordination chemistry of lanthanides and actinides with reference to electronic spectra and magnetic properties.

Module IV Bioinorganic Chemistry

Metal ions in Biology, Molecular mechanism of ion transport across membrane ,ionophores ,photosynthesis, PSL, PSH, nitrogen fixation, oxygen uptake proteins, cytochormes and ferrodoxins.

Module V Reaction mechanism

Reaction mechanism in coordination compounds; thermodynamic and kinetic stability, equilibrium constants, formation constants, lability, inert complexes,

kinetics of substitution reactions in octahedral and square planar complexes, trans effect – theories of trans effect, atom transfer reactions; electron transfer reactions- inner sphere mechanism- Taube mechanism, outer sphere mechanism - Marcus equation.

No.	Course Outcome	Cognitive Level
1.	Predict the isomers possible for the metal complexes	An
2.	. Explain the stability of metal complexes	U
3.	Comprehend the bonding in transition metal complexes using crystal field theory, ligand field theory, and M.O. theories	U/A
4.	Explain inert and labile complexes and mechanism of reactions	U/An
5.	Predict the structure of the complexes from their magnetic moment values	A
*Remember (R), Understand (U), Apply (A), Analyse (An),Evaluate (E), Create (C), Skill (S)		

References

1. J.E. Huheey, E.A. Keiter and R. L. Keiter. Inorganic Chemistry: Principles of structure and reactivity, 4th Edition, Addison Wesley Publ. Co., 1993 (Chapter 11, 12, 13 and 15).

2. F.A. Cotton, G. Wilkinson and P.L. Gaus. Basic Inorganic Chemistry, 3rd Ed., John Wiley 1995.

3. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Ed. Wiley Eastern, New Delhi, 1999 (4th and 5th eds. preferred)

4. D.F. Shriver and P.W. Atkins. Inorganic Chemistry, 5th Ed., Oxford University Press, 2010

5. D. Banerjea. Coordination Chemistry, 3rd Ed, Tata McGraw – Hill, New Delhi. 2009

6. N.N. Greenwood and A. Earnshaw. Chemistry of the Elements, 2nd Ed. Pergamon Press, Exeter, Great Britain, 1997.

7. J.D. Lee. Concise Inorganic Chemistry, 5th Ed. Chapman and Hall, 1996.

8. G. Rodgers. Introduction to coordination, solid state and descriptive Inorganic chemistry,

3rd Ed. McGraw–Hill, 2012.

9. Bodie Douglas, Darl McDaniel and John Alexander. Concept and Models of Inorganic

Chemistry, 3rd Ed. J Wiley, 2006.

10. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong. Shriver and Atkins

Inorganic Chemistry, Oxford University Press, 2006.

11. Sutton, D. Electronic Spectra of Transition Metal Complexes, McGraw-Hill: New York, 1968

12. Mabbs, F.E. and Machin, D.J. Magnetism and Transition Metal Complexes Chapman andHall: U.K, 1973.

MCH 2104: Introduction to Marine Environment

Credits: 3

Module I General Introduction

Dimensions of ocean, Physical properties of Seawater, Sea Water Density, Compressibility Effects, Water Column Stability, T - S Diagrams, Surface Density Distributions, Horizontal, Vertical and Seasonal Temperature Distributions, Surface Salinity Distributions, Vertical Profiles of Salinity, Vertical Distribution of Density, Sound Transmission in the Sea, tides and tidal currents in shallow seas, estuaries and rivers.

Module II Estuaries

Classification and nomenclature; tides in estuaries; estuarine circulation and mixing; depth –averaged and breadth – averaged models; sedimentation in estuaries; salinity intrusion in estuaries; effect of stratification; coastal pollution; mixing and dispersal of pollutants in estuaries and near-shore areas; coastal zone management.

Module III The Ocean floor

General topography of the ocean floor, continental shelves, slopes, submarine canyons, submarine ridges and trenches. Morphologic and tectonic domains of the ocean floor. Structure and composition of oceanic crust - hydrothermal vents- chemical and biological significance of hydrothermal vents systems. Ocean margins and their significance; geochronology of oceanic sediments, Mineral resources.

Module IV Sea as a Biological Environment

Classification of the marine environment and marine organisms – plankton, nekton, benthos – marine ecosystems, marine food web, trophic structure - primary and secondary production and factors influencing them. Physico-chemical factors affecting marine life – light, temperature, salinity, pressure, nutrients, dissolved gases; adaptation and biological processes.

Module V Marine Ecology

Nekton and fisheries oceanography, Benthic organisms; coastal marine communities and community ecology – estuaries, coral reefs and mangrove communities, deep-sea ecology including hydrothermal vent communities.

No.	Course Outcome	Cognitive Level
1.	Introduction about the world oceans and basic physical properties of ocean and seawater, which includes vertical and spatial distribution of temperature, salinity, density, sound transmission etc.	An
2.	In-depth knowledge of estuarine environment around us, its classification, circulation pattern etc.	U
3.	Assessment of coastal pollution, the importance of coastal regions and coastal zone management.	An
4.	Introduce the students into topography ocean floor, which also includes hydrothermal vents and different types sediment deposition.	U
5.	Information about micro and macro living things in oceanic waters and benthic environment. It also deals with ecological structure in the ocean.	A
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. J. W. Nybakken, Marine Biology – An Ecological Approach, 5th Ed., Addison Wesley Longman Inc., 2001.

2. A. C. Duxbury, A. B. Duxbury, K. A. Sverdrup, An Introduction to World Oceans, 6th Ed., McGraw-Hill, 2000.

3. E. P. Odum, Fundamentals of Ecology, Nataraj Publishers, 1996.

4. T. Garrison, Oceanography, 2nd Ed., Wadsworth Publishing, 1995.

MCH 2105 Quantitative Chemical Analyses (Practical)

Credits: 2

1. Separation and estimation of simple binary mixtures of metal ions in solutions
2. Titrimetric estimations:
    1. Complexometric titrations using EDTA for the estimation of Ca, Mg, Zn, Ni, hardness of water.
    2. Redox titrations with ceric sulphate, dichromate and permanganate for the estimations of ferrous iron, zinc, arsenous oxide and sodium oxalate.
3. Estimations of
    1. Phenol, salicylic acid, aspirin, aniline and sulphanilic acid (Bromate-bromide method)
    2. Glucose and sucrose (Fehling's method)
    3. Acids and esters in a mixture
    4. Carboxylic acids and carboxylic groups (iodometric method)
    5. Iodine value and saponification value of vegetable oils
    6. Estimation of Nitrogen (Kjeldhal's method)

No.	Course Outcome	Cognitive Level
1.	Predict the results and identify errors associated with a chemical analysis based on the analytical technique and nature of the sample	U/A
2.	Analyse and accurately determine the concentration of analyte in a given sample using conventional analytical laboratory techniques	An
3.	Evaluate experimental data using statistical and error analysis methods	E
4.	Communicate results of chemical analyses and report the relative error associated with these results	A
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. J.Bassett, R.C.Denney,G.H. Jeffery and J. Mendham. Vogel's Text Book of Quantitative Inorganic Analysis, 5thedn. Longman Scientific and Technical, 1989.

2.B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R Tatchell. Vogel's textbook of Practical Organic Chemistry, 5thedn, Longman Scientific and Technical, 1989

3. Mann and Saunders. Practical Organic Chemistry,4thedn, Orient Longman, 2004.
4. F.J. Welcher, Standard Methods of Chemical Analysis: Vol. 2, R.E. Kreiger Pub., 2006.
5. G. Pass, H. Sutcliffe, Practical Inorganic Chemistry, Chapman & Hall, 1974.
6. J.R. Adams, J.R. Johnson, J.F. Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979.
7. I.M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic analysis, 3rd Edn., McMillian, 1968.

MCH 2106 Separation and synthetic methods (Practical)

Credits: 2

1. Separation and Identification of organic binary mixtures
    1. Separation of components by physical and chemical methods
    2. Purification of components by suitable method
    3. Characterization of functional groups, if any, by systematic analysis
    4. Preparation and purification of solid derivative
    5. Determination of physical constants

2. Preparation of organic compounds involving nitration, sulphonation, halogenisation oxidation, diazotisation, Friedel – Crafts reaction, Claisen condensation, Grignard reaction, benzoin condensation, Benzilic acid rearrangement and catalytic hydrogenation

3. Chromatographic techniques : Column Chromatography, Paper chromatography, Thin layer chromatography

4. Synthesis and Characterization (Metal content and interpretation of IR and electronic spectra) of Inorganic complex compounds (common transition metals and common oxygen, nitrogen or sulphur donor ligands organometallic compounds.

No.	Course Outcome	Cognitive Level
1.	Learn how to handle organic chemicals, glassware and precautions to be taken for safety in a chemistry lab	U
2.	Able to separate the components from a mixture using suitable methods and analyse the components using various reagents and reactions	U/A
3.	Able to perform experiments individually and gain knowledge about principles and techniques involved in various experiments	An
4.	Evaluate the properties of synthesized compounds through spectroscopic and analytical data	U/An/E
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham. Vogel's Text Book of Quantitative Inorganic Analysis, 5thedn., Longman Scientific and Technical, 1989
2. A.I. Vogel. Practical Organic Chemistry, ELBS, 1994
3. Mann and Saunders. Practical Organic Chemistry,4thedn, Orient Longman, 2004
4. G. Pass and H. Sutcliffe. Practical Inorganic Chemistry 2ndedn., Science Paperbacks,1985
5. K. Nakamoto. Infrared and Raman Spectra of Inorganic and Coordination Compounds 6thedn. Wiley-Interscience, 2009.
6. J.R. Adams, J.R. Johnson, J.F. Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979.
7. F.J. Welcher, Standard Methods of Chemical Analysis: Vol. 2, R.E. Kreiger Pub., 2006

MCH 2107 Surface Chemistry and Colloids

Credits: 3

Module I Surface Chemistry:

Different types of surfaces. Properties of surface phase. Thermodynamics of surface.

Examination of surfaces using ESCA, Auger, SEM and STM.Surface tension of solutions.

Gibb's adsorption equation and its verification.Surfactants and miscelles. Surface films: different types, Surface pressure and Surface potential, and their measurements and interpretation. The Gas- solid inter phase. Types of adsorption. Heat of adsorption, The Langmuir theory kinetic and statistical derivation. Multilayer adsorption- the BET theory and Harkins- Jura theory.

Module II Surfactants:

Structure of surfactants in solution; critical micellation concentration (CMC); temperature dependence; influence of chain length and salt concentration; surfactant parameter. Emulsions: macro- and micro-emulsions; aging and stabilization of emulsions; Phase behaviour of micro emulsions. Vesicles, lipid bilayer membrane.

Module III Colloids:

Types of colloids, Stability and zeta potential, Properties of colloids, Kinetic, optical and electro kinetic properties. Electrophoresis, Electro osmosis, spontaneous aging of colloids, Coagulation or flocculation, Donnan membrane equilibrium and its applications.

No.	Course Outcome	Cognitive Level
1.	To introduce the concepts of adsorption and desorption	U
2.	To explain many of the proposed hypotheses of surfaces in terms of fundamental concepts	A
3.	To understand different surface analysis techniques	U
4.	To acquire the knowledge about the preparation and properties of colloids and emulsions	A
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References:

1. P.W. Atkins, Physical Chemistry, ELBS, 1994.
2. D.A. McQuarrie, J.D. Simon, Physiacl chemistry: A Molecular Approach, University Science Books, 1997
3. A.W. Adamson, A.P. Gast, Physical Chemistry of Surfaces, 6th Edn., John Wiley & sons, 1997.

MCH 2108 Analytical Chemistry

Credits: 3

Module I Vacuum and Gas Pressure

Concepts of vacuum (Low, medium, high and ultra-high vacuum; vacuum pumps and gauges; pressure measurements;); kinetic theory concepts (molecular density; mean free path of particles in the gas phase; incident molecular flux on surfaces; gas exposure; sticking coefficient; surface coverage; variation of parameters with pressure).

Module II Over layers and Diffraction

Two-dimensional lattice; reciprocal space; over layer structure; low energy electron diffraction (LEED).

Module III Imaging and Depth Profiling

Basic concepts in surface imaging; Secondary Electron Microscopy (SEM); Secondary Auger Microscopy (SAM); Scanning Probe Microscopy (SPM); Scanning Tunneling Microscopy (STM); Transmission Electron Microscopy (TEM); surface imaging; depth profiling. Associated techniques of microscopy and spectroscopy.

Module IV Chemical Analysis

Non-destructive techniques: Wavelength and energy dispersive X-ray fluorescence spectroscopy (WDS and EDS); X-ray absorption spectroscopy (XANES and EXAFS); secondary ion mass spectrometry (SIMS); temperature programmed desorption (TPD); thermal desorption spectroscopy (TDS). Destructive techniques: Atomic absorption spectroscopy (AAS); inductively coupled plasma-atomic emission spectroscopy (ICP-AES).

Module V Electro analytical Techniques

Voltametry; Coulometry; Amperometry; Potentiometry; Polarography; Electrolytic conductivity; Impedance spectroscopy.

No.	Course Outcome	Cognitive Level
1	Understand the basic concepts of kinetic theory of gases, interactions and parameters governing their distribution	U/E
2	discuss the fundamentals of crystallography such as overlayers and diffraction	An/E
3.	Know and understand the basics of surface imaging (SEM, SAM, SPM, STM and TEM) and depth profiling techniques.	An/A
4.	Provide thorough understanding of non- destructive and destructive trace elemental analytical techniques	A/An
5	Gain strong knowledge about electrochemical tools in qualitative and quantitative analysis.	A/An

References: -

1. R. Wiesendanger, Scanning Probe Microscopy and Spectroscopy, Cambridge University Press, 1994.
2. Frank A. Settle, Handbook of instrumental techniques for analytical chemistry, Prince Hall, New Jersey, 1997.
3. K. W. Kolasinski, Surface science: Foundations of catalysis and nanoscience, John Wiley and Sons, West Susses, 2002.
4. D. A. Skoog, D. M. West, F. J. Holler and S. R. Couch, Fundamentals of analytical chemistry. Brooks/Cole Cengage learning, New Delhi, 2004.
5. P. Atkins and J. de Paula, Atkins' physical chemistry, 8th Ed., Oxford University Press, New Delhi, 2008.
6. T. Pradeep, Nano: The essentials, McGraw-Hill Education, New Delhi, 2010.
7. F. Scholz, Electro analytical Methods, Springer, 2nd Ed., 2010.

MCH 2109 Atmospheric Chemistry

Credits: 3

Module I Introduction

Gas laws and properties, black body radiation and radiation laws -Atmospheric Composition andStructure: Chemical composition of earth's atmosphere Major and minor constituents, Vertical structure, Lifetimes, radiation balance – Carbon, Oxygen, Nitrogen and Sulphur cycles. of the Atmosphere – temperature regulation in the thermosphere, stratosphere and troposphere. Radiation balance and Green houseeffect, global warming- climate past and future.

Module II Fundamentals of Atmospheric Chemistry

Biogeochemical cycles of Carbon, Oxygen, Nitrogen and Sulphur cycles, halogen and trace element cycles- Photochemical processes – photo dissociation and ionisation, Reactions of electronically excited species, Chemical kinetics – Unimolecular, bimolecular, and termolecular reactions. Condensed-phase, surface and heterogeneous reactions.

Module III Atmospheric Aerosols

Sources, sinks and physical and chemical properties, Formation, growth and transformations of aerosols, Aerosol-cloud interactions, Stratospheric Aerosols, Aerosol climate feedbacks

Module IV Stratospheric Chemistry

Chapman model, Hox, Nox, CIox cycles, chemical mechanisms of polar ozone depletion, Anthropogenic impacts: Oxygen only chemistry, reaction scheme, Chapman layers. Influence of trace constituents – catalytic cycles, Null cycles, holding cycles and reservoirs, natural sources and sinks of catalytic species. Heterogeneous and homogenous chemistry. Consequences of ozone perturbation, ozone variations and trends.

No.	Course Outcome	Cognitive Level
1.	Module I gives basic information about the origin, composition and reactions of the atmospheric gases and its influence global climatic changes.	Understand
2.	Module II discuss about the most important atmospheric gases such as Carbon, Nitrogen, Oxygen Sulphur and its importance in global biogeochemical cycle. The basics of photochemical reactions in atmospheric environment also discussed here.	Understand
3.	The role of aerosols in different components of atmosphere was discussed in module III. It also gives information about the source, faith and transport of aerosols.	Analyse
4.	The module introduces the different types of catalysts which have influence on the atmospheric trace gas transport and global climatic changes.	Analyse
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. R.P. Wayne. Chemistry of Atmospheres, Oxford University Press (2000)

2. P.V. Hobes. Introduction to Atmospheric Chemistry, Cambridge University Press (1999)

3. Nigel Bunce Environmental Chemistry, WuerzPublising Ltd. (1991).

4. Jacob, Daniel. Introduction to Atmospheric Chemistry . Princeton University Press, 1999

5. Seinfeld J.H and Pandis S.N, Atmospheric Chemistry and Physics ,2ndEd.,John Wiley andSons,Inc.,2006

SEMESTER II

MCH 2201: Thermodynamics

Credits: 4

Module I Classical Thermodynamics

Extensive and intensive properties - state functions and path functions - types of processes -Zeroth law of thermodynamics. internal energy and enthalpy, Joule-Thomson effect –second law of thermodynamics - spontaneous processes - Entropy: Definition –entropy a state function - Third law of thermodynamics: Nernst heat theorem.

Module II Spontaneity and Equilibrium

Condition for equilibrium and spontaneity under constraints, Driving force for natural changes.The properties of A and G,Gibbs energy of real gases, temperature dependence of the Gibbs energy

Module III Irreversible Thermodynamics

Simple examples of irreversible processes. General theory of non-equilibrium processes.Entropy production from heat flow. Matter flow and current flow. The phenomenological relations. Onsager reciprocal relation, Application of irreversible thermodynamics to diffusion. Thermal diffusion, Thermo osmosis and thermo molecular pressure difference, electro kinetic effects, the Glansdorf-Prigogine equation. Far from equilibrium region. Principle of minimum entropy production. Thermodynamic analysis of stability. Stability criterion and Le-Chatelier Braun Principle.

Module IV Statistical Thermodynamics

Microstates. Concept of ensemble Canonical and Grand Canonical ensemble. Maxwell Boltzmann distribution.Quantum statistics: Bose Einstein

Statistics ,Thermodynamic probability, Fermi- Dirac Statistics, Relation between Maxwell Boltzmann, Bose Einstein and Fermi -Dirac Statistics The Partition functions. Partition function for free linear motion, for free motion in a shared space, for linear harmonic vibration. Complex partition functions and partition function for particles in different force fields. Langevin's partition function and its use for the determination of dipole moment.

Module V Bioenergetics

Coupled reactions, ATP and its role in bioenergetics, high energy bond, free energy and entropy change in ATP hydrolysis, thermodynamic aspects of metabolism and respiration, glycolysis, biological redox reactions.

No.	Course Outcome	Cognitive Level
1.	Explain fundamental thermodynamic properties, energy and entropy concept of the systems, and solve the problems behind it.	U/A
2.	Describe fundamental idea on the way of the distribution of particles, the relation between thermodynamic properties and partition function and statistical interpretation of various thermodynamic properties.	U
3.	Become familiar with postulates, entropy production, thermal osmosis, thermoelectric phenomena and Onsager relations of irreversible thermodynamic processes.	U
4.	Investigate the role of thermodynamic process in various metabolic pathways of living cells and find the queries and answers behind it.	An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. C. Kalidas, M.V. Sangaranarayanan. Non-equilibrium thermodynamics, Macmillan
India, 2002

2. K.M. Botham, D.K Granner, P. A. Weil, D. Bender and V.W. Rodwell. Harper's Illustrated Biochemistry, Tata McGraw Hill, 2015.

3. Tinoco, K. Sauer, J.C. Wang and J.D. Puglisi. Physical Chemistry: Principles and

Applications in Biological Science, 5thedn, Prentice Hall, 2013

4. F.W. Sears and G.L. Salinger.Thermodynamics, kinetic theory and statistical thermodynamics, 3rdedn, Addison Wesley, 1998.

5. J. Kestin, and J.R. Dorfman.A course in Statistical Thermodynamics, Academic
Press, 1971.

6. P.W. Atkins and J de Paula. Physical Chemistry, 9thedn., Oxford University Press, 2010

7. F.W. Sears. Thermodynamics, Kinetic Theory of Gases and Statistical Thermodynamics, 3rdedn, Addision Wesley, 1978.

8. G.W. Castellan. Physical Chemistry, 3rdedn, Addison Wesley, 1983

9. F. Daniels and R.A. Alberty. Physical Chemistry 6thedn., John Wiley, 1984

10. T.L. Hill. Statistical Thermodynamics, Addison Wesley, 1986.

MCH 2202: Synthetic Organic Chemistry and Chemistry of Natural Products

Credits: 4

Module I Alkaloids and Bio Organic Chemistry

Total synthesis of quinine, morphine and reserpine. Nucleic Acids: types of nucleic acids - DNA& RNA polynucleotide chain. Components - biological functions. Structure and role of (genetic code) DNA and RNA (Nucleotides only) Biosynthesis of Cholesterol

Module II Proteins

Peptides and their synthesis - synthesis of tripeptide. Merrifield synthesis, Determination of tertiary structure of proteins, Bio-synthesis of proteins.

Module III Modern Synthetic Methods, Reactions and Reagents

Principles and synthetic processes involving phase transfer catalysis, (Nitriles from Alkly halides, Alcohol from Alkyl halides) polymer supported reagents (synthesis of oligo saccharides), (micro oven, esterification, deacetification and hydrolysis).

Synthesis of simple organic molecules using standard reaction like acetylation alkylation of enamines and active methylene compounds, Grignard reactions, Phosphorus and sulphur ylides Robinson annulation, Diels Alder reactions, protection and deprotection of functional groups (R- OH, R-CHO, RCO-R, R-NH2 and R-COOH).

Uses of the following reagents: DCC, Trimethylsilyliodide, 1, 3-Dithiane (umpolung), diisobutylaluminimumhydride (DIBAL), 9BBN, Trimethylsilylchlorode.

Module IV Planning Organic Synthesis and Retrosynthetic Analysis

(Synthesis of the following target molecules: longifolene, cubane, 5-hexenoic acid, trans-9-methyl I-decalone, bicyclo (4,1,0) heptan-2 one and onocerin.

An introduction to retrosynthesis - Synthon, Synthetic equivalent, Target molecule, Functional group interconversion - Disconnection approach - One group disconnection - Disconnection of alcohols, olefins and ketones - Logical and illogical disconnections, Two group disconnection -

1,2 - 1,3 - 1,4 - 1,5 - and 1,6 - deoxygenated skeletons and dicarbonyls. Retro Diels Alder reaction - pericyclic reactions - Retrosynthesis of some heterocycles containing two nitrogen atoms.

Module V Heterocycles, Vitamins and Steroids

Imidazole, oxazole, thiazole, flavones, isoflavones, anthocyanins, pyrimidines (cytocine and Uracil only) and purines (adenine.Guanine only). Synthesis of parent and simple alkyl or aryl susbstitution derivatitives are expected. Synthesis of vitamin A1 (Reformatsky and Wittig reaction methods only).Conversion of cholesterol to progesterone, estrone and testosterone.

No.	**Course Outcome**	**Cognitive Level**
1.	Acquires the ability to design reactions	U
2.	Acquires the knowledge to transform molecules using functional group interconversion	A
3.	Interpret the structure-function relationships of the proteins, and nucleic acids	E
4.	Relate the structure of DNA with its function in Replication and gene expression that include both transcription and translation	U
5.	Explain the reactivity and other properties of heterocyclic compounds	U/An
6.	Develop synthetic strategies for heterocyclic compounds.	An/E
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References:

1. Guide book to Organic synthesis by Ramond K. Mackie and David M. Smith, ELBS Publication.

2. Chemistry of alkaloids by Pelletier.

3. Introduction to Alkaloids by G.A. Swan

4. Organic Chemistry V Edition, 1986, VolII by I.L. Finar, ELBS Publication

5. Outlines of Biochemistry V Edition by Eric E. Conn, Paul. R. Stumpf, George Bruening and Roy H. Dole, John Wiley and Sons.

6. Principles of Biochemistry General aspects by L. Smith, Robert L. Hill I. Robert Lehman, Robert J. Let Rowitz, Philip Handlar and Abrahim white. McGraw Hill Int. (7th Edition)

7. Biochemistry by LubertStryer, WH. Freeman and Co., New York

8. Chemistry of organic natural products by Agarwal, Geol Publishing House.

9. Organic synthesis by R.E. Ireland, Prentice Hall of India, Geol Publishing House.

10. Principles of Organic synthesis by R.O.C. Norman, Champan and Hall, NY, 1980.

11. Advanced Organic Chemistry by Francis. A. Carey Richard J. Sundberg, 3rd Edition, Plenum, Press, New York, 1990.

12. Advanced Organic Chemistry by Jerry March, IV edition Wiley Eastern Ltd., New Delhi.

13. Organic Chemistry, 6th Edition, 1992. RT.Morrison, R.S. Boy, Prentice Hall of India Pvt. Ltd., New Delhi.

14. Micheal B. Smith, Organic Syntheis, McGraw Hill, International Editor, 194.

15. Stuart Warren, Work book for organic synthesis, The Disconnection Approach John Wiley & Sons (Asia) Pvt. Ltd.,

16. W. Carruther, Jain Coldham, Modern Methods of organic synthesis, 4th Edition.

MCH 2203: Molecular Spectroscopy

Credits: 3

Module I Vibrational spectroscopy

Infrared Spectroscopy, interpretation of infrared spectra, functional group absorptions, FT-IR - advantages and disadvantages, Near & far IR spectroscopy , applications of IR spectroscopy.

Module II Raman spectroscopy

Classical and quantum theory, Comparison of IR and Raman spectra – complementary nature and mutual exclusion principle, applications of Raman spectroscopy.

Module III Ultraviolet/Visible/Fluorometric Spectroscopy

Energy level and selection rules; effect of substituents, conjugation, conformation and geometry;Woodward-Fisher & Fisher-Kuhn rules, applications in structure determination; Derivative spectroscopy, Fluorescence spectroscopy, factors affecting fluorescence & intensity; applications.

Module IV Resonance Spectroscopy

Nuclear Magnetic Resonance-1H-NMR spectroscopy- chemical shifts, diamagnetic shielding, hybridization effects, magnetic anisotropy, mechanism of spin-spin coupling, the origin of spin-

Spinsplitting, Pascal's triangle, coupling constant, magnetic equivalence, failure of the N+1 rule, Theory of Chemical shift and spin – spin coupling, AB, AX, ABC, AMX patterns; chemical shift reagents, spin decoupling methods, Nuclear Overhauser Effect (NOE) , Introduction to 1H-1H cosy and its applications. Introduction and applications of 2D NMR; solid state NMR, magnetic imaging.

13C-NMR spectroscopy: Introduction, Chemical shift, peak assignments, 1H decoupled spectra (off resonance, selective 1H decoupling, 1H noise decoupling); chemical shift; chemical shift equivalence; Hetero 2D NMR techniques: HMBC, HMQC.

Spectrometry of other important nuclei Introduction to 15N, 19F, 31P, basic concepts.

Electron Spin Resonance Spectroscopy- Introduction, derivative curves, g values, hyperfine splitting, ESR spectra of free radicals, applications.

Module VI Mass Spectrometry, CD & ORD

Basic principle and theory; Analysis of mass spectrum, HRMS and advantages spectra of representative compounds, recognition of molecular ion peak, metastable peak, isotopic peaks, applications.

Optical Rotatory Dispersion and Circular Dichroism Definition, cotton effect and stereochemistry, octant rule and applications.

No.	**Course Outcome**	**Cognitive Level**
1.	Understand the interaction light with matter and the key concepts of spectroscopy to probe the structure of molecule	U
2.	Identify the relationship between molecular spectra and molecular properties	A
3.	Evaluate the utility of various spectroscopy as a qualitative and quantitative method	E
4.	To expose the students to a level of handling experimental techniques using modern instrumentation	A
5.	Apply the data obtained from sophisticated instruments like FTIR, NMR, UV-Vis, Fluorescence and mass spectrometers for the structure determination and chemical analysis	A
6.	Able to predict the sign of ORD/CD of optically active Compounds	A
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. Silverstein RM and Webster FX. Spectrometric Identification of Organic Compounds. John Wiley and Sons, New York. Latest Edition.

2. Chatten LG. Pharmaceutical Chemistry, Vol. I & II. Marcel Dekker, New York. Latest Edition.

3. James WD and Kenneth HT. Analytical Chemistry by Oipen Learning: Thermal Methods. John Wiley and Sons, New York. Latest Edition.

4. Abraham RJ, Fisher J and Bftus P. Introduction to NMR Spectroscopy. John Wiley and Sons, New York. Latest Edition.

5. Pavia DL, Lampman GM and Kriz GS. Introduction to Spectroscopy. Harcourt College Publishers, Orlando. Latest Edition.

6. Atta-Ur Rahman's volumes on Natural products and spectroscopy.

MCH 2204: Marine Chemistry

Credits: 3

Module I Ocean as a Chemical System

History of oceanography, important oceanographic expeditions and oceanographic institutions of the world. Origin of seawater, structure of water, ion-water interactions, the polarized water molecule, colligative properties of seawater, comparison of river and sea water, hydrological cycle and budget.

Module II Classification of elements based on their distribution

Composition of sea water, salinity and chlorinity concepts, the major and minor constituents, constancy of relative composition, behavior of elements - chemical exchanges across interfaces and residence times in seawater, geochemical balance of oceans. Primary, cosmogenic and artificial nuclides, Applications of radioisotopes in oceanography

Module III Dissolved gases in sea water

Factors affecting the concentration of gases in seawater, pH, alkalinity, specific alkalinity, buffer capacity, sea water - carbon dioxide equilibria, precipitation and dissolution of carbonates, global carbon cycle. Biological pump and controls on atmospheric composition - emission of greenhouse gases.

Module V Micronutrients

Nitrogen, phosphorus and silicon, their cycles, distribution profiles and their effect on phytoplankton growth, N/P ratio.

Module VI Organic matter in the sea

Dissolved and particulate: Nature, origin and distribution, Photosynthesis and Primary production.

No.	Course Outcome	Cognitive Level
1.	Gain a comprehensive understanding of the properties and interactions of the substances present in the marine environment.	U
2.	Explain the differences between conservative and non-conservative elements and discuss their behaviour, distribution and cycling in the oceans with specific examples of nutrients, major and minor elements.	U
3.	Explain the importance of dissolved gases in seawater and their role in the key processes operating in the marine environment.	U
4.	Discuss about the importance of micronutrients in marine environment	An
5.	Identify marine chemical processes that influence the organic matter fate and transport in the sea.	An
6.	*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)	

References

1. A. C. Duxbury, A. B. Duxbury, K. A. Sverdrup, An Introduction to World Oceans, 6th Ed., McGraw-Hill, 2000.
2. T. Garrison, Oceanography, 2nd Ed., Wadsworth Publishing, 1995.
3. F. J. Millero, Chemical Oceanography, 2nd Ed., CRC Press, 1996 or 3rd Ed., CRC Press 2006.
4. J. P. Riley, R. Chester, Introduction to Marine Chemistry, Academic Press, 1971.
5. Seawater: Its Composition, Properties and Behaviour, The Open University Oceanography Series, Pergamon, 2nd Ed., 1995.
6. J. P. Riley, G. Skirrow, Chemical Oceanography, Vols. I to III, Academic Press,1975.

7. K. Grasshoff, K. Kremling, M. Ehrhardt Ed., Methods of Seawater Analysis, 3rd completely revised and extended edition, Wiley-VCH, 1999.

MCH 2207 Biogeochemistry

Credits: 4

Module I Introduction, overview and concepts:

Major element cycles in the deep ocean, Mass balance between river input and oceanic sediment outputs for minor and trace elements. Oceanic circulation and chemistry, Biological Pump, Primary Production in the ocean, nutrient supply, Use of nutrients as water mass tracers, primary producers, seasonal cycles, spring bloom, nitrogen fixation. The Iron hypothesis, Elemental Stoichiometry and Redfield ratio. Influence of biota on the geochemical cycling of inorganic and organic substances through the atmosphere, hydrosphere, and lithosphere.

Module II Biogeochemical Cycles:

Biogeochemical cycles of carbon, nitrogen and sulfur. The oceanic carbonate system, global ocean-atmosphere interactions, biogeochemical cycles and climate change. Biogeochemistry of carbon, sulfur, selected metals, and organic compounds of natural and anthropogenic origin. The carbon cycle, The sulfur Cycle, Isotope effects – Mass dependent and mass independent effects, Isotope geothermometers, Isotope fractionation in the geochemical cycles of carbon and sulfur. Relations among isotope age curves, Stable isotope variations of Heavy elements, Si, P and Fe Biogeochemical cycles.

Module III Climate change effects/feedbacks on C-cycle:

Air-sea carbon dioxide fluxes, Ocean acidification and carbonate chemistry, Effect of ocean acidification on the speciation of metals in seawater, Benthic processes of biogeochemical cycles. UVR effects on aquatic ecosystem: a changing climate perspective.

No.	Course Outcome	Cognitive Level
1	Provide a fundamental understanding of the major elemental cycles in the ocean and the geochemical process occurring during the transfer of minor and trace elements from land to ocean through riverine input and also within the sedimentary phase in the oceans	U/E
2	discuss the importance of biogeochemical cycles in the ocean circulation, nitrogen and carbon fixation, primary production, carbon sequestration etc	An/E
3.	Understand and identify the processes involved in biogeochemical cycles (C, N, Si, P, Fe, S), mutual interaction between climate and biogeochemical processes and Stable isotope variations of Heavy metals Si, P and Fe.	An/E
4.	Discuss air – sea CO_2 flux based on surface ocean pCO_2, ocean acidification and carbonate chemistry and impacts of ocean acidification on metal speciation in sea water.	A/An
5	Know and understand benthic process in biogeochemical cycles and carbon burial and Climate change induced effects of UV radiation on aquatic ecosystem, Productivity measurements using C and N isotopes.	A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. Libes, S.M. (2009). Introduction to Marine Biogeochemistry. Elsevier, Amsterdam.
2. William H. Schlesinger and Emily S. Bernhardt, Biogeochemistry: An Analysis of Global Change. Academic Press, 3rd Edition, 2013
3. Chemical cycles in the evolution of the earth. C.B. Gregor, R.M. Garrels, F.T. Mackenzie and J.B. Maynard.

4. Stable Isotope geochemistry, JochenHoefs (VI th Ed) Springer, 2009.

5. UV effects on aquatic organisms and ecosystems – E.W Helbling and H Zagarese (VolEdts)– Donat Peter Hader and GuilioJori, 2003.

6. Chemical Oceanography, Frank J Millero (4th Edn) CRC Press, 2013.

MCH 2208 Isotope Geochemistry

Credits: 4

Module I Introduction and Scope of Isotope geochemistry:

Concept of systems and equilibrium, thermodynamic variables, Equations of state, Energy and laws of thermodynamics, path independence, state functions and first law, entropy and second law, the third law and absolute entropy, Gibbs free energy, Helmholtz free energy

Module II Chemical properties and isotopic systematics:

Stable Isotope geochemistry, fractionation of isotopes, H, C, O and S; Stable Isotope Geochemistry - variations in the isotopic ratios of sulphur, carbon and oxygen, lithium and barium in geological systems.

Basics of stable isotope mass spectrometry, continuous flow and duel inlet methods, their accuracies, precision, resolving power and sensitivities, equilibrium and kinetic fractionations, vital effects.

Determination of sedimentation rates using radioisotopes, the radiocarbon method, and accelerator mass spectrometry. Dating of sediments, corals, tree rings: 210-Pb, C-14, U-Th.

Module III Applications in climate studies:

C-12, C-13, O-16, O-18, C, Mg, N and their ratios Stable isotopes and their applications to paleoclimate reconstruction - ice ages, causes of ice ages, Milankovitch Theory - cycles in eccentricity, precession and obliquity (tilt); foraminifera, oxygen and carbon isotopic variations in planktic and benthic foraminifera in marine sediment cores and corals.

Dating of past coral terraces and determination of paleo-sea level. Reconstruction of paleo- temperatures using Mg/Ca in foraminifera. Productivity, new production and their measurements using ^{14}C, ^{13}C and ^{15}N isotopes.

No.	Course Outcome	Cognitive Level
1	gain basics of thermodynamics- systems, thermodynamic variables, laws of thermodynamics, Gibbs free energy, Helmholtz free energy.	U/E
2	Understand general concepts of stable isotope geochemistry, isotopic fractionation and variations of isotopic ratios of elements in the geological systems.	An/E
3.	Know and understand the fundamentals, principle and application of stable isotope mass spectrometry and accelerator mass spectrometry, Kinetic fractionation of stable isotopes and its effects	An/E
4.	Provide a general knowledge about the determination of sedimentation rates using radioisotopes-radiocarbon method and accelerated mass spectrometry, age dating using different radioactive isotopes.	A/An
5	Familiarize the application of stable isotope and their ratios in paleoclimatic reconstruction, reconstruction of paleo environmental and paleo sea - level change using Mg/Ca ratios in foraminifera, Productivity measurements using C and N isotopes.	A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References:

1. A.P. Dickin (2000) Radiogenic Isotope Geology. Cambridge University Press, 490p.
2. Gunter Faure (1986) Principles of Isotope Geology, Wiley, New York
3. Hoefs, Jochen (2015) Stable Isotope Geochemistry, Springer
4. Todd E. Dawson & Rolf T.W. Seigwolf (2007). Stable Isotopes as Indicators of Ecological Change, Academic Press.
5. Mark Baskaran (Editor) 2011. Handbook of Environmental Isotope Geochemistry, Springer (2 volumes).
6. Heinrich D Holl & Karl Turekian (eds.) 2010. Isotope Geochemistry - A derivative of the Treatise on Geochemistry. Academic Press, p. 752.

7. William M. White (2014). Isotope Geochemistry, Wiley-Blackwell, 496 p.

MCH 2209: Environmental Impact Assessment

Credits: 4

Module I EIA Introductory Concepts:

Introduction to Environmental planning EIA process: evaluation of proposed actions: scoping EIA methodologies Impact Assessment Methodologies: Measurement of environmental impact, EIA Models, role of GIS in EIA base line study.

Coastal Regulation Zone (CRZ): Coastal Regulation Zone (CRZ) Notification, 2011, Island Protection Zone (IPZ) Notification, 2011, Importance of CRZ Notification, Objectives, Limit of the CRZ Area, Allowed and not allowed activities in Coastal Zones, ICZMP.

Module II EIA Case studies:

River valley projects: thermal power plants: mining projects: oil refineries and petrochemicals:tourism coastal zone development, EIA Regulations in India.

Module III Generalized approach to impact analysis:

EIA guidelines 2006, Notification of Government of India Procedure for reviewing Environmental impact analysis and statement. Baseline information and predictions (land, water, atmosphere, energy etc.). Concept and strategies of sustainable development, Cost-Benefit analysis, Environmental priorities in India and sustainable development.

Guidelines for Environmental audit: Definitions and concepts, partial audit, compliance audit, methodologies and regulations, 1SO14000, Consumption audits, pollution audits, hazardous issues and its voluntary audits.

No.	Course Outcome	Cognitive Level
1.	Understand the different compartment of EIA processes.	U
2.	Gives brief idea about the coastal regulation zones, different CRZ notification and ICZMP.	U/ An
3.	Assess different type of EIA studies and EIA regulation in India.	An
4.	Gain information about the different EIA notifications in India and what are the drawback of each notification and it get rectified.	U
5.	Analyse different type of Environmental audits, ISO 14000 certification processes.	An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. John Glasson, Riki Therivel, Andrew Chadwick (2005) Introduction to Environmental impact assessment. Taylor and Francis

2. Richard K. Morgan (2002) Environmental impact assessment: A methodological approach. Kluwer Academics

3. David P. Lawrence (2003) Environmental impact assessment: Practical solutions to recurrent problems. John Wiley & Sons

4. Canter Larry. Environment Impact Assessment, 2nd edn., McGraw Hill Science, 1995.

5. G.J. Rau, and C.D. Wooten. Environmental Impact Analysis Handbook, McGraw Hill.Reference Book, 1980.

6. Glasson, John, Rikki Therievel and Andrew Chadwic. Introduction to Environmental Impact Assessment, 4th edn., Routledge, 2012

7. Kulkarni, Vijay and T.V. Ramchandra. Environmental Management. The Energy and Resources Institute (TERI), 2009

8. Eccleston, Charles H. Environmental Impact Assessment: A Guide to Best Professional Practices, CRC Press, 2011.

9. Morris, Peter and Riki Therivel. Methods of Environmental Impact Assessment (Natural and Built Environment Series). Routledge, 2009.

10. P. Leelakrishnan. Environmental Law in India, 3rd edn., ButterworthsWadhwa, 2008.

11.Dwivedi, S.N., Natarajan, R and Ramachandran, S., "Coastal Zone Management in Tamilnadu".

MCH 2210: Palaeooceanography

Credits: 4

Module I Fundamentals of palaeoceanography :

Elements of climate, global climatic variation.Ocean's place in the climate system; Milankovitch theory of climate change.

Module II Approaches to palaeoceanography :

Global paleoceanographic evolution.Carbon, silica, phosphorus and nitrogen cycles and their evolution. Importance of palaeoceanographic studies for the modern chemical cycling and processes.

Module III Palaeoceanographic techniques, proxies and significance :

Concept of proxies in palaeoceanography – quantitative and qualitative proxies; Use of proxies for reconstruction of oceanic temperature, circulation, biological productivity, nutrient cycling, alkalinity, carbonate ion concentration, redox processes; Linear and non-linear oceanic responses to climate forcing.

No.	Course Outcome	Cognitive Level
1.	Understand the factors that affect climate and the interactions between various components of the climate system to make inferences from paleoclimate data regarding mechanisms for change.	U/A
2.	Learn the concepts of modeling the general circulation of the ocean and atmosphere	U
3.	Identify the tools for paleoclimatology research to be used to gain information about the climate of a particular time period, and what information would be extracted with a particular tool	U/An
4.	Assess how present day climate change compares to climate change during key periods of Earth's history, and how the past can inform our understanding of the present and future.	E
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References:

1. Thomas J. M. Schopf, Paleoceanography, Harvard University Press, 1980.

2. Fischer, Gerhard, Wefer, Gerold (Eds.), Use of Proxies in Paleoceanography, Springer-Verlag, 1999.

3. Fatima Abrantes , Alan Mix (Editors). Reconstructing Ocean History: A Window Into the Future, Springer, 2012

4. C. Hillaire-Marcel, Anne de Vernal (Editors), Proxies in Late CenozoicPaleoceanography: 1 (Developments in Marine Geology), Elsevier Science, 2007.

MCH 2205 Environmental Analyses (Practical)

Credits: 2

1. Sampling of water (microlayer, surface , sub-surface) and sediment (surficial and sub - surface)
2. Filtration and storage of samples.
3. Determination of salinity – Physical and Chemical methods.
4. Determination of DO- concept of A.O.U
5. Determination of BOD and COD.
6. Determination of pH – Spectrophotometric method.
7. Determination of alkalinity.
8. Determination of Eh.
9. Determination of nutrients – nitrite, nitrate, ammonia and phosphate – both water and sediment.
10. Determination of pigments (chlorophyll a, b, c and phaeopigments).
11. Determination of organic matter in water, sediment and particulates – TOC, POC and SOC.
12. Sample preparation, handling and determination of trace metals in environmental samples.

No.	Course Outcome	Cognitive Level
1.	Develop analytical abilities for environmental and ecological analysis parts of laboratories in higher studies, professional bodies andresearch institutes.	An
2.	Understand the appropriate methods and principlebehind the practical protocols	U
3.	Learn sampling methods and analysis of soil, air and water samples	U/A
4.	Optimize and choose appropriate methods for environmental analysis	A
5.	Conclude the results and prepare scientific reports/ practical record books	An/E
6.	Connect knowledge of theoretical courses with the practical implications	A
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. K. Grasshoff, M. Ehrhardt and K. Kremling. Methods of Seawater Analysis. 3Rd Edn.Wiley -VCH, 1999.

2. APHA, Standard Methods for the Examination of water and waste water, 22nd Edn. 2012.

3. IOC Manuals and Guides -12. Chemical methods for use in Environemntal Monitoring, UNESCO, 1983.

4. IOC Manuals and Gudes – 15. Procedures for sampling Sea Surface Micro – layer, UNESCO. 1985.

5. J.D. Strickland and T.R. Parsons. A Practical Handbook of Sewater Analysis, Unipub,1084.

6. T.R. Parsons, Y. Maita and C. M. Lalli. A manual of Chemical and Biological Methods for Seawater Analysis, Pergamon Press. 1984.

MCH 2206 Physico - Chemical Methods (Practical)

Credits: 2

1. **Phase diagram**
    1. Construction of Phase diagrams of simple eutectics
    2. Effect of KCl/succinic acid on miscibility temperature
    3. Construction of phase diagrams of three component systems with one pair of partially miscible liquids
2. **Distribution law**
    1. Distribution coefficient of iodine between an organic solvent and water
    2. Distribution coefficient of benzoic acid between benzene and water
3. **Surface tension - Determination of surface tension of a liquid by**
        1. Capillary rise method
        2. Drop number method
4. **Polarimetry**
        1. Kinetics of the inversion of sucrose in the presence of HCl
        2. Determination of the concentration of a sugar solution
        3. Determination of the concentration of HCl
5. **Refractometry**
    1. Identification of pure organic liquids and oils
    2. Determination of molar refractions of pure liquids
    3. Determination of concentration of solutions (KCl- water, Glycero -water)
6. **Viscocity**
        1. Determination of viscosity of pure liquids
        2. Verification of Kendall's equation
        3. Determination of composition of binary liquid mixtures – alcohol-water, benzene – nitrobenzene

No.	Course Outcome	Cognitive Level
1.	To conduct the experiment on various instrumental techniques	A
2.	To measure various physical and chemical properties	A
3.	To describe the principles behind the experiment performed in the laboratory	U
4.	To interpret the experimental results obtained by various techniques	An
5.	The students will acquire knowledge of experimental techniques for controlling the chemical reactions	C
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001.
2. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8^{th} Edn., McGraw Hill, 2009.

OST 2207 Analytical Methods in Marine Environment

Credits: 3

Module I Electro analytical Techniques

Voltametry; Coulometry; Amperometry; Potentiometry; Polarography; Electrolytic conductivity.

Module II Spectrophotometry

Fundamental laws of photometry, interference and photometric error, Basic instrumentation for UV-Vis, IR and Fluorescence spectrophotometers. Flame Spectrophotometry – Flame emission spectrometry, Atomic absorption Spectro photometry – general principles and instrumentation, interferences, Cold vapour techniques for estimation of Mercury, metal hydride generation techniques, Electro thermal atomisation. Atomic fluorescence spectrometry, Inductively coupled Plasma analysis.

Module III Chromatographic Techniques

Classification of chromatographic techniques. Experimental techniques and applications of Ion exchange, Column, Thin Layer and Paper chromatography. HPLC and Gas Chromatography – Principle, Instrumentation and Detectors. Methods and applications.

Module IV NMR Spectroscopy

NMR – Basic Principles and Instrumentation of Continuous Wave and Pulsed Fourier Transform NMR Spectrophotometers.

Module V Mass Spectrometry

Mass Spectrometry – Basic Principles, Instrumentation – Sample flow, Ionisation methods, mass analysers, Ion collecting systems, Analysis of data.

No.	Course Outcome	Cognitive Level
1.	Discuss about the various types of electro-analytical techniques and its applications	U
2.	Understand the basic instrumentation of various spectrometers.	U
3.	Explains about the different types of chromatographic techniques and data interpretations	U/ An
4.	Brief discussion about basic concepts in different NMR techniques	U
5.	It gives through knowledge of different parts of Mass spectroscopy and data collection and interpretations.	An
6.	*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)	

References

1. J.M. Mermet, M.Otto, R.Kellner , Analytical Chemistry, Wiley –VCH, 2004.
2. D.A. Skoog, D.M. West, F.J.Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8thEdn, Saunders College Pub, 2007.
3. G.D. Christian, J.E. O'Reilly, Instrumental Analysis, Allyn and Bacon, 1986.
4. J.H. Kennedy, Analytical Chemistry: Principles, Saunders College Pub 1990.
5. J.G. Dick, Analytical Chemistry, R.E. Krieger Pub.1978.

SEMESTER III

MCH 2301: Solution Chemistry, Kinetics and Photochemistry

Credits: 3

Module I Ideal solution and Colligative properties

Kinds of solutions, ideal solution, Analytical form of chemical potential in ideal solution, Chemical potential of the solute in a binary ideal solution, Application of the Gibbs-Duhem equation, the chemical potential in ideal solutions, binary solutions The lever rule, Temperature – composition diagram, Fractional distillation, Azeotropes, The chemical potential in ideal dilute solutions, Henry's law and the solubility of gases, Chemical equilibrium in the ideal solutions

Module II Equilibria in Non-ideal Systems

The concept of activity, The rational system of activities, Activities and reaction equilibrium, Activities in electrolytic solutions, The Debye-Huckel theory of the structure of dilute ionic solutions, Equilibria in ionic solutions, dilution law, Dissociation constant, Acids and bases, Protolytic equilibrium, , Hydrolysis, Dissociation constant for polybasic acids, Buffer solutions, Amphoteric electrolytes. Solubility product.

Module III Kinetics

Solution Kinetics - Potential energy surfaces - transition state theory- activation/ thermodynamic parameters.Various theories of Unimolecular reactions, Elementary Reactions in Solutions: Influence of solvent properties on rate. Different types of molecular interactions in solution. Diffusion and activation controlled reactions. Kinetics in the excited state -Jablonski diagram.Kinetics of Unimolecular and bimolecular photophysical and photochemical processes. Resonance

energy transfer rates-Fluorescence quenching kinetics in solution and gas phase. Fast reaction kinetics -Relaxation methods, Stopped flow method, Laser Flash Photolysis, flow tube methods, and Laser based experimental techniques.

Module IV Photochemistry

Quantum yield, chemical actinometry, excimers and exciplexes, photosensitization, chemiluminescence, bioluminescence, thermoluminescence, Principle of utilization of solar energy, solar cell and their working. Quenching of fluoresecence and its kinetics, Stern- Volmer equation, concentration quenching, fluorescence and structure, delayed fluorescence, E- type and P- type, Effect of temperature on emissions.

No.	Course Outcome	Cognitive Level
1.	Understand the different theories of reaction rates	U
2.	Apply integrated rate equations to solve for the concentration of chemical species during a reaction of different order	A
3.	Interpret potential energy profiles and use them to determine the activation energy and potential energy changes for a reaction	C
4.	Understand the differences between the kinetics of reactions in the gas phase and liquid phase	U
5.	Evaluate and explain the distinction between diffusion control and activation control of reaction rates in solutions	E
6.	Learn basic concepts of photochemistry and Understand the mechanism and kinetics of photophysical process	U
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. P.W. Atkins and J de Paula. Physical Chemistry, 9thedn., Oxford University Press, 2010

2. S. Glasstone. Introduction to Electrochemistry, Nabu Press, 2014.

3. G.W. Castellan. Physical Chemistry, 3rdedn., Addison Wesley, 1983

4. F. Daniels and R.A. Alberty. Physical Chemistry, 6thedn., John Wiley, 1984

5. A.A. Frost and R.G. Pearson. Kinetics and Mechanisms, John Wiley, 1961

6. K.J.H. Laidler. Chemical Kinetics, Tata McGraw Hill, 1993

7. S. Glasstone. Textbook of Physical Chemistry, Macmillan India Ltd., 1995

MCH 2302: Marine Natural Products

Credits: 4

Module I Drugs and pharmaceuticals from Marine Sources

Introduction, Marine secondary metabolites and their function, Biosynthetic pathways of terpenes, sterols and phenolic compounds, Some major marine drugs – anticancer agents, antimicrobial and antiviral compounds, analgesics (examples only), Marine organisms having potential bioactive compounds – Corals, marine micro organisms, marine plants, marine toxins as drugs, Fish and shell fish. Marine drug developmet – problems and challenges.

Module II Seafood proteins

Nutritional value of seafood proteins, bioactive peptides, Isolation of seafood peptides-Functional value – Calcium binding, antibacterial and anti-oxidant activity. Marine enzymes – Isolation and applications, Anti-freeze proteins – applications, Cold adapted enzymes – applications.

Module III Seaweeds -Nutritional value, bioactive properties and uses

Proximate composition, seaweeds as dietary supplements, Seaweeds as sources of bioactive compounds – antioxidant, anti-bacterial and anti-viral activities, Industrial applications of seaweeds – agriculture, aqua culture feed, anti-fouling agents, biosorption of heavy metals. Seaweed hydrocolloids – Agar, alginate, carrageenan – structure, extraction, properties and biological activity.

Module IV Marine Macromolecules as Nutraceutical Carriers and Biofilm

Matrix design for delivery of nutraceuticals, Marine macromolecules as delivery system, Biodegradable and edible films, Marine macro molecules as food coatings and edible films – marine proteins and marine polysaccharides, Nanotechnology for marine polysaccharide films and particles, Marine macromolecules as hydrogels and membrane for drug delivery, marine polysaccharides as Scaffolds.

Module V Isolation Techniques

Introduction, different extraction methods, purification by solvent extraction, chromatographic techniques (size exclusion, ion exchange, counter current), Idea about different spectroscopic techniques (already discussed in core paper).

No.	Course Outcome	Cognitive Level
1	Gain a general idea about marine secondary metabolites, Bioactive compounds from different marine organisms, major marine drugs, problems and challenges of marine drug development.	U/E
2	Understand nutritional value, bioactive properties and isolation of sea food proteins and its components, Isolation and applications of marine enzymes, applications of antifreeze proteins and cold adapted enzymes.	An/E
3.	Examine nutritional value and bioactive properties and applications of sea weeds, sea weed hydrocolloids.	An/E
4.	Know and understand the applications of marine macromolecules as drug /nutraceutical delivery, biodegradable and edible systems, nanoparticles, hydrogels and scaffolds.	A/An
5	Be familiar with different isolation methods (solvent extraction, chromatographic techniques), spectroscopic techniques	A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. Chemistry of marine natural products. Paul J Scheuer, 1973. Academic Press.
2. Handbook of Marine natural products. Fatturosso, Emesto, Gerwick, William H, Taglialatela Scafati, Orazio (Eds.) 2012. Springer.
3. Bioactive marine natural products. Bhakuni, Dewari S and Rawat P.S . 2005.

4. Handbook of Marine Biotechnology, S K Kim, 2015. Springer.
5. Marine products for health care. Functional and Bioactive nutraceutical compounds from the ocean. Vazhiyil Venugopal. CRC Press. 2009.

6. Seigler, D.S. (1998). Introduction to Terpenes. In: Plant Secondary Metabolism. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-4913-0_18
7. W. David Nes, 2011. Biosynthesis of Cholesterol and Other Sterols Chemical Reviews 111 (10), 6423-6451 DOI: 10.1021/cr200021m
8. W. Vermerris and R. Nicholson 2006, Phenolic Compound Biochemistry Springer https://doi.org/10.1007/978-1-4020-5164-7

MCH 2303: Instrumental Methods in Marine Chemistry

Credits: 3

Module I Electroanalytical Techniques

Voltammetry; Coulometry; Amperometry; Potentiometry; Polarography; Electrolytic conductivity.

Module I Spectrophotometry

Fundamental laws of photometry, interference and photometric error, instrumentation of photometers. Flame Spectrophotometry – Flame emission spectrometry, Atomic absorption Spectrophotometry – general principles and instrumentation, interferences, Cold vapour techniques for estimation of Mercury, metal hydride generation techniques, electro thermal atomisation. Atomic fluorescence spectrometry, Inductively coupled Plasma analysis.Basic instrumentation for UV-Vis, IR and Fluorescence spectrophotometers.

Module II Chromatographic Techniques

Classification of chromatographic techniques. Experimental techniques and applications of Ionexchange, Column, Thin Layer and Paper chromatography. HPLC and Gas Chromatography –Principle, Instrumentation and Detectors. Methods and applications.

Module III NMR Spectrometry

NMR – Basic Principles and Instrumentation of Continuous Wave and Pulsed Fourier Transform NMR Spectrophotometers.

Module IV Mass Spectrometry

Mass Spectrometry – Basic Principles, Instrumentation – Sample flow, Ionisation methods, mass analysers, Ion collecting systems, Analysis of data, Fourier Transform Mass Spectrometry, MS-MS, ICP-MS, SIMS, IMMA.

No.	Course Outcome	Cognitive Level
1.	Discuss about the various types of electro-analytical techniques and its applications	U
2.	Understand the basic instrumentation of various spectrometers.	U
3.	Explains about the different types of chromatographic techniques and data interpretations	U/ An
4.	Brief discussion about basic concepts in different NMR techniques	U
5.	It gives through knowledge of different types of Mass spectroscopy instruments and how each part works and finally and interpretations of mass spectra.	An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. J.M. Mermet, M.Otto, R.Kellner , Analytical Chemistry, Wiley –VCH, 2004.
2. D.A. Skoog, D.M. West, F.J.Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8thEdn, Saunders College Pub, 2007.
3. G.D. Christian, J.E. O'Reilly, Instrumental Analysis, Allyn and Bacon, 1986.
4. J.H. Kennedy, Analytical Chemistry: Principles, Saunders College Pub 1990.
5. J.G. Dick, Analytical Chemistry, R.E. Krieger Pub., 1978.

MCH 2304: Marine Pollution

Credits: 3

Module – I Marine Pollution

Definition, Categories of additions, Pollutant and its classification. Organic wastes: BOD, COD, dilution factor, Fluctuations in DO, Consequences of organic discharges to estuaries with examples; Sewage treatment: Primary, Secondary and Tertiary treatment processes. Solid waste pollution: Classification and disposal of solid wastes.

Module – II Marine Pollution II

Oil spills and cleanup: Sources, Major accidental spills, fate of spilled oil on the sea, consequences of oil spills and treatment of oil spills.

Pesticide pollution: inputs, fate in the sea, factors affecting the bioaccumulation of pesticides, DDT the most wide spread molecule, Impact of pesticides on the Environment, Mode of poisoning of pesticides, Methods to minimize pesticide pollution.

Conservative pollutants: Measures of contamination, toxicity, measurement of toxicity, acute and chronic exposure, Detoxification. Metal pollution in coastal waters (Hg, Pb, Cd, Cu, Zn and Fe).

Radioactive Pollution: Sources, Classification and effects of radiation; Protection and control from radiation: Maximum permissible dose concept, dose limits, Disposal of radioactive wastes; Beneficial aspects of radiation and food safety.

Module III Industrial Pollution

Sources, nature and their treatment processes with reference to wastes from paper and pulp and soap manufacturing industries.

Marine corrosion: Definition, corrosion reactions, classification of corrosion, factors affecting corrosion of metals in sea water and prevention of marine corrosion. The state of some seas in the world (pollution aspect); The North sea, The Mediterranean sea and the Baltic sea.

Module – IV Monitoring Strategies

Indicator organisms: Criteria for selection of indicator organism: Quantisation of pollution load, basic pre-requisites, response to different pollution load and time integration capacity, Macro algae; crustaceans and mollusks as indicator organisms for monitoring of trace metal pollution; Red tides : distribution, types of poisoning, effects and methods to minimize red tides in the sea. Concepts of bioavailability, bio concentration and bio magnification. Monitoring strategies of marine pollution: Critical pathway approach and Mass balance approach.

No.	**Course Outcome**	**Cognitive Level**
1.	Understand a set of core facts about anthropogenic change to the oceans.	U
2.	Assess the key aspects of ocean acidification, deoxygenation, chemical pollution, and deleterious impacts on fish and plankton.	U/An
3.	Able to communicate the effects of marine pollution on global climate.	An
4.	Develop or enhance skills in team work, inductive reasoning, interpretation of complex data, and the sharing of complex scientific data and interpretations with non-technical audiences.	S
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. Riley J.P and Skirrow, G. 1975. Chemical Oceanography (Vol: 3)
2. Goldberg, E.D. 1976. The health of the oceans.
3. Clark, R.B. 1986. Marine Pollution.
4. Phillips J.D.H. 1980. Quantitative aquatic biological indicators.
5. Sharma, B.K and Kaur, H. 1994. Thermal and radioactive pollution.
6. Sharma, B. K and Kaur, H. 1994. Water Pollution.
7. Chandler, K.A. 1985. Marine and offshore corrosion.
8. Metcalf and Eddy. Waste water engineering, treatment and Resources recovery, 5th edn., McGraw-Hill Science, 2013.
9. J. Albaiges. Marine Pollution, Hemisphere Publ. Corp., 1989.
10. E.D. Goldberg. The Health of the Ocean, The UNESCO Press, 1976.
11. L. Landner. Chemicals in the Aquatic Environment, Springer Verlag, 1989.
12. P. Dent, Marine Pollution Year Book, Pergamon Press, 1990.
13. J.W. Moore and S. Ramamoorthy. Organic Chemicals in Natural Waters, Springer Verlag, 1984.
14. J.W.Moore. Inorganic Contaminants of Surface Water, Springer Verlag, 1991.
15. D.W. Connell and G. J. Miller. Chemistry and Ecotoxicology of Pollution, John Wiley and Sons, 1984.

MCH 2307: Marine Geochemistry

Credits: 3

Module I Fundamentals of geochemistry:

Geochemical classification of elements. Geochemistry of crust, mantle and core of the earth. Geochemical Cycle. Mobility of elements, Isomorphism, polymorphism and atomic substitution. Thermodynamics and chemical reactions.

Module II Isotope geochemistry:

Introduction to isotope geology, Isotopes, isobars and isotones, stable and radioactive isotopes. Radioactive decay schemes. Decay constant, half life, parent-daughter relations. Rb-Sr and Sm- Nd systematics and their use in geochemistry. Short-lived isotopes.

Module III Stable isotopes:

Processes of isotope fractionation, δ-notation for C, O, N and S isotopes, fractionation factor. Water isotopes – O, H fractionation in the hydrologic cycle and applications.

Module IV Marine sedimentary processes:

Sedimentary environments and facies; Weathering and transportation; Coastal and continental

shelf sedimentation processes; Pelagic Sedimentation and sedimentary processes; Source to sink and processes governing their transport. Chemical sedimentation: authigenic mineralization and detrital clay minerals.

Module V Marine geochemical processes:

Nutrients, major, minor and trace elemental distribution in marine sediments; Carbon, nitrogen,

phosphorus and sulphur cycling in marine sediments; Early diagenesis in marine sediments – dissolved constituents of sediment pore water, influence of bioturbation. Mineralizatione of oxygen and nitrate distribution in marine sediments;

Nitrification and denitrification; Benthic fluxes, redox reactions. Reactivity of iron in marine sediments – pathways if iron input, iron as a limiting nutrient in oceans; early diagenesis; Sulphate reduction in marine sediments – biotic and abiotic processes; Hydrothermal processes and mineralization – black smokers and massive sulphide formation.

No.	Course Outcome	Cognitive Level
1	Attain fundamental knowledge about major and minor elements, geochemistry of the interiors of the earth, geochemical reactions, energy transfer	U/An
2	Understand fundamentals of isotope geochemistry, atomic species, stable and radioactive isotopes, paleoclimatic conditions using Rb-Sr and Sm-Nd systematics.	U/E
3.	Identify the natural and anthropogenic changes in the oceanic systems, reconstruct paleoenvironmental conditions and identify biogeochemical pathways can be done through isotope fractionation.	A/An
4.	Know and understand the basic concepts, principles, theories and data associated with the biogeochemical process occurring in the oceanic environment	A/An
5	familiarise the basic sources and sinks of chemicals, their distribution and their variability in the marine systems	A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References:

1. Holland, H. D., and K. K. Turekian, eds. Treatise on Geochemistry. Elsevier Science, 2003.

2. Roy Chester and Tim. D. Jickells, Marine Geochemistry, Wiley-Blackwell, 3rd Edition, 2012.

3. H. D. Schulz and M. Zabel, Marine Geochemistry, Springer, 2nd Edition, 2006

4. Jochen Hoefs, Stable isotope geochemistry, Springer-Verlag, 1996, 2009.
5. Gunter Faure, Principles of Isotope Geology. J. Wiley & Sons, 2004.
6. Harry Elderfield, Heinrich D. Holland, Karl K. Turekian, The Oceans and Marine Geochemistry, Elsevier, 2006.
7. William M. White, Isotope Geochemistry, Wiley-Blackwell, 2015.

MCH 2308: Polar Sciences

Credits: 3

Module I Introduction to the polar systems:

Antarctica and Arctic – major characteristics and differences; Significance of polar oceans and ice sheets to Earth System. Role of polar oceans on deep ocean circulation and global climate system. Indian polar initiatives.

Module II Antarctica:

Major features and processes: cryosphere, atmosphere, biosphere, and hydrosphere. Antarctic discovery and exploration; Antarctica as a unique natural laboratory; Significance of Antarctica in global climate and sea level; Antarctic ice sheets as archive of global climate change.

Module III Southern Ocean:

Significance of Southern Ocean to the global ocean circulation, biogeochemical cycles, and climate; Oceanography – characteristic water masses, oceanic fronts, nutrient and carbon cycling - HNLC conditions, biological processes; iron fertilization; Acidification of Southern Ocean

Module IV Arctic:

Major features and processes: cryosphere, atmosphere, biosphere, and hydrosphere. Arctic fjords –functioning and importance; Role of Arctic in climate change; response of Arctic to global warming and climate change. Arctic sea ice system – importance to the global oceanography and climate.

No.	Course Outcome	Cognitive Level
1	gain general understanding of the polar regions of the earth - Antarctica and Arctic, Role of polar oceans on deep ocean circulation and global climate change and Indian polar initiatives.	U/E
2	Know and understand the major features and process in different components of Antarctica and Arctic regions - cryosphere, atmosphere, biosphere and hydrosphere, rich unique natural resources, significance of Antarctica and Arctic in terms global climate and sea level change and paleoclimatic change.	An/E
3.	Attain a general idea about Southern Ocean through the physical, chemical and biological oceanographic studies	An/E
4.	understand the challenges facing the polar regions and need for the protection of the polar regions as it is very much connected to global climate change	A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References:

1. Bettina Kaiser, Polar Science and Global Climate: An International Resource for Education & Outreach. Pearson Bookshop, 2010.
2. Turner, J. & Marshall, G. J., Climate Change in the Polar Regions. Cambridge University Press, 2011.
3. David W. H. Walton, Antarctic Science, Cambridge University Press, 1987.
4. Veronika Meduna, Science on Ice: Discovering the Secrets of Antarctica, Auckland University Press, 2013.
5. Committee on Future Science Opportunities in Antarctica and the Southern Ocean, Future Science Opportunities in Antarctica and the Southern Ocean, The National academy Press, 2011.
6. Stephen Rintoul et al. (Editors), The Southern Ocean Observing System: Initial Science and Implementation Strategy. Scientific Committee on Antarctic Research, 2011
7. Mark Serreze and Roger Barry, The Arctic Climate System, Cambridge University Press, 2009.

8. Climate Change and Arctic Sustainable Development - Scientific, social, cultural and educational challenges. UNESCO Publishing, 2009.

MCH 2309: Coastal Zone Management

Credits: 3

Module I Coastal Zone:

Coastal zone, Coastal zone regulations, Beach profile, Surf zone, Off shore, Coastal waters, Estuaries, Wet lands and Lagoons, Living resources, Non-living resources.

Modules II Wave Dynamics:

Wave classification , Airy's Linear Wave theory, Deep water waves , Shallow water waves, Wave pressure, Wave energy, Wave Decay, Reflection, Refraction and Diffraction of waves, Breaking of waves, Wave force on structures, Vertical, Sloping and stepped barriers Force on piles.

Module III Coastal Processes:

Erosion and depositional shore features, Methods of protection, Littoral currents, Coastal aquifer, Sea water intrusion, Impact of sewage disposal in seas.

Module IV Harbours:

Structures near coast, Selection of site, Types and selection of break waters, Need and mode of dredging, Selection of dredgers, Effect of Mangrove forest.

References

1. Richard Sylvester, "Coastal Engineering, Volume I and II", Elseiner Scientific Publishing Co.,1999.

2. Quinn, A.D., "Design & Construction of Ports and Marine Structures", McGraw-Hill Book Co.,1999.

3. Ed. A.T. Ippen, "Coastline Hydrodynamics", McGraw-Hill Inc., New York, 1993.

4.Dwivedi, S.N., Natarajan, R and Ramachandran, S., "Coastal Zone Management in Tamilnadu"

.

No.	Course Outcome	Cognitive Level
1.	Give necessary knowledge on coastal zone management especially on the important coastal resources and fisheries, the principles for coastal conservation and management.	U
2.	Create knowledge to balance between development needs and protection of natural resources	U/An
3.	Assessment of coastal processes and their impacts	U/ An
4.	Analyse the effect of harbor structures on coastal ecosystem	An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

MCH 2310: Science Writing and IPR

Credits: 3

Module I Science Writing :

Introduction to science writing – goals, key elements – critical aspects – precision, clarity, objectivity.Genre in science writing -- articles, reviews, memoirs, project reports, proposals, popular science.Communication of research results, foundations and structure of a good scientific paper.English language considerations in writing a paper.Ethical issues - plagiarism. Presentation of data, figures, tables, references. Presentation of papers at conferences and preparation of audio--visual tools.

Module II Science Journalism:

Science communication and science popularization. Science popularization in the Indian context; Basics of popular science writing for magazines and newspapers; Research communication versus popular communication; Science communication through R&D newsletters, reports, etc.; Creation of information resources, e.g. encyclopaedic publications, etc; Use of modern IT tools in science communication; Role of graphic arts in popular science communication; Production of S&T publications

Module III IPR:

IPR, overview of IPR, Types of IPR, Indian laws and procedures. IP as source of information and access to information, Classification and tools for accessing the information, IPR in Engineering, pharmaceutical, biotechnological and computer related inventions, Prosecution, Infringement and Enforcement of IPR.

Module IV Patents:

Overview of Patent Act, legislations, International / global patent. Content of regular patent application, Claims of patent application, Specific types claims, Patent claim design, patent specification drafting in pharmaceutical, biotechnological engineering and computer science related inventions, Drafting issues in prosecution and infringement.

No.	Course Outcome	Cognitive Level
1.	Understanding of philosophy and ethics, writing skills of good research paper	U
2.	Knowledge about various indexing platforms of research journals and to find out predatory research journals using different data bases	U
3.	Identify various categories of intellectual property law and apply the criteria for intellectual property protection to in academic and research activities	U/A
4.	Understand the procedure involved in filing and prosecuting trademark, copyright and patent applications;	U/A
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References:

1. The Craft of Scientific Writing, Michael Alley, 3rd ed., Springer, 1996.

2. Intellectual Property Rights in India: General Issues and Implications, Prankrishna Pal, Deep & Deep Publications Pvt. Ltd, 2008.

3. R.L. Dominoswki, Research Methods, Prentice Hall, 1981.

4. J.W. Best, J.V. Kahn, Research in Education, 10th Edn., Pearson/Allyn&Bacon, 2006.

5. H.F. Ebel, C. Bliefert, W.E. Russey, The Art of Scientific Writing, Wiley-VCH, 2004

MCH 2305: Physico-Chemical Methods (Practical)

Credits: 2

1. Phase Diagram
   I. Simple eutectic
   II. Compound formation
   III. Miscible liquids
   IV. Partially miscible liquids
2. Critical solution temperature and effect of electrolytes and non-electolytes

2.1. Three component system

3. Distribution coefficients

3.1. Partition coefficient

4. I-I3 equilibrium
5. Kinetics – Acid – base catalysed hydrolysis of esters, dependence of temperature and ionic strength on the rate of reactions
6. Adsorption

6.1. To investigate the adsorption of oxalic acid from aqueous solution by activated charcoal, and examine the validity of Freundlich and Langmuir's adsorption isotherms.

6.2. To determine the adsorption isotherms of acetic acid from aqueous solutions by charcoal.

No.	Course Outcome	Cognitive Level
1.	To conduct the experiment on various instrumental techniques	A
2.	To measure various physical and chemical properties	A
3.	To describe the principles behind the experiment performed in the laboratory	U
4.	To interpret the experimental results obtained by various techniques	An
5.	The students will acquire knowledge of experimental techniques for controlling the chemical reactions	C
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. Findlay Alexander. Practical Physical Chemistry, 6th edn., Longman and Co., London, Newyork, 1935.
2. D.P. Shomaker and C.W. Gailand, J.W. Nibler. Experiments in Physical Chemistry, 6th edn., 1997.
3. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 200.
4. B. Viswanathan, Practical Physical chemistry, Viva Pub., 2005.
5. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8thEdn., McGraw Hill, 2009.

MCH2306: Instrumental techniques in aquatic analysis (Practical)

Credits: 2

1. Analysis of trace metals in water/sediment/biological samples.
2. Flame photometry – Determination of sodium, potassium, calcium and lithium.
3. Atomic Absorption Spectrophotometry

a. Flame methods – Trace analysis of copper, cadmium, zinc, lead, manganese, iron b. Hydride generation – Determination of mercury, arsenic, selenium, tin

4. ICP – Analysis of trace metals in water.
5. Gas chromatography (GC) and HPLC – Separation and identification of marine organic compounds.
6. Interpretation Exercises using spectra:
    a) Interpretation of FTIR spectrum with reference to stretching vibrations of functional groups.
    b) Absorption spectra (UV-VIS) reading and interpretation of chromophores
    c) Interpretation of NMR spectrum with reference to calculation of chemical shifts and general comments
    d) Identification of molecular ions in Mass spectra

No.	Course Outcome	Cognitive Level
1	Preapare aquatic samples for trace metal analysis	U/E
2	Analyse samples for trace metals using sophisticated instruments	An/E
3.	Determine cations and anions in the water samples using ion chromatography	An/E
4.	Intrepretation of various results suing spectra	A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. D.T.E. Hunt and A.L. Wilson. The Chemical Analysis of Water, 2nd edn., Royal Society of Chemistry, 1986

2. Instrumental Manuals of AAS, Fluorescence Spectrophotometer, GC and CHN Analyzer.

3. R.M. Silverstein and F.X. Webster, Spectrometric Identification of Organic Compounds, 6th edn., Wiley, 2006.

4. R. Dyer John. Applications of Absorption Spectroscopy of Organic Compounds, Prentice-Hall, 1978.

5. E. Pretsch, P. Bhlmann and M. Badertscher. Structure Determination of Organic Compounds, Springer-Verlag, 4th edn., 2009.

6. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch. Fundamentals of Analytical Chemistry, 9th edn., Cengage Learning, 2013.

7. IOC Manuals and Guides-11. The determination of Petroleum Hydrocarbons in Sediments, UNESCO, 1982. R.M Silverstein, Spectrometric identification of Organic compounds

8. IOC Manuals and Guides-13.Manual for monitoring Oil and Dissolved/Dispersed Petroleum Hydrocarbons in Marine Waters and on Beaches UNESCO, 1984

9. Aquatic Environment Analytical Methods. Methods of Analysis of Hydrocarbons in Marine and Protection: Other Samples, MAFF, 1988

10. Aquatic Environment Analytical Methods. Methods of Analysis of Trace Metals in Marine and Protection: Other Samples, MAFF, 1989

11. J.Bassett, R.C. Denney, G.H.Jeffery and J.Mendham. Vogel's Text Book of Quantitative Inorganic Analysis 4th edn., ELBS, 1982.

OST 2307: Marine Chemistry

Credits: 3

Module I Ocean as a Chemical System

History of oceanography, important oceanographic expeditions and oceanographic institutions of the world.Origin of seawater, structure of water, ion-water interactions, the polarized water molecule, colligative properties of seawater, comparison of river and sea water.

Module II Classification of elements based on their distribution

Composition of sea water, salinity and chlorinity concepts, the major and minor constituents, constancy of relative composition, residence time, geochemical balance of oceans. Primary, cosmogenic and artificial nuclides, Applications of radioisotopes in oceanography

Module III Dissolved gases in sea water

Factors affecting the concentration of gases in seawater, pH, alkalinity, specific alkalinity, buffer capacity, sea water - carbon dioxide equilibria, precipitation and dissolution of carbonates, global carbon cycle.

Module IV Micronutrients

Overview of micronutrient cycles-Nitrogen, phosphorus and silicon, their cycles, distribution profiles and their effect on phytoplankton growth, N/P ratio.

Module V Organic matter in the sea

Dissolved and particulate organic matter- Nature, origin and distribution.

No.	Course Outcome	Cognitive Level
1.	Gain a comprehensive understanding of the properties and interactions of the substances present in the marine environment.	U
2.	Explain the differences between conservative and non-conservative elements and discuss their behavior, distribution and cycling in the oceans with specific examples of nutrients, major and minor elements.	U
3.	Explain the importance of dissolved gases in seawater and their role in the key processes operating in the marine environment.	U
4.	Discuss about the importance of micronutrients in marine environment	An
	Identify marine chemical processes that influence the organic matter fate and transport in the sea.	An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)		

References

1. A. C. Duxbury, A. B. Duxbury, K. A. Sverdrup, An Introduction to World Oceans, 6th Ed.,McGraw-Hill, 2000.
2. T. Garrison, Oceanography, 2nd Ed., Wadsworth Publishing, 1995.
3. F. J. Millero, Chemical Oceanography, 2nd Ed., CRC Press, 1996 or 3rd Ed., CRC Press 2006.
4. J. P. Riley, R. Chester, Introduction to Marine Chemistry, Academic Press, 1971.
5. Seawater: Its Composition, Properties and Behaviour, The Open University Oceanography Series, Pergamon, 2nd Ed., 1995.
6. J. P. Riley, G. Skirrow, Chemical Oceanography, Vols. I to III, Academic Press, 1975.
7. K. Grasshoff, K. Kremling, M. Ehrhardt Ed., Methods of Seawater Analysis, 3rd completely revised and extended edition, Wiley-VCH, 1999.