5 Year Int. MSc. Chemistry with Specialization in
Chemical Biology / Applied Electrochemistry

Curriculum and Syllabi

DEPARTMENT OF SCIENCES

AMRITA VISHWA VIDYAPEETHAM

COIMBATORE, TAMILNADU – 641112

INDIA

April 2022

Course Code	Course Title	L T P	Cr	ES		Course Code	Course Title	L T P	Cr	ES
SEMESTER 1						**SEMESTER 2**				
22MAT106	Single Variable Calculus	3 1 0	4			22MAT117	Multivariable Calculus	3 1 0	4	
22BIO101	Basic principles of Biology	2 1 0	3			22BIO111	Cellular and Molecular Biology	2 1 0	3	
22PHY104	Mechanics	3 1 0	4			22PHY111	Basics of Electricity and Magnetism	3 1 0	4	
22CHY103	General Chemistry	3 1 0	4			22CHY112	Principles of Physical Chemistry	3 1 0	4	
22CSA103	Introduction to Scientific Computing using Python	3 0 1	4			22PHY184	Physics Lab – I Mechanics, Electricity & Magnetism	0 0 2	1	
21ENG101	Communicative English	2 0 2	3			22CHY183	Chemistry Lab - I	0 0 2	1	
22ADM101	Foundations of Indian Heritage	2 0 0	2			21ENG111	Professional Communication	1 0 2	2	
	TOTAL		**24**			22ADM111	Glimpses of Glorious India	2 0 0	2	
						22AVP103	Mastery Over Mind	1 0 2	2	
							TOTAL		**23**	
SEMESTER 3						**SEMESTER 4**				
22CHY204	Physical Organic Chemistry	3 1 0	4			22PHY211	Basics of Electronics	3 1 0	4	
22PHY201	Waves, Oscillations and Ray optics	3 1 0	4			22CHY213	Principles of Organic Chemistry	3 1 0	4	
22PHY202	Introduction to Mathematical Physics	3 1 0	4			22CHY215	Principles of Inorganic Chemistry	3 1 0	4	
21SSK201	Life Skills-I	1 0 2	2			22CHY214	Quantum Chemistry	2 1 0	3	
21ENV200	Environmental Science and Sustainability	3 0 0	3			21SSK211	Life Skills-II	1 0 2	2	
22CHY283	Chemistry Lab-II	0 0 2	1			22CHY284	Inorganic Chemistry Lab	0 0 5	2	
22PHY281	Physics Lab – II Optics	0 0 2	1			22CHY285	Organic Chemistry Lab	0 0 5	2	
22CSA281	Programming Lab I	0 0 2	1				Amrita Value Programme II	1 0 0	1	
	Amrita Value Programme I	1 0 0	1				**TOTAL**		**22**	
	TOTAL		**21**							
SEMESTER 5						**SEMESTER 6**				
22CHY304	Chemistry of Main Group elements	3 1 0	4			22CHY315	Equilibria, Dilute solutions, Surface,and Photochemistry	3 1 0	4	
22CHY305	Organic Synthesis – I	3 1 0	4			22CHY316	Electrochemistry	3 1 0	4	
22CHY306	Molecular Symmetry and Group Theory	2 1 0	3			22CHY317	Coordination Chemistry	3 1 0	4	
22CHY307	Molecular Spectroscopy	3 1 0	4			22CHY318	Organic Synthesis – II	3 1 0	4	
22CHY391[@]	Open Elective/Live in Lab[@]	3 0 0	3				**Core Elective – I**	3 0 0	3	
22CHY385	Physical Chemistry Lab	0 0 5	2				Professional Elective – II	3 0 0	3	
22CHY308	Analytical Chemistry	3 1 0	4			22CHY386	Advanced Organic Chemistry Lab (Integrated MSc Only)	0 0 6	3	
	Professional elective - I	3 0 0	3			22CHY398	Project (Exit option)	0 0 6	3	
	TOTAL		**27**				**TOTAL**		**25**	
							TOTAL	**142**		
							TOTAL (for BSc. Exit-option)	**145**		
SEMESTER 7						**SEMESTER 8**				
22CHY521	Statistical and Irreversible Thermodynamic	2 1 0	3			22CHY525	Molecular Modelling and Simulation	3 0 2	4	
22CHY522	Physical Methods in Chemistry	3 0 1	4			22CHY526	Bioorganic and Natural ProductsChemistry	3 1 0	4	
22CHY523	Organometallic Chemistry	3 1 0	4			22CHY527	Solid State Chemistry	2 1 0	3	
22CHY524	Frontiers in Organic Chemistry	3 1 0	4			22CHY528	Bioinorganic Chemistry	2 1 0	3	
	Core Elective - II	3 0 0	3			22CHY586	Advanced Physical Chemistry Lab	0 0 6	3	
	Core Elective - III	3 0 0	3				**Core Elective –IV**	3 0 0	3	
22CHY585	Advanced Inorganic Chemistry Lab	0 0 6	3				**Core Elective –V**	3 0 0	3	
21SSK301	Life skills III	1 0 2	2			22RM500	Research Methodology	2 0 0	2	
	TOTAL		**26**				**TOTAL**		**25**	
							TOTAL (for BSc Honrs. Exit-option) = 193			
SEMESTER 9						**SEMESTER 10**				
22CHY695	Dissertation - Phase 1		10			22CHY698	Dissertation – Phase 2		10	
22CHY691	Comprehensive Viva voce		2							
	TOTAL		**12**				**TOTAL**		**10**	
							TOTAL CREDITS = 215			

Electives

Code	Chemistry ELECTIVES	L T P	Cr	Code	Professional Electives	L T P	Cr
	POOL A (Chemical Biology)						
22CHY531	Chemical Biology	3 0 0	3	22CSA571	Data Structures and Algorithms	3 0 0	3
22CHY532	Medicinal Chemistry	3 0 0	3	22CSA572	Machine Learning I	3 0 0	3
22CHY533	Biosensors	2 0 2	3	22CSA574	Foundations Of Data science	2 0 2	3
22CHY534	Nanomaterials for Biological Applications	2 0 2	3	22CSA575	IoT (workshop based course)	3 0 0	3
22CHY535	Biomaterials	3 0 0	3	22CHY561	Statistical Analysis of Process Data	3 0 0	
22CHY536	Introduction to Bioinformatics	2 0 2	3	22CHY562	Safety and Hazard Management inChemical Industries	3 0 0	3
22CHY537	Bio electrochemistry	3 0 0	3				3
22CHY538	Bio microfluidics	2 0 2	3				
	POOL B (Applied Electrochemistry)						
22CHY541	Electroanalytical Techniques	2 0 2	3				
22CHY542	Photoelectrochemistry	3 0 0	3		**OPEN ELECTIVES (Chemistry)**		
22CHY543	Electrochemical Energy storage systems	2 0 2	3	22OEL299	History and Philosophy of Science	3 0 0	3
22CHY544	Industrial Electrochemistry	2 0 2	3	22OEL300	EU History of Science and Technology	3 0 0	3
22CHY545	Nanomaterials for Electrochemical Applications	2 0 2	3				
22CHY546	Electroorganic Chemistry	3 0 0	3				
22CHY547	Corrosion Science	3 0 0	3				
22CHY548	Sustainable chemical sciences	3 0 0	3				

Open Electives UG				
Course Code	**Course Title**	**L – T – P**	**Cr.**	**ES**
21OEL231	A Journey towards Free India	3 0 0	3	J
21OEL232	Political Leadership	3 0 0	3	J
21OEL233	Social issues in Contemporary India	3 0 0	3	J
21OEL234	The Story of Indian Business	3 0 0	3	J
21OEL235	Industrial Psychology	3 0 0	3	J
21OEL236	Advertising	3 0 0	3	J
21OEL237	Basic Statistics	3 0 0	3	J
21OEL238	Citizen Journalism	3 0 0	3	J
21OEL239	Creative Writing for Beginners	3 0 0	3	J
21OEL240	Desktop Support and Services	3 0 0	3	J
21OEL241	Development Journalism	3 0 0	3	J
21OEL242	Digital Photography	3 0 0	3	J
21OEL243	Emotional Intelligence	3 0 0	3	J
21OEL244	Essence of Spiritual Literature	3 0 0	3	J
21OEL245	Film Theory	3 0 0	3	J
21OEL246	Fundamentals of Network Administration	3 0 0	3	J
21OEL247	Gender Studies	3 0 0	3	J
21OEL248	Glimpses of Indian Economy and Polity	3 0 0	3	J
21OEL249	Graphics and Web-designing Tools	3 0 0	3	J
21OEL250	Green Marketing	3 0 0	3	J
21OEL251	Healthcare and Technology	3 0 0	3	J
21OEL252	History of English Literature	3 0 0	3	J
21OEL253	Indian Writing in English	3 0 0	3	J
21OEL254	Industrial Relations and Labour Welfare	3 0 0	3	J
21OEL255	Introduction to Ancient Indian Yogic and Vedic Wisdom	3 0 0	3	J
21OEL256	Introduction to Computer Hardware	3 0 0	3	J
21OEL257	Introduction to Event Management	3 0 0	3	J
21OEL258	Introduction to Media	3 0 0	3	J
21OEL259	Introduction to Right to Information Act	3 0 0	3	J
21OEL260	Introduction to Translation	3 0 0	3	J
21OEL261	Linguistic Abilities	3 0 0	3	J
21OEL262	Literary Criticism and Theory	3 0 0	3	J
21OEL263	Macro Economics	3 0 0	3	J
21OEL264	Managing Failure	3 0 0	3	J
21OEL265	Media Management	3 0 0	3	J
21OEL266	Micro Economics	3 0 0	3	J
21OEL267	Micro Finance, Small Group Management and Cooperatives	3 0 0	3	J
21OEL268	Negotiation and Counselling	3 0 0	3	J
21OEL269	New Literatures	3 0 0	3	J
21OEL270	Non-Profit Organization	3 0 0	3	J
21OEL271	Personal Effectiveness	3 0 0	3	J
21OEL272	Perspectives in Astrophysics and Cosmology	3 0 0	3	J
21OEL273	Principles of Marketing	3 0 0	3	J
21OEL274	Principles of Public Relations	3 0 0	3	J
21OEL275	Science, Society and Culture	3 0 0	3	J
21OEL276	Statistical Analysis	3 0 0	3	J
21OEL277	Teamwork and Collaboration	3 0 0	3	J
21OEL278	The Message of Bhagwad Gita	3 0 0	3	J
21OEL279	Understanding Travel and Tourism	3 0 0	3	J

21OEL280	Videography	3 0 0	3	J
21OEL281	Vistas of English Literature	3 0 0	3	J
21OEL282	Web-Designing Techniques	3 0 0	3	J
21OEL283	Organic Farming	3 0 0	3	J
21OEL284	Basic Legal Awareness on Protection of Women and Rights	3 0 0	3	J
21OEL285	Ritual Performances of Kerala	3 0 0	3	J
21OEL286	Documenting Social Issues	3 0 0	3	J
21OEL287	Fabrication of Advanced Solar Cell	3 0 0	3	J
21OEL288	Basic Concepts of X-ray Diffraction	3 0 0	3	J
21OEL289	Introduction to FORTRAN and GNUPLOT	3 0 0	3	J
21OEL290	Introduction to Porous Materials	3 0 0	3	J
21OEL291	Forensic Science	3 0 0	3	J
21OEL292	Introduction to solar Physics	3 0 0	3	J
21OEL293	Recycling Recovery and Treatment Methods for Wastes	3 0 0	3	J
21OEL294	Acting and Dramatic Presentation	2 0 2	3	J
21OEL295	Computerized Accounting	2 0 2	3	J
21OEL296	Kerala Mural Art and Painting	2 0 2	3	J
21OEL297	Painting	2 0 2	3	J
21OEL298	Reporting Rural Issues	3 0 0	3	J

Amrita Value Programmes I & II for UG programmes			
Course Code	Title	L-T-P	Credits
22ADM201	Strategic Lessons fromMahabharatha	1-0-0	1
22ADM211	Leadership from Ramayana	1-0-0	1
22AVP210	Kerala Mural Art and Painting	1-0-0	1
22AVP218	Yoga Therapy and Lessons	1-0-0	1
22AVP212	Introduction to Traditional IndianSystems of Medicine	1-0-0	1
22AVP201	Amma's Life and Message to themodern world	1-0-0	1
22AVP204	Lessons from the Upanishads	1-0-0	1
22AVP205	Message of the Bhagavad Gita	1-0-0	1
22AVP206	Life and Message of SwamiVivekananda	1-0-0	1
22AVP207	Life and Teachings of SpiritualMasters of India	1-0-0	1
22AVP208	Insights into Indian Arts andLiterature	1-0-0	1
22AVP213	Traditional Fine Arts of India	1-0-0	1
22AVP214	Principles of Worship in India	1-0-0	1
22AVP215	Temple Mural Arts in Kerala	1-0-0	1
22AVP218	Insights into Indian Classical Music	1-0-0	1
22AVP219	Insights into Traditional IndianPainting	1-0-0	1
22AVP220	Insights into Indian Classical Dance	1-0-0	1
22AVP221	Indian Martial Arts and SelfDefense	1-0-0	1
22AVP209	Yoga and Meditation	1-0-0	1

Syllabus

SEMESTER 1

22MAT106 Single Variable Calculus 3 1 0 4

Unit 1

Trigonometry: Expansions of sin nθ, cosθ, tan nθ in powers of Sin θ, Cos θ, Tan θ. Expansion of Sinnθ, Cosnθ, Sinθ, Cosθ in terms of Sines and Cosines of Multiplies of θ – Power series for Sin θ, Cos θ, Tan θ - Hyperbolic Functions - Inverse Hyperbolic Functions - Logarithm of complex numbers - Summation of Trigonometric Series - Gregory Series - Euler Series.

Unit 2

Differentiation Applications of Derivative: Mean Value theory – Concavity and Curve Sketching – Maxima and Minima.

Unit 3

Differential Equations of First Order: (Advanced Engineering Mathematics, E. Kreyszig) Formation of Differential Equations. Solutions of Differential Equations (Variable Separable, Homogeneous Equations and Equations reducible to Homogeneous Form, Linear and Equations reducible to Linear Form, Exact Differential Equations and Equations reducible to Exact form). Differential Equations not of the first degree (solvable for 'p', solvable for 'y', solvable for 'x', Clairaut's Equation). Applications.

Unit 4

Differential Equations of Higher Order: Homogeneous Linear Differential Equations with Constant Coefficient and Euler- Cauchy Differential Equations, Basis of Solutions and Wronskian. Non homogeneous Equations - Method of Undetermined Coefficients and Method of Variation of Parameters.

Unit 5

Boundary Value Problems for Second Order Equations: Green's function, Sturm Comparison Theorems and Oscillations, Eigenvalue Problems. Applications.

Recommended Reading

1. Calculus, G. B. Thomas Pearson Education, 2009, 11th Edition.
2. Advanced Engineering Mathematics, E. Kreyszig, John Wiley and Sons, 2002, 8th Edition.
3. Mathematics for Degree students, P. K. Mittal, S. Chand & Co, New Delhi.
4. Mathematics for B.Sc. Branch I Vol. I, Vol. II, P. Kandasamy and K. Thilagavathy, S. Chand & Co.

22BIO101 Basic Principles of Biology 2 1 0 3

Unit 1: Introduction

Salient features of life, importance of biology on the frontiers of science and technology. Brief history of biology. How plants, animals and microorganisms shaped human history.

Unit 2: **The logical structure of biology**

Concepts of complexity, emergent properties, adaptation, optimality, diversity, chance and necessity, structure function relationship, theme and variations, individual variability and plasticity. Nature of experimentation in biology and statistical inference.

Unit 3: **Broad overview of life on earth**

Origin and progression of life on earth, evolution, concept of adaptive versus neutral evolution. Classification/taxonomy and phylogeny. Molecular relationships between life forms.

Unit 4: **Biological information**

Nature of biological information, mechanisms of transmission of information - genetic, epigenetic, cultural and other mechanisms of inheritance. Central dogma of molecular biology.

Unit 5: **Mechanism of perpetuation of life**

Mechanism of perpetuation of life at molecular, cellular, organismal and population levels.

Recommended Reading

1. Principles of Biology: Interactive textbook from Nature Education
2. Biology: N. Campbell and J. Reece (2005) 7th edition, Pearson, Benjamin, Cummings

22PHY104 Mechanics 3 1 0 4

Unit 1

One dimensional Kinematics. Kinematics in 2D and 3 D: Projectile Motion, Circular Motion. Non-inertial frames and pseudo Forces-Rotating Coordinate Frame, Fictitious Forces, Coriolis Force, Tides, Foucault Pendulum.

Unit 2

Newton's Laws of Motion - Forces, Frictional Forces-Work, Kinetic Energy, Work-Energy Theorem, Potential Energy, Conservation of Energy Newton's law of gravitation, Motion in uniform gravitational field.

Unit 3

Centre of Mass, Conservation of linear momentum, collisions, systems with variable mass. Torque, Angular momentum, Moment of Inertia, Conservation of Angular momentum, Kinetic Energy of Rotation.

Unit 4

Stress, Strain, Hooke's law Elastic properties of matter. Kinematics of moving fluids, Equation of continuity, Euler's equation, Bernoulli's theorem, Viscous fluids, Reynold's number, Surface tension, Surface energy.

Unit 5:

Special theory of Relativity-Lorentz transformations, relativistic kinematics and mass-energy equivalence.

Recommended Reading

1. David Halliday, Robert Resnick & Jearl Walker, Fundamentals of Physics, John Wiley, 9E, 2012
2. Kittel et al, Mechanics, Berkeley Physics Course Vol-1, Tata McGraw Hill, 2011
3. R.P. Feynman, R. P. Leighton and M. Sands, Feynman Lectures on Physics Vol.1, Narosa, 2003
4. Landau, Lev D., and Evgenij M. Lifshitz. Mechanics: Course of Theoretical Physics. Vol. 1. 3rd ed. Butterworth-Heinemann, 1976. ISBN: 9780750628969.
5. https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/index.htm

6. Lectures by Walter Lewin on Classical Mechanics, https://www.youtube.com/watch?v=wWnfJ0-xXRE&list=PLyQSN7X0ro203puVhQsmCj9qhlFQ-As8e

22CHY103 General Chemistry 3 1 0 4

Unit 1: Atomic structure [14 h]

Bohr's model of hydrogen atom, Ritz combination principle, hydrogen spectrum, Bohr-Sommerfeld theory. Planck's quantum theory of radiation, dual character of electrons - de Broglie's equation, Heisenberg's uncertainty principle, photoelectric effect, Compton, Zeeman and Stark effects. Schrodinger wave equation, Eigen values, significance of wave function (ψ and ψ^2) and quantum numbers. Schrodinger wave equation for hydrogen and hydrogen-like systems, probability distribution of electrons around the nucleus, distribution of electrons in orbitals, shapes of atomic orbitals - s, p, d and f. Aufbau principle, Hund's rule, Pauli's exclusion principle, electronic configuration of elements.

Unit 2: Chemical bonding [16 h]

Electrovalency and ionic bond formation, lattice energy. Born-Lande equation and Born-Haber cycle and their applications, solvation enthalpy and solubility of ionic compounds. Covalent bonding, formation of H_2, orbital theory of covalency. Hybridisation – VSEPR theory, sigma and pi bonds, formation of covalent compounds. Properties of covalent compounds. Molecular orbital theory – homo diatomic molecules and hetero di and triatomic molecules. Polar and non-polar covalent bonds, polarization of covalent bond - polarizing power, polarisability of ions and Fajan's rule, dipole moment, percentage ionic character from dipole moment, dipole moment and structure of molecules. Co-ordinate covalent compounds and their characteristics. Metallic bond - free electron, valence bond and band theories.

Unit 3: Structure and Bonding in Solids [14 h]

Crystalline and amorphous solids, isotropy and anisotropy, indices - Miller indices, space lattice and unit cell, types of crystals - molecular, covalent, metallic and ionic crystals. Close packing of spheres – hexagonal, cubic and body centered cubic packing – density, coordination numbers, tetrahedral and octahedral holes. Body centered and primitive structures. Interstices in packing. Defects in crystals – stoichiometric, non-stoichiometric, extrinsic and intrinsic defects. Bonding in crystals - metallic, ionic and covalent bonding. Crystal systems - Bravais lattices, reciprocal lattice, interplanar spacing in different crystal systems and fractional coordinates. Ionic solids - structures of MX, MX_2 and MX_3.

Unit 4: Acids, Bases and Non-aqueous solvents [10 h]

Conjugate acids and bases, hard and soft acids and bases - Pearson's concept, HSAB principle and its application. Buffer solutions. Non-aqueous solvents - general characteristics of non-aqueous solvent - melting point, boiling point, latent heat of fusion and vaporization, and dielectric constant. Reactions in non-aqueous solvents like liquid ammonia, liquid SO_2 and liquid HF - complex formation, redox, precipitation and acid base type.

Unit 5: Chemical Analysis and Stoichiometric Calculation [6 h]

Titrimetry - fundamental concepts, theory of indicators. Acid base, redox, precipitation and complexometric titrations. Problems based on stoichiometry. Gravimetry principle and calculations involving estimation of barium, calcium and nickel. Data analysis, significant figures, precision and accuracy. Types of errors, mean and standard deviation.

Recommended Readings

1. Atkins, P. and Overton, T., 2010. Shriver and Atkins' inorganic chemistry. Oxford University Press, USA.
2. Catherine E. H. and Alan G. S. 2012. Inorganic Chemistry (Fourth Edition), Pearson, UK.
3. Marion Clyde Day Jr, Joel Selbin, Harry H Sisler. 2012. Theoretical Inorganic Chemistry. LLC.
4. Vogel, A. I. and Jeffery, G.H. 2009. Vogel's Quantitative Chemical Analysis, 6th Ed. Wiley.
5. F. A. Cotton and G. Wilkinson. 1987. Advanced Inorganic Chemistry, 5th edition, John Wiley and Sons, New York.

22CSA103 Introduction to Scientific Computing using Python 3 0 1 4

UNIT 1: Introduction to Python Programming

History of Python Programming Language, thrust areas of Python in physics, Integrated Development Environments, installation and use of python distribution: Anaconda, Spyder, Jupiter notebooks. Fundamental programming with Python - Designing a Program, identifiers, keywords, operators, and expressions. Arithmetic, Logical and Assignment operators, Precedence, Data types: Basic data types: Strings and numbers, displaying an output, type conversion, basic string operations& methods, format specifiers.

Unit 2: Tuples, Lists & Dictionaries

Tuples: immutable sequences, creating tuple, basic tuple operations. Lists**:** mutable sequences, basic list operations, List methods Dictionaries: basic dictionary operations, dictionary method User input variable.

Unit 3: Control structures

Decision Structures: If, If ----else, if ….elif…..else, nested if decision flow statements.

Repetition Structures: condition controlled: while loop. Count controlled: for loop, sentinals, continue and break statements, try and except statements

Unit 4: Functions & Files

Built in function, modules, void function, flow charting, hierarchy charts, Local variables and scope, passing an argument function, value returning functions, Random number generation

Files: introduction to file input and output

Unit 5: Scientific computing packages

Numpy: -Array object, creating array, matrix, indexing, slicing, resizing, reshaping, arithmetic operations, functions, matrices and vector operations Matplotlib: basic plotting, Scipy: Linear algebra operations, equation solving.

Recommended Readings

1. Mark Lutz, “Learning Python” O'Reilly Media,2013.
2. Robert Johansson, “Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib” Apress, 2019.
3. Rubin H. Landu, Manuel J. Paez, and Cristian C.Bordeianu, “Computational Physics Problem solving with Python” - Third Edition, Wiley VCH, 2015.

21ENG101 **Communicative English** **2 0 2 3**

Unit 1

Kinds of sentences, usage of preposition, use of adjectives, adverbs for description, Tenses, Determiners- Agreement (Subject – Verb, Pronoun- Antecedent) collocation, Phrasal Verbs, Modifiers, Linkers/ Discourse Markers, Question Tags

Unit 2

Paragraph writing – Cohesion - Development: definition, comparison, classification, contrast, cause and effect - Essay writing: Descriptive and Narrative

Unit 3

Letter Writing - Personal (congratulation, invitation, felicitation, gratitude, condolence etc.) Official (Principal / Head of the department/ College authorities, Bank Manager, Editors of newspapers and magazines)

Unit 4

Reading Comprehension – Skimming and scanning- inference and deduction – Reading different kinds of material –Speaking: Narration of incidents / stories/ anecdotes- Current News Awareness

Unit 5

Prose: John Halt's 'Three Kinds of Discipline' [Detailed]

Max Beerbohm's 'The Golden Drugget' [Detailed]

Poems: Ogden Nash- 'This is Going to Hurt Just a Little Bit' [Detailed]

Robert Kroetsch– 'I am Getting Old Now', Langston Hughes- 'I, Too' [Detailed]

Wole Soyinka- 'Telephone Conversation' [Non- Detailed]

Kamala Das- 'The Dance of the Eunuchs' [Non-Detailed]

Short Stories: Edgar Allan Poe's 'The Black Cat', Ruskin Bond's 'The Time Stops at Shamili' [Non- Detailed]

Recommended Readings

1. Ruskin Bond, Time Stops at Shamli and Other Stories, Penguin Books India Pvt Ltd, 1989
2. Syamala, V. Speak English in Four Easy Steps, Improve English Foundation Trivandrum: 2006
3. Beerbohm, Max, The Prince of Minor Writers: The Selected Essays of Max Beerbohm (NYRB Classics), Phillip Lopate (Introduction, Editor), The New York Review of Book Publishers.
4. Edger Allan Poe. The Selected Works of Edger Allan Poe. A Running Press, 2014.
5. Online sources
6. Ruskin Bond, Time Stops at Shamli and Other Stories, Penguin Books India Pvt Ltd, 1989
7. Martinet, Thomson, A Practical English Grammar, IV Ed. OUP, 1986.
8. Murphy, Raymond, Murphy's English Grammar, CUP, 2004

22ADM101 Foundations of Indian Heritage 2 0 0 2

UNIT 1

Introduction to Indian Culture - Introduction to Amma's life and Teachings – Symbols of Indian Culture.

UNIT 2

Science and Technology in Ancient India - Education in Ancient India - Goals of Life – Puru sharthas - Introduction to Vedanta and Bhagavad Gita.

UNIT 3

Introduction to Yoga - Nature and Indian Culture - Values from Indian History – Life and work of Great Seers of India.

TEXTBOOKS:

1. The Glory of India (in-house publication)
2. The Mother of Sweet Bliss, (Amma's Life & Teachings)

SEMESTER 2

22MAT117 Multivariable Calculus 3 1 0 4

Unit 1

Matrices: Matrix, Algebraic operations, Transpose of a matrix, Inverse of a matrix, Properties of matrices, Kinds of matrices: Symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices, Orthogonal and unitary matrices, Determinant of a matrix, Properties of determinants.

Unit 2

Systems of Linear Equations: Linear System of Equations, Gauss Elimination, Consistency of a linear system of equations.

Unit 3

Eigen value problems: Eigen values, Eigen vectors, Properties of Eigen values and Eigen vectors, Cayley-Hamilton theorem, Some Applications of Eigen value Problems, Similarity of Matrices, Diagonalization of a matrix, Quadratic forms and Canonical form of a quadratic form.

Unit 4

Vector differentiation: Limit of a vector function – continuity and derivative of vector function - Geometrical and Physical significance of vector differentiation - Partial derivative of vector function – gradient and directional derivative of scalar point functions – Equations of tangent plane and normal line to a level surface. Divergence and curl of a vector point function – solenoid and irrational functions – physical interpretation of divergence and curl of a vector point function.

Unit 5

Integration of vector functions – Line, surface and volume integrals. Gauss - Divergence Theorem – Green's Theorem – Stoke's Theorem (Statements only). Verification of theorems and simple problems.

Recommended Readings

1. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2002, 8th Edition.
2. Textbook of Matrix Algebra, Suddhendu Biswas, PHI, 2012.
3. Vector Calculus with Applications to Physics, Shaw James Byrnie - 2009
4. T. K. Manickavasakam Pillay, Vector Calculus, 2004.

22BIO111 Cellular and Molecular Biology 2 1 0 3

Unit 1: Biomolecules

Structure, function and interrelationships between all important biomolecules (like proteins, carbohydrates, nucleic acids and lipids) that collectively carry out the essential functions of life.

Unit 2: Cell structure, organelles and cell division

Introduction to cell biology. Classification of living organisms. Prokaryotic cells, eukaryotic cells. Structure and function of cytoplasm, nucleus, mitochondria, ribosomes, endoplasmic reticulum, rough endoplasmic reticulum, lysosomes, the Golgi complex, peroxisomes, vacuoles. Plant cell organelles, cytoskeletal elements and architecture, cell division and cell cycle.

Unit 3: Membrane structure and function

Membrane structure and function. Structure and composition of the cell membrane, membrane proteins, transport across the cell membrane.

Unit 4: Molecular biology

Genes and chromosomes, chromosomal elements, DNA as genetic material. Structure of chromosome, histones and nucleosomes. DNA replication - semi-conservative replication, DNA polymerases, events at the replication form, replication of the lagging strand, telomeres, consequences of defects in telomerase. Replication of genomes - origins of replication, control of DNA replication.

Unit 5: Molecular genetics

Gene expression - promoters, terminators. Transcriptional initiation, elongation and termination, RNA polymerases, the genetic code, codons and anticodons, the ribosome and translation. Gene mutations - missense versus nonsense mutations, insertions, deletions and frameshifts. Genetic reversion and suppression, spontaneous mutations and effects of environmental factors. Principles of genetic engineering - gene cloning and genomics. Perspectives in genetic engineering - applications, moral and ethical issues.

Recommended Readings

1. David L Nelson, and Michael M Cox et al., Lehninger principles of biochemistry WH Freeman; 7th edition, (2017).
2. Bruce Alberts et al., Essential Cell Biology; Richard Goldsby and Thomas J, &F/Garland, 4th Edition, (2014).
3. Alberts, Bruce.; Molecular Biology of the Cell, Garland Science; 5th edition (2008).

22PHY111 Basics of Electricity and Magnetism 3 1 0 4

Unit 1: Vector analysis

Review of vectors, Dot products, Cross products, and Triple products. Differential calculus: Gradient, Divergence, Curl, Second derivatives, Integral calculus: Fundamental theorem of calculus, Fundamental theorem of gradient, Fundamental theorem of divergence, Fundamental theorem of curls, Curvilinear coordinates: Spherical coordinates, Cylindrical coordinates. Dirac delta function.

Unit 2: Electrostatics

Coulomb's law. Superposition principle. Electric field – discrete and continuous distribution, Gauss's law, Applications of Gauss's law.

Unit 3: Electric Potential

The curl of electric field, Electric potential, meaning of electric potential, Equipotential surfaces, Potential of localized charge distribution, Work and energy in electrostatics, Energy of a point charge distribution, Energy of continuous charge distribution, Conductors and Capacitors, Charging and discharging of RC Circuit.

Unit 4: Magnetostatics

Magnetic fields, Magnetic forces, Currents, Biot-Savart law, Divergence and Curl of magnetic field, Ampere's law and its applications.

Unit 5: Electrodynamics

Ohm's law, EMF, Motional EMF. Electromagnetic induction: Faraday's law, Lenz's law, induced electric field, Maxwell's correction to Ampere's law, Examples of LC, LR, LCR circuits.

Recommended Readings

1. Introduction to Electrodynamics – David J. Griffiths, 4th edition, Pearson Publication, 2015.
2. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of physics, 9th Edition, John Wiley, 2012.
3. Richard P. Feynman, Robert P. Leighton and Matthew Sands, Feynman Lectures on Physics Vol.1, 1E, Narosa Publishing House, 2008.
4. Lectures by Prof. Dipan Ghosh on "Electromagnetic Theory" - https://nptel.ac.in/courses/115/101/115101005/
5. Lectures by Prof. Walter Lewin on Electricity and Magnetism- https://www.youtube.com/watch?v=x1-SibwIPM4&list=PLyQSN7X0ro2314mKyUiOILaOC2hk6Pc3j&index=2

22CHY112 Principles of Physical Chemistry 3 1 0 4

Unit 1: Gaseous state [14 h]

Kinetic theory of gases, ideal gas equation, Maxwell distribution of energy and velocities, collision parameters. Relation between mean free path and coefficient of viscosity. van der

Waals equation, other state equations, law of corresponding states, liquefaction, Andrews curves, critical parameters, methods for liquefaction. Determination of molecular mass by limiting density method, critical phenomena, critical constants and their determination. Numerical problems.

Unit 2: Thermodynamics – I [13 h]

Thermodynamic processes - reversible and irreversible, isothermal and adiabatic processes. State and path functions. Exact and inexact differentials, concept of heat and work. First law of thermodynamics. Relation between Cp and Cv. Calculation of w, q, dE and dH for expansion of ideal and real gases under isothermal and adiabatic conditions of reversible and irreversible processes. Thermochemistry - Enthalpy change of a reaction and different enthalpy changes - relation between enthalpy of reaction at constant volume and at constant pressure. Temperature dependence of heat of reaction - Kirchhoff's equation. Bond energy and its calculation from thermochemical data - integral and differential heats. Numerical problems.

Unit 3: Thermodynamics-II [12 h]

Second law of thermodynamics - different statements of the law, Carnot's cycle and efficiency of heat engine, Carnot's theorem. Thermodynamic scale of temperature - concept of entropy - definition and physical significance of entropy - entropy as a function of P, V and T. Entropy changes during phase changes, entropy of mixing. Entropy criterion for spontaneous and equilibrium processes in isolated system, Gibb's free energy (G) and Helmholtz free energy (A) - variation of A and G with P, V and T – Gibb's - Helmholtz equation and its applications. Thermodynamic equation of state – Maxwell's relations. Numerical problems.

Unit 4: Thermodynamics – III [7h]

Third law of thermodynamics - need for third law, calculation of absolute entropy, unattainability of absolute zero, thermodynamic systems of variable composition. Fugacity functions, partial molar quantities, thermodynamics of ideal solutions, real solutions and regular solutions, dilute solutions of nonelectrolytes, Henry's law, Raoult's law, Gibbs-Duhem equations, Gibbs-Duhem-Margules equations, and activity and standard states of non-electrolytes. Numerical problems.

Unit 5: Chemical Kinetics [14 h]

Molecularity and order of a reaction, rate law expression and rate constant. First, second, third and zero order reactions, pseudo-first order reactions (pseudo-unimolecular reactions). Complex, parallel, chain, opposing and consecutive reactions. Equilibrium and steady state approximations - mechanism of these reactions. Effect of temperature on reaction rates - Arrhenius equation and its derivation, activation energy, characteristics of activated complex. Theories of reaction rates – collision theory – derivation of rate constant of bimolecular gases reaction – failure of collision theory – Lindemann's theory of unimolecular reaction. Theory of absolute reaction rates – derivation of rate for a bimolecular reaction. Eyring equation – significance of entropy and free energy of activation. Numerical problems.

Recommended Readings

1. Atkins, P., Atkins, P.W. and de Paula, J., 2006. Atkins' physical chemistry. Oxford university press.
2. Gilbert William Castellan. 1983. Physical Chemistry, Addison Wesley; 3rd revised edion
3. Ira Levin, 'Physical Chemistry', 6th edition, Tata Mcgraw-Hill Education, 2011.
4. Samuel Glasstone, Textbook of Physical Chemistry, , Macmillan; 2nd edition.
5. Keith J Laidler, Chemical Kinetics, Pearson Publications, Third edition, 2003

6. James E House, Principles of Chemical Kinetics, Second Edition, Academic Press, 2007
7. Silbey, Alberty and Bawendi, Physical Chemistry, Fourth Edition, John Wiley and Sons

22PHY184 Physics Lab - I Mechanics, Electricity and Magnetism 0 0 2 1

1. Determination of acceleration due to gravity using bar pendulum.
2. Determination of Young's Modulus of a given bar by Uniform bending method.
3. Determination of Rigidity modulus of the given wire using Torsional pendulum.
4. Determination of Coefficient of viscosity of a given liquid by Poiseulle's method.
5. Studying the liquid flow through series and parallel combinations of capillaries.
6. Melde's String-Verification of laws of vibration.
7. Studies on different exciting modes of sonometer wire.
8. Determination of spring constant of the given spring
9. Determination of velocity of sound in air using Kundt's tube apparatus.
10. Determination of surface tension of the given liquid.
11. Study of collision parameters in two dimension.
12. Studying magnetic field along the axis of the coil-verification of superposition principle of magnetic field.
13. Mapping of electric field.
14. Study of Mutual inductance
15. Deducing the magnetic properties of a sample from its Hysteresis curve on CRO

22CHY183 Chemistry Lab - I 0 0 2 1

1. Estimation of sodium hydroxide and sodium carbonate in a mixture by double indicator method.
2. Estimation of calcium permanganometry
3. Estimation of Ferrous iron permanganometry
4. Estimation of ferrous iron using external and internal indicators.
5. Estimation of ferric iron using external and internal indicators.
6. Estimation of copper sulphate by iodometry titration
7. Estimation of iron in the given sample of haematite
8. Gravimetric estimation of barium as barium sulphate.
9. Gravimetric estimation of sulphate as barium sulphate.
10. Gravimetric estimation of copper as copper (I) thiocyanate.
11. Gravimetric estimation of nickel as nickel dimethyglyoximate.

21ENG111 Professional Communication 1 0 2 2

Unit 1

Vocabulary Building: Prefixes and Suffixes; One word substitutes, Modal auxiliaries, Error Analysis: Position of Adverbs, Redundancy, misplaced modifiers, Dangling modifiers – Reported Speech

Unit 2

Instruction, Suggestion & Recommendation - Sounds of English: Stress, Intonation - Essay writing: Analytical and Argumentative

Unit 3

Circulars, Memos – Business Letters - e - mails

Unit 4

Reports: Trip report, incident report, event report - Situational Dialogue - Group Discussion

UNIT 5

Listening and Reading Practice - Book Review

Recommended Readings

1. FelixaEskey. Tech Talk, University of Michigan. 2005
2. Michael Swan. Practical English Usage, Oxford University Press. 2005
3. Anderson, Paul. Technical Communication: A Reader Centered Approach, V Edition, Hercourt, 2003.
4. Raymond V. Lesikar and Marie E. Flatley. Basic Business Communication, Tata Mc Graw Hill Pub. Co. New Delhi. 2005. Tenth Edition.
5. Thampi, G. Balamohan. Meeting the World: Writings on Contemporary Issues. Pearson, 2013.
6. Lynch, Tony. Study Listening. New Delhi: CUP, 2008.
7. Kenneth, Anderson, Tony Lynch, Joan Mac Lean. Study Speaking. New Delhi: CUP, 2008.
8. Marks, Jonathan. English Pronunciation in Use. New Delhi: CUP, 2007.
9. Syamala, V. Effective English Communication For You (Functional Grammar, Oral and Written Communication): Emerald, 2002.

22ADM111 Glimpses of Glorious India 2 0 0 2

Unit 1

1. Relevance of Sri Rama and Sri Krishna in this Scientific Age
2. Lessons from the Epics of India
3. Ramayana & Mahabharata

Unit 2

4. Who is a Wise Man?
5. A Ruler’s Dharma
6. The Story of King Shibi

Unit 3

7. Introduction to the Bhagavad Gita
8. Bhagavad Gita – Action without Desire

Unit 4

9. Role and Position of Women in India
10. The Awakening of Universal Motherhood

Unit 5

11. Patanjali's Astanga - Yoga System for Personality Refinement
12. Examples of Heroism and Patriotism in Modern India

Recommended Readings

1. Common Resource Material II (in-house publication)
2. Sanatana Dharma - The Eternal Truth (A compilation of Amma's teachings on Indian Culture)

22AVP103 **Mastery Over Mind** **1 0 2 2**

Unit 1

Causes of Stress: The problem of not being relaxed. Need for meditation -basics of stress management at home and workplace. Traditions and Culture. Principles of meditation– promote a sense of control and autonomy in the Universal Human Value System. Different stages of Meditation. Various Meditation Models. Various practices of Meditation techniques in different schools of philosophy and Indian Knowledge System.

Unit 2

Improving work and study performance. Meditation in daily life. Cultivating compassion and good mental health with an attitude of openness and acceptance. Research and Science of Meditation: Significance of practising meditation and perspectives from diverse fields like science, medicine, technology. Philosophy, culture, arts, management, sports, economics, healthcare, environment etc. The role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology. The effect of practicing meditation for the wholesome wellbeing of an individual.

Unit 3

Communications: principles of conscious communication. Relationships and empathy: meditative approach in managing and maintaining better relationships in life during the interactions in the world, role of MAOM in developing compassion, empathy and responsibility, instilling interest, and orientation to humanitarian projects as a key to harness intelligence and compassion in youth. Methodologies to evaluate effective awareness and relaxation gained from meditation. Evaluating the global transformation through meditation by instilling human values which leads to service learning and compassion driven research.

Recommended Readings

1. Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019
2. Swami Amritaswarupananda Puri," The Color of Rainbow "published by MAM, Amritapuri.
3. Craig Groeschel, "Winning the War in Your Mind: Change Your Thinking, Change Your Life" Zondervan Publishers, February 2019
4. R Nagarathna et al, "New Perspectives in Stress Management "Swami Vivekananda Yoga Prakashana publications, Jan 1986
5. Swami Amritaswarupananda Puri "Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation", August 2019
6. Swami Amritaswarupananda Puri "From Amma's Heart - Amma's answer to questions raised during world tours" March 2018
7. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.

8. Mata Amritanandamayi Devi "Compassion: The only way to Peace: Paris Speech", MA Center, April 2016.
9. Mata Amritanandamayi Devi "Understanding and collaboration between Religions", MA Center, April 2016.
10. Mata Amritanandamayi Devi "Awakening of Universal Motherhood: Geneva Speech" M A center, April 2016

SEMESTER 3

22CHY204 **Physical Organic Chemistry** **3 1 0 4**

Unit 1: Basic concepts [15 h]

Acids and Bases – Acidity - pKa, basicity. Factors influencing acidity and basicity, HSAB principle. Electron displacement effects – resonance, inductive, electromeric, mesomeric and hyper conjugative effects. Reactive intermediates - generation, structure and reactivity reactions and rearrangement involving of carbocations, non-classical carbocations, carbanions, carbon radicals, radical ions, carbenes, nitrenes, isonitrenes, arynes and Bunte salt. Nomenclature and structural isomerism in monocyclic and bicyclic substituted alkanes.

Unit 2: Aromaticity [11 h]

Delocalised chemical bonding – 1,3-butadiene, frontier orbitals. Criteria for aromaticity – energy, structural and electronic criteria for aromaticity – relationship among them. Aromatic, antiaromatic and homoaromatic compounds. Aromaticity in annulenes, polycyclic and nonbenzenoid compounds, charged rings - aromatic cations and anions. Heteroaromatic systems.

Unit 3: Strain and Stability [10 h]

Thermochemistry of stable molecules - thermochemistry of reactive intermediates. Relationships between structure and energetics. Electronic effects, highly-strained molecules, long bonds, small rings, large rotation barrier and molecular mechanics.

Unit 4: Energy Surfaces and Kinetic Analyses [13 h]

Reaction coordinate diagram, activated complex, transition state theory, Arrhenius rate law. Boltzmann distributions, activation parameters, Hammond postulate, Curtin-Hammett principle, microscopic reversibility. Kinetic vs. thermodynamic control, kinetic experiments. Baldwin rules. Kinetic analysis of simple and complex mechanisms, steady state and saturation kinetics, methods to follow kinetics, calculating rate constants, Marcus theory and multiple reaction coordinates.

Unit 5: Linear Free Energy Relationship [11 h]

Isotope effects, substituent effects, linear free energy relationship (LFER), Hammet plots, steric and polar effects – Taft parameters. Solvent effects-Grunwald-Weinstein plots, Schleyer adaptation, acid base effects and conditions to create LFER.

Recommended Reading

1. Anslyn, E.V. and Dougherty, D.A., 2006. Modern physical organic chemistry. University science books.

2. Clayden, J., Greeves, N. and Warren, S., 2012. Organic chemistry. Oxford university press.
3. Carey, F.A. and Sundberg, R.J., 2007. Advanced organic chemistry: part A: structure and mechanisms. Springer Science & Business Media.
4. Isaacs, N.S., 1995. Physical organic chemistry. Longman Scientific & Technical.
5. Smith, M.B., 2020. March's advanced organic chemistry: reactions, mechanisms, and structure. John Wiley & Sons.

22PHY201 Waves, Oscillations and Ray Optics 3 1 0 4

Unit 1

Free oscillations of simple systems: free oscillations of systems with one degree of freedom, Linearity and superposition principle, free oscillations of systems with two degree of freedom, Beats

Unit 2

Free oscillations of systems with many degrees of freedom: Transverse mode of continuous string, General mode of continuous string and Fourier analysis. Modes of non-continuous system with N degrees of freedom.

Unit 3

Forced oscillations: Damped driven one dimensional Harmonic oscillator, Resonance in a system with two degrees of freedom, filters, forced oscillations of closed systems with many degrees of freedom.

Travelling wave: Harmonic travelling waves in one dimension and phase velocities.

Unit 4

Modulation, Pulse and wave packets: Group velocity, Pulse, Fourier analysis of pulses, Fourier analysis of travelling wave packets.

Unit 5

Geometrical optics: Fermat's principle- Laws of reflection and refraction. Images formed by plane mirror, Spherical mirror, Spherical refracting surfaces, Thin lens, system of thin lens aberrations, Matrix methods in optics, determining Cardinal points, optical instruments.

Recommended Readings

1. Frank S. Crawford, Jr., Waves, Berkeley Physics Course- Volume- 3, McGraw-Hill Book Company.
2. Hecht, Eugene, Optics, 2nd Ed, Addison Wesley, 1987.

22PHY202 Introduction to Mathematical Physics 3 1 0 4

UNIT 1: Fourier analysis

Periodic Functions, Trigonometric Series, Fourier Series, Functions of any Period p = 2L, Even and Odd Functions, Half Range Expansions (theorem statement only), Complex Fourier Series, Applications of Parseval’s Identity.

UNIT 2:

Fourier Integrals, Sine and Cosine Integrals, Fourier Transforms - Sine and Cosine Transforms, Properties, Convolution Theorem, diffraction theory- Fourier method.

UNIT 3: Laplace Transforms:

Laplace Transforms, Inverse Transforms, Properties, Transforms of Derivatives and Integrals, Second Shifting Theorem, Unit Step Function and Dirac-Delta Function,

UNIT 4:

Differentiation and Integration of Transforms, Convolution, Initial and Final Value Theorems, Periodic Functions, Solving Linear Ordinary Differential Equations with Constant Coefficients, System of Differential Equations and Integral Equations.

UNIT 1: Partial Differential Equations

Basic Concepts, Modelling; Vibrating String, Wave Equation, Separation of Variables, Use of Fourier Series, D'Alembert's Solution of the Wave Equation, Heat Equation; Solution by Fourier Series.

Recommended Readings

1. E Kreyszig, Advanced Engineering Mathematics, 10th Ed., John Wiley and Sons, 2015.
2. P. P. G. Dyke,An Introduction to Laplace Transforms and Fourier series, 2nd Ed.,Springer, 2014.
3. Larry C. Andrews and Bhimson, K. Shivamoggi, The Integral Transforms for Engineers,Prentice Hall India Learning Private Limited, 2003.

21SSK201 Life Skills – I 1 0 2 2

Soft skills and its importance: Pleasure and pains of transition from an academic environment to work-environment. Need for change. Fears, stress and competition in the professional world. Importance of positive attitude, self-motivation and continuous knowledge upgradation.

Self Confidence: Characteristics of the person perceived, characteristics of the situation, Characteristics of the Perceiver. Attitude, Values, Motivation, Emotion Management, steps to like yourself, Positive Mental Attitude, Assertiveness.

Presentations: Preparations, Outlining, Hints for efficient practice, Last minute tasks, means of effective presentation, language, Gestures, Posture, Facial expressions, Professional attire.

Vocabulary building: A brief introduction into the methods and practices of learning vocabulary. Learning how to face questions on antonyms, synonyms, spelling error, analogy etc. Faulty comparison, wrong form of words and confused words like understanding the nuances of spelling changes and wrong use of words.

Listening Skills: The importance of listening in communication and how to listen actively.

Prepositions and Articles: A experiential method of learning the uses of articles and prepositions in sentences is provided.

Problem solving; Number System; LCM &HCF; Divisibility Test; Surds and Indices; Logarithms; Ratio, Proportions and Variations; Partnership; Time speed and distance; work time problems;

Data Interpretation: Numerical Data Tables; Line Graphs; Bar Charts and Pie charts; Caselet Forms; Mix Diagrams; Geometrical Diagrams and other forms of Data Representation.

Logical Reasoning: Family Tree; Linear Arrangements; Circular and Complex Arrangement; Conditionalities and Grouping; Sequencing and Scheduling; Selections; Networks; Codes; Cubes; Venn Diagram in Logical Reasoning.

Recommended Readings

1. A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
2. Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
3. Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa& Co.
4. The Hard Truth about Soft Skills, by Amazone Publication.
5. Quantitative Aptitude, by R S Aggarwal, S Chand Publ.
6. Verbal and Non-verbal Reasoning, R S Aggarwal, S Chand Publ.
7. Data Interpretation, R S Aggarwal, S Chand Publ.
8. Nova GRE, KAPAL GRE, Barrons GRE books;
9. Quantitative Aptitude, The Institute of Chartered Accountants of India.
10. More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
11. The BBC and British Council online resources
12. Owl Purdue University online teaching resources
13. www.thegrammarbook.com online teaching resources
14. www.englishpage.com online teaching resources and other useful websites.

21ENV200 Environmental Science and Sustainability 3 0 0 3

Unit 1

State of Environment and Unsustainability, need for Sustainable Development, Traditional conservation systems in India, People in Environment, Need for an attitudinal change and ethics, Need for Environmental Education, Overview of International Treaties and Conventions, Overview of Legal and Regulatory Frameworks.

Environment: Abiotic and biotic factors, Segments of the Environment, Biogeochemical Cycles, Ecosystems (associations, community adaptations, ecological succession, Food webs, Food chain, ecological pyramids), Types of Ecosystems – Terrestrial ecosystems, Ecosystem Services, Economic value of ecosystem services, Threats to ecosystems and conservation strategies.

Biodiversity: Species, Genetic & Ecosystem Diversity, Origin of life and significance of biodiversity, Value of Biodiversity, Biodiversity at Global, National and Local Levels, India as a Mega-Diversity Nation (Hotspots) & Protected Area Network, Community Biodiversity Registers. Threats to Biodiversity, Red Data book, Rare, Endangered and Endemic Species of India. Conservation of Biodiversity. People's action.

Impacts, causes, effects, control measures, international, legal and regulatory frameworks of: Climate Change, Ozone depletion, Air pollution, Water pollution, Noise pollution, Soil/ land degradation/ pollution

Unit 2

Linear vs. cyclical resource management systems, need for systems thinking and design of cyclical systems, circular economy, industrial ecology, green technology. Specifically apply

these concepts to: Water Resources, Energy Resources, Food Resources, Land & Forests, Waste management. Discuss the interrelation of environmental issues with social issues such as: Population, Illiteracy, Poverty, Gender equality, Class discrimination, Social impacts of development on the poor and tribal communities, Conservation movements: people's movements and activism, Indigenous knowledge systems and traditions of conservation.

Unit 3

Common goods and public goods, natural capital/ tragedy of commons, Cost benefit analysis of development projects, Environment Impact Assessment (EIA), Environment Management Plan (EMP), Green business, Eco-labelling, Problems and solutions with case studies.

Global and national state of housing and shelter, Urbanization, Effects of unplanned development case studies, Impacts of the building and road construction industry on the environment, Eco-homes/ Green buildings, Sustainable communities, Sustainable Cities.

Ethical issues related to resource consumption, Intergenerational ethics, Need for investigation and resolution of the root cause of unsustainability, Traditional value systems of India, Significance of holistic value-based education for true sustainability.

Recommended Readings

1. R. Rajagopalan, Environmental Studies: From Crisis to Cure. Oxford University Press, 2011, 358 pages. ISBN: 9780198072089.
2. Daniel D. Chiras, Environmental Science. Jones & Bartlett Publishers, 01-Feb-2012, 669 pages. ISBN: 9781449645311.
3. Andy Jones, Michel Pimbert and Janice Jiggins, 2011. Virtuous Circles: Values, Systems, Sustainability. IIED and IUCN CEESP, London. URL:http://pubs.iied.org/pdfs/G03177.pdf
4. Annenberg Learner, The Habitable Planet, Annenberg Foundation 2015. URL: http:// www.learner.org/courses/envsci/unit/pdfs/textbook.pdf.

22CHY283 **Chemistry Lab - II** **0 0 2 1**

Part A

1. Estimation of equivalent weight of an acid
2. Estimation of glucose
3. Estimation of phenol and aniline
4. Estimation of acetone
5. Estimation of acid value of an oil
6. Estimation of iodine value and sap value of an oil
7. Estimation of Nitrogen – Kjeldahl method
8. Estimation of formaldehyde
9. Estimation of ester

Part B

1. Construction of isotherms for acetic acid adsorption on activated charcoal

2. Determination of critical solution temperature for the phenol water system and effect of ionic electrolytes
3. Determination of molecular weight by Rast's method-colligative properties
4. Determination of partition coefficient of iodine in CCl4-water mixture
5. Determination of average molecular weight of a polymer by viscosity measurements
6. Determination of calorific value of fuels by bomb calorimetry
7. Determination of Arrhenius parameters for ester hydrolysis reaction
8. Determination of order of ion exchange reactions
9. Polarimetric determination of the rate of inversion of the sugar

Recommended Readings

1. Mann F. G., and Saunders, B. C.2009. 'Practical Organic Chemistry' 4th edition, Pearson Education.
2. Ahluwalia V. K. and Dhingra. S. 2000. 'Comprehensive Practical Organic Chemistry' Universities Press.
3. Furnis, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, T. R.1989. 'Vogel's Textbook of Practical Organic Chemistry', ELBS/Longman.
4. Vogel, A. I. 1985. 'A Textbook of Qualitative Analyses', 4th edition, Longmans publications.
5. Pass G., Sutcliffe, H. 1974. 'Practical Inorganic Chemistry', 2nd edition, Chapman & Hill,
6. Parshall, G. W. 1974. 'Inorganic Synthesis', Vol. 15, Tata McGraw-Hill Education.
7. Das. R.C. and Behara. B., 1983. 'Experiments in Physical Chemistry', Tata McGraw-Hill.
8. Findly. A., 1972.' Practical Physical Chemistry', 9th edition, Wiley.
9. Yadav, J.B.2010. 'Advanced Practical Physical Chemistry', Krishna Prakashan Media, 29th edition.
10. Shoemaker, D.P., Garland, C.W. and Steinfeld, J.I., 2018. *Experiments in physical chemistry*. McGraw-Hill.
11. Malati, M.A., 1999. *Experimental inorganic/physical chemistry: an investigative, integrated approach to practical project work*. Elsevier.
12. Atkins, P., Atkins, P.W. and de Paula, J., 2014. *Atkins' physical chemistry*. Oxford university press.

22PHY281 **Physics Lab - II Optics** **0 0 2 1**

1. Determination of focal length of combination of lenses and nodal distance using nodal slide Assembly.
2. Studying the resolving power of a telescope.
3. Studying the dispersive power of prism.
4. Newton's ring experiment.
5. Studying the Interference fringes in Wedge shaped films.
6. Determination of wavelength of spectral lines using diffraction grating.
7. Verification of Law of Malus.
8. Determination of refractive index of the liquids using Snell's law.
9. Diffraction at single, double and multiple slits using laser - studying the intensity distribution.
10. Diffraction at circular aperture using laser and estimation of size of particles.
11. Determination of numerical aperture of optical fiber and losses of light in fiber due to Bending and beam profile analysis of Laser.

12. Determination of refractive index of given glass plate using Michelson interferometer

22CSA281 **Programming Lab - I** **0 0 2 1**

1. 2D and 3D plotting of functions (Scilab, Python)
2. Curve fitting
3. Least square fit Goodness of fit& standard constant
4. Solution of Linear system of equations: Gauss elimination
5. Solution of Linear system of equations: Gauss Seidal method
6. Solution of ODE First Order Differential equation:
7. Solution of ODE second order Differential equation

List of Experiments

1. Ohms law to calculate R,
2. Hooke's law to calculate spring constant
3. Solution of mesh equations of electric circuits
4. Solution of coupled spring mass systems
5. Radioactive decay
6. Current in RC, LC circuits with DC source
7. Newtons law of cooling
8. Classical equations of motion
9. Current in RC, LC circuits with DC source
10. Newtons law of cooling
11. Classical equations of motion
12. Harmonic oscillator •
13. Damped Harmonic oscillator- Overdamped- Critical damped
14. Forced Harmonic oscillator

Recommended Readings

8. A Survey of Computational Physics- Introductory Computational Science" Rubin H. Landau, Manuel José Páez, Cristian C. Bordeianu, 2008, Princeton university press.
9. Introduction to Numerical programming: Steven A. Gottlieb and Rubin H. Landau, CRC Press.

Amrita Values Programme I **1 0 0 1**

Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches

the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

Lessons from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

Lessons from the Upanishads

Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

Message of the Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

Life and Message of Swami Vivekananda

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

Life and Teachings of Spiritual Masters India

Sri Rama, Sri Krishna, Sri Buddha, Adi Shankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri Ramana Maharshi, Mata Amritanandamayi Devi.

Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in

Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability

Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma's words "it is a big step in restoring the lost harmony of nature".

Benefits of Indian Medicinal Systems

Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendor of our temples makes art enthusiast spellbound, warmth and grandeur of color combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the Vasthupurusha.

Organic Farming in Practice

Organic agriculture is the application of a set of cultural, biological, and mechanical practices that support the cycling of farm resources, promote ecological balance, and conserve biodiversity. These include maintaining and enhancing soil and water quality; conserving wetlands, woodlands, and wildlife; and avoiding use of synthetic fertilizers, sewage sludge, irradiation, and genetic engineering. This factsheet provides an overview of some common farming practices that ensure organic integrity and operation sustainability.

Ayurveda for Lifestyle Modification:

Ayurveda aims to integrate and balance the body, mind, and spirit which will ultimately leads to human happiness and health. Ayurveda offers methods for finding out early stages of diseases that are still undetectable by modern medical investigation. Ayurveda understands that health is a reflection of when a person is living in harmony with nature and disease arises when a person is out of harmony with the cycles of nature. All things in the universe (both living and nonliving) are joined together in Ayurveda. This leaflet endow with some practical knowledge to rediscover our pre- industrial herbal heritage.

Life Style and Therapy using Yoga

Yoga therapy is the adaptation of yogic principles, methods, and techniques to specific human ailments. In its ideal application, Yoga therapy is preventive in nature, as is Yoga itself, but it is also restorative in many instances, palliative in others, and curative in many others. The therapeutic effect comes to force when we practice daily and the body starts removing toxins and the rest is done by nature.

SEMESTER 4

22PHY211 **Basics of Electronics** **3 1 0 4**

Unit 1

Introduction: Circuit Theory: Nodal and Mesh analysis current and Voltage sources, Thevenin's theorem, Norton's Theorem, Open and closed circuit.

Semiconductors: Intrinsic& Extrinsic semiconductors, Doping in a semiconductor, PN Junction, Diode: forward reverse biasing and energy bands.

Unit 2

Diodes and Transistors: Diode characteristics, Ideal diode, rectifiers and filters, Clippers and clampers, Zener diode; Line and load regulation, Optoelectronic devices: LED, Photodiode, Schottky diode,

Transistor: Bipolar Junction Transistor, Transistor biasing, Load line analysis, Operating points, Transistor amplifier: current and voltage amplifiers.

Unit 3

JFET: Construction, biasing and applications in switches, variable resistance and choppers

MOSFET: Characteristics and operation of D- MOSFET & E- MOSFET, Digital switching using MOSFET, CMOS Applications

Thyristors: Four-layer diode, Silicon controlled rectifier,

Unit 4

Integrated Circuits: Differential amplifier, Operational Amplifier, Characteristics of ideal opamp, negative feedback, filters, nonlinear opamp circuits: Integrators, Differentiator

Unit 5

Digital Logic: Digital logic circuits CMOS and Bipolar (TTL), Combinational logic, sequential logic, Combinational logic, Sequential logic circuits: Counters & Flipflops

Recommended Readings

1. Fundamental of Electrics circuits: C. K. Alexander and M. N. O. Sadiku, Third edition, Tata McGraw Hill
2. The Art of Electronics: P. Horwitz and W. Hill (1989) 2nd edition,Cambridge University Press
3. Electronic Devices and Circuits: Robert L. Boylestad& Louis Nashelsky
4. Digital Principles and Their Applications: Donal P. Leach, Albert PaulMalvino and Gautam Saha (2006) Tata McGraw Hill
5. Electronic Principles: A. Malvino and D. Bates (2006) 7th edition, Mc-Graw-Hill

22CHY213 Principles of Organic Chemistry 3 1 0 4

Unit 1: Stereochemistry [13 h]

Optical and geometrical isomerism – Atropisomerism. Stereochemistry - symmetry and stereochemistry, chirality and symmetry, optical activity and chirality. Methods to determine configuration. Stereochemical descriptors, topicity relationships, molecules with more than one stereogenic centre. Asymmetric synthesis – methods of resolution, optical purity. Stereoselectivity, stereospecificity and regioselectivity.

Unit 2: Conformational Analysis [9 h]

Conformational analysis - acyclic and cyclic systems – four, five and six-membered rings. Conformations of mono and di substituted of six membered rings. Conformational effects on the reactivity of acyclic and cyclic systems. Kinetically and thermodynamically favoured products. Chemoselectivity, regioselectivity, enantioselectivity, and stereoselectivity.

Unit 3: Substitution Reactions [19 h]

Aliphatics nucleophilic substitution - the S_N1, S_N2, borderline, S_Ni mechanisms and their stereochemistry. Factors affecting the rates of S_N1, S_N2 and S_Ni. Neighbouring group participation. Substitution vs elimination reaction. Aromatic electrophilic and nucleophilic substitutions - mechanism – factors influencing, *ipso* substitution and directive effect.

Unit 4: Addition Reactions [12 h]

Hydrogenation of alkene - syn and anti-additions. Electrophilic addition to alkenes - Markovnikov's Rule – HX, H_2O, H_2SO_4, halogen, oxymercuration, hydroboration oxidation. Oxidation of alkenes to diols. Conjugate addition to alkenes. Nucleophilic addition- Nucleophilic addition reaction to carbonyl group - reactivity of aldehydes and ketones -

molecular orbitals explanation. Addition of oxygen, nitrogen, sulfur and carbon based nucleophiles to carbonyls. Reactions with ylides.

Unit 5: Elimination Reactions [7 h]

E1, E2, and E1cB reactions – mechanisms – factors influencing elimination - stereochemistry. Zaitsev and Hoffmann rule – dehydrohalogenation, dehydration of alcohols, quaternary ammonium salts. Pyrolytic elimination.

Recommended Reading

1. Solomons, T.G. and Fryhle, C.B., 2011. Organic chemistry. John Wiley & Sons.
2. Bruice, P.Y., 2017. Organic chemistry. Pearson.
3. Carey, F.A. and Sundberg, R.J., 2007. Advanced organic chemistry: part A: structure and mechanisms. Springer Science & Business Media.
4. March's Advanced Organic Chemistry: M. Smith and J. March, 6th edition, Wiley-Interscience
5. Clayden, J., Greeves, N. and Warren, S., 2012. Organic chemistry. Oxford university press.
6. Nasipuri, D., 2005. Stereochemistry of organic compounds: principles and applications. New Age International.

22CHY215 Principles of Inorganic Chemistry 3 1 0 4

Unit 1: Periodic Properties and s-Block Elements [12 h]

Periodicity in properties – atomic, ionic, covalent radii, ionization potential, electron affinity, electronegativity, effective nuclear charge – Slater's rule and their trends in periodic table. s-block elements - general characteristics – atomic and ionic radii, ionization energy, electropositive character, reducing property, hydration of ions, flame coloration, lattice energy, diagonal relationship and chemical properties. Ellingham diagram - extraction of alkali and alkaline earth metals. Uses of alkali and alkaline earth metals, synthesis and applications of compounds and complexes.

Unit 2: p Block Elements [15 h]

General characteristics – metallic and non-metallic character. Extraction of p-block elements. Boron compounds - Lewis acids and back bonding. Graphite, intercalation compounds, carbides, silicates and silicones and their applications. Allotropy in P and S. Compounds of N and P. Anomalous behavior of second row elements. Structure of ozone. Hydrides, halides, oxides, oxoacids, persulfuric acids and nitrides of group VI and VII elements. Interhalogen compounds and their structure. Isolation of noble gases. Preparation, properties, structure and uses of noble gas compounds.

Unit 3: d Block Elements [10 h]

Transition metals - general characteristics, metallic character, oxidation states, size, density, melting and boiling points, ionization energy, color, magnetic properties-spin only magnetic moments, reducing properties and catalytic properties. Nonstoichiometric compounds, complex and alloy formation. Difference between first and other two rows of d block elements and their compounds. Extractive metallurgy – Ellingham diagram. Compounds of transition metals (other than coordination compounds).

Unit 4: f Block Elements [8 h]

Position in the periodic table, general characteristics of lanthanides and actinides. Lanthanide contraction and its consequences. Isolation of lanthanides from monazite - ion exchange resin method. Actinides – occurrence, preparation and comparison with lanthanides. Uranium, thorium and plutonium - important compounds - preparation, properties and uses.

Unit 5: Nuclear Chemistry [15 h]

Nuclear structure, mass and charge, mass defect, binding energy, stability rules, magic numbers, nuclear quantum numbers and nuclear parity. Models of nucleus, shell model, liquid drop model, semi empirical mass equation, equations of radioactive decay and growth, half-life and average life. Determination of half-lives. Types of nuclear reactions. Radiation chemistry - radiochemical methods, measurement of radioactivity, measurement of radiations – gas detector, scintillation counter and semiconductor detectors. Applications of nuclear and radiation chemistry, isotope dilution analysis, activation analysis, radiometric titrations, radiation dosimetry, hydrated electron. Effective utilisation of nuclear energy – nuclear reactors.

Recommended Readings

1. Atkins, P. and Overton, T., 2010. Shriver and Atkins' inorganic chemistry. Oxford University Press, USA.
2. Housecroft, C.E. and Sharpe, A.G., 2008. Inorganic chemistry (Vol. 1). Pearson Education.
3. Lee, J.D., 2008. Concise inorganic chemistry. John Wiley & Sons.
4. Douglas, B.E., McDaniel D. and Alexander J. 2000. Concepts and models of inorganic chemistry. Wiley.
5. Arnikar, H.J., 1995. Essentials of nuclear chemistry (No. 1653). New Age International.
6. Source book on atomic energy, Glaston
7. Huheey, J.E., Keiter, E.A., Keiter, R.L. and Medhi, O.K., 2006. Inorganic chemistry: principles of structure and reactivity. Pearson Education India.
8. Cotton, F.A., Wilkinson, G., Murillo, C.A. and Bochmann, M., 1999. Advanced inorganic chemistry. John Wiley and Sons, Inc.

22CHY214 Quantum Chemistry 2 1 0 3

Unit 1: Quantum Chemistry – Introduction [6 h]

Mechanics as a means for study of systemic characteristics. Limitations of classical mechanics while dealing with quantum entities - black body radiation, UV-catastrophe. Quantization of energy, dual behaviour of quantum entities, photoelectric effect, principle of uncertainty. Postulates of quantum mechanics - postulate I – wave functions, postulate II - operators in quantum mechanics, operator algebra, postulate III – eigen values, eigen value equations, postulate IV – expectation value, postulate V – time dependent and time independent Schrodinger equation.

Unit 2: Applying Schrodinger Equation to Various General Systems [12 h]

Translational motion of a quantum entity - particle in a box, quantum mechanical tunneling. Vibrational motion - harmonic oscillator. Rotational motion - rigid rotator, particle on a ring and particle on a sphere. Basic ideas on angular momentum.

Unit 3: Variation and Perturbation Methods [10 h]

One electron atomic system - hydrogen atom – wave function, orbitals. Multielectron atomic systems - the variation method – variation theorem, extension of the variation method, determinants, simultaneous linear equations and linear variation functions. Perturbation theory-nondegenerate perturbation theory, perturbation treatment of helium atom ground state, perturbation theory for a degenerate energy level, perturbation treatment of first excited states of helium. Time dependent perturbation theory - interaction of radiation with matter.

Unit 4: Angular Momentum and Electron spin [7 h]

Angular momentum - operators, ladder operators, orbital and spin angular momenta, angular momentum in many electron atoms. Atomic states, term symbols, splitting of term levels into atomic levels, spin-orbit interaction. Electron spin – eigen values and eigen functions of spin operator - matrix methods - spin-orbitals. Pauli principle - antisymmetric wave function.

Unit 5: Chemical Bonding - Quantum Mechanical Approach [10 h]

Hydrogen molecule ion and hydrogen molecule - molecular orbital and valence bond theory - homo and hetero nuclear diatomic molecules. The concept of directed valences and hybridization. Quantum mechanics in band theory of metallic solids. The virial theorem and chemical bonding.

Recommended Readings

1. Levin I.N., 2008. Quantum Chemistry 6th Edition, Prentice-Hall.
2. McQuarrie, D.A., 2008. Quantum chemistry. University Science Books.
3. Atkins, P.W. and Friedman, R.S., 2011. Molecular quantum mechanics. Oxford university press.
4. Prasad, R.K., 2019. Quantum chemistry. New Age International.
5. Szabo, A. and Ostlund, N.S., 2012. Modern quantum chemistry: introduction to advanced electronic structure theory. Courier Corporation.
6. Piela, L., 2013. Ideas of quantum chemistry. Elsevier.
7. Chandra, A.K., 1994. Introductory quantum chemistry. Tata McGraw-Hill Education.

21SSK211 Life Skills - II 1 0 2 2

Professional Grooming and Practices: Basics of Corporate culture, Key pillars of Business Etiquette. Basics of Etiquette: Etiquette – Socially acceptable ways of behaviour, Personal hygiene, Professional attire, Cultural Adaptability. Introductions and Greetings: Rules of the handshake, Earning respect, Business manners. Telephone Etiquette: activities during the conversation, Conclude the call, To take a message. Body Language: Components, Undesirable body language, Desirable body language. Adapting to Corporate life: Dealing with people.

Group Discussions: Advantages of Group Discussions, Structured GD – Roles, Negative roles to be avoided, Personality traits to do well in a GD, Initiation techniques, How to perform in a group discussion, Summarization techniques.

Listening Comprehension advanced: Exercise on improving listening skills, Grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc.

Reading Comprehension advanced: A course on how to approach middle level reading comprehension passages.

Problem solving – Money Related problems; Mixtures; Symbol Based problems; Clocks and Calendars; Simple, Linear, Quadratic and Polynomial Equations; Special Equations;

Inequalities; Functions and Graphs; Sequence and Series; Set Theory; Permutations and Combinations; Probability; Statistics.

Data Sufficiency: Concepts and Problem Solving.

Non-Verbal Reasoning and Simple Engineering Aptitude: Mirror Image; Water Image; Paper Folding; Paper Cutting; Grouping Of Figures; Figure Formation and Analysis; Completion of Incomplete Pattern; Figure Matrix; Miscellaneous.

Special Aptitude: Cloth, Leather, 2D and 3D Objects, Coin, Match Sticks, Stubs, Chalk, Chess Board, Land and geodesic problems etc., Related Problems

Recommended Readings

1. A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
2. Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
3. Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa& Co.
4. The Hard Truth about Soft Skills, by Amazone Publication.
5. Quantitative Aptitude, by R S Aggarwal, S Chand Publ.
6. Verbal and Non-verbal Reasoning, R S Aggarwal, S Chand Publ.
7. Quantitative Aptitude by AbjithGuha, Tata McGraw hill Publ.
8. More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
9. The BBC and British Council online resources
10. Owl Purdue University online teaching resources
11. www.thegrammarbook.com online teaching resources
12. www.englishpage.com online teaching resources and other useful websites.

22CHY284 Inorganic Chemistry Lab 0 0 5 2

(Inorganic Semimicro Qualitative Analysis Lab)

Phase I: Simple salt analysis

Phase II: Two cation and two anion mixture

Phase III: Four cation and two anion mixture

Recommended Readings

1. Svehla, G., 2012. Vogel's qualitative inorganic analysis, 7/e. Pearson Education India.

22CHY285 Organic Chemistry Lab 0 0 5 2

Separation and analysis of binary mixtures of organic compounds

Separation, preliminary investigations, determinations of saturation/ unsaturation, detection of special elements by Lassaigne’s test.

Functional group identification, derivative preparation, determination of melting points of the derivatives. Calculation of Rf values from thin layer chromatography (TLC) for the following mixtures

(a) Acid and hydrocarbon

(b) Phenol and Aldehyde

(c) Phenol and acid

(d) Phenol and amine

(e) Acid and ester

(f) Halo compound and aldehyde

(g) Acid and Aldehyde

(h) Amine and aldehyde

(i) Amine and ketone

(j) Alcohol and hydrocarbon

Recommended Readings

1. Smith, P.W.G., Hannaford, A.J., Furnis B.S. and Tatchell, A.R. 1989. Vogel's Textbook of Practical Organic Chemistry", ELBS/Longman.
2. Shriner, R. L., Hermann, C. K. F, Morrill, T. C., Curtin, D. Y., Fuson, R.C. 2003. Systematic Identification of Organic Compounds. John Wiley & Sons.
3. Mann and Saunders 2009. Practical Organic Chemistry. Pearson edition, 2009.

SEMESTER 5

22CHY304 Chemistry of Main Group Elements 3 1 0 4

Unit 1:Alkali and Alkaline Earth Metals [12 h]

Synthesis and structure of hydrides, amides, alkoxides and coordination compounds of alkali and alkaline earth metals. Crown ethers and cryptands as complexing agents for alkali metal ions. Alkali and alkaline earth metals in liquid ammonia and other solvents. Unusual anions. Organometallic chemistry of alkali and alkaline earth metals - synthesis, structures, fluxionality and reactivity.

Unit 2: Triels and Crystallogens [16 h]

Synthesis, structure, bonding and reactivity of boron hydrides. STYX numbers. Wade's rule - closo, nido and arachno structure of boranes, carboranes and metallocene carboranes. Borides. Compounds of triels with nitrogen and halogens. Allotropic forms of carbon - fullerenes, CNTs and graphenes. Carbides. Hypervalent carbon compounds. Compounds of crystallogens with nitrogen and halogens. Element to element multiple bond compounds Organometallic chemistry of boron, aluminium, gallium, indium, thallium, silicon, germanium and tin – syntheses, structure and application.

Unit 3: Pnictogen and Chalcogens [12 h]

Preparation and properties of compounds of pnictogen and chalcogens with nitrogen, halogen and other important compounds. Element to element multiple bond compounds – homonuclear and heteronuclear compounds, and dπ-pπ bonding. Organometallic compounds of phosphorous, arsenic, antimony, bismuth, sulphur, selenium and tellurium – syntheses and properties.

Unit 4: Halogen and Noble Gases [8 h]

Application of hydrogen halides as nonaquous solvents. Halides of transition metals. Oxohalogen fluorides. Polyhalide anions and halogen cations. Apicophilicity. Chemistry of astatine. Synthesis and structure of fluorides, fluoroanions, fluorocation, oxo compounds of xenon and other elements of noble gases. Clathrate compounds.

Unit 5:Inorganic Chains, Rings, Cages and Clusters [12 h]

Introduction and nomenclature of inorganic polymers, chains, rings, cages and clusters. Borazine, boron cage compounds, sulphur-nitrogen compounds, polymeric sulphur nitride, silicates, polysilicone, fullerenes and polymers with P-N bonds. Isopoly anions, heteropoly anions, Keggin and Dawson polyoxometallates, metal clusters. Main group element clusters and main group element-transition metal mixed clusters.

Recommended Readings

1. Cotton, F.A., Wilkinson, G., Murillo, C.A. and Bochmann, M., 1999. Advanced inorganic chemistry. John Wiley and Sons, Inc.
2. Greenwood, N.N. and Earnshaw, A., 2012. Chemistry of the Elements. Elsevier.
3. González-Moraga, G., 2013. Cluster chemistry: introduction to the chemistry of transition metal and main group element molecular clusters. Springer Science & Business Media.
4. Akiba, K.Y., 2011. Organo Main Group Chemistry. John Wiley & Sons.
5. Huheey, J.E., Keiter, E.A., Keiter, R.L. and Medhi, O.K., 2006. Inorganic chemistry: principles of structure and reactivity. Pearson Education India.
6. Housecroft, C.E. and Sharpe, A.G., 2008. Inorganic chemistry (Vol. 1). Pearson Education.
7. Purcell, K.F. and Kotz, J.C., 2010. Inorganic chemistry. Holt-Saunders International Editions.

22CHY305 Organic Synthesis - I 3 1 0 4

Unit 1: Oxygen Functional Groups [12 h]

Carbonyl compounds - aldehydes and ketones - enolates. Active methylene compounds-synthesis and application of ethyl acetoacetate, diethyl malonate and cyanoaceto esters. Mono, di- and unsaturated carboxylic acids – preparation and reactions. Carboxylic acid derivatives – preparation and reaction of acid chlorides, anhydrides, amides, esters. Hemiacetal, hemiketal, acetal, orthoester, ether, epoxides - preparation and reactions.

Unit 2: Nitrogen Functional Groups [12 h]

Amino compounds – nomenclature and classification. Carbylamine reaction, diazotization – comparison of aliphatic and aromatic amines. Reductive amination of aldehydic and ketonic compounds. Amidine, azide, azo, diazoalkanes, cyanates, nitrile, nitrite, oxime, carbamate ester, nitro compounds, and diazonium salts – preparation and reactions.

Unit 3: C-C, C-N, and C-O/S bond formation [12 h]

C-C bond formation – aldol, Arndt-Eistert, Bardhan-Sengupta, Baker-Venkataraman, Barbier, Baylis-Hillman, Benzoin, Dieckmann, Friedel–Crafts, Michael, Perkin, Claisen, Robinson annulations, Vilsmeier, Wittig, Knoevenagel, and Ullmann Reactions. C-N bond formation – Mannich, Mitsunobu, Ritter, Gabriel, Ugi, Doebner, Buchwald-Hartwig, and Stork enamine reactions. Formation of azides and hydrazines. C-O and C-S bond formation –Fischer

esterification, Williamson's ether synthesis, Barton, Prins, Darzen, Baeyer-Villiger, and Mitsunobu reactions.

Unit 4: Oxidation [12 h]

Alcohols to carbonyl compounds - chromium(VI) oxidants, dimethyl sulfoxide - Swern oxidation, manganese(IV) oxide, silver carbonate, hypervalent iodine(III) and (V) reagents, ceric ammonium nitrate (CAN), N-oxyl radical. Alkenes to epoxides by H_2O_2, hydroperoxides and peroxyacids. Prevost oxidation and Woodward modifications. Oxidative cleavage of 1,2-diols - periodic acid. Oxidation of allylic and benzylic C-H bonds - NBS, DDQ, chloranil-T, SeO_2, and TEMPO. Oppenauer and Corey-Kim oxidation.

Unit 5: Reduction [12 h]

Catalytic hydrogenation - homogeneous and heterogeneous catalytic reductions. Dissolving metal reductions. Non-metallic reductions - Wolff-Kishner, diimide reductions, and Hantzsch ester. Metal hydride reductions - Nucleophilic metal hydrides, Sodium cyano borohydride, Li and Na borohydrides, $LiAlH_4$, DIBAL-H and Red-Al. Electrophilic metal hydrides - BH_3 and AlH_3. Hydrogenolysis - use of tri-n-butyl tin hydride.

Recommended Readings

1. Carey, F.A. and Sundberg, R.J., 2007. Advanced organic chemistry: part B: reaction and synthesis. Springer Science & Business Media.
2. Smith, M.B., 2020. March's advanced organic chemistry: reactions, mechanisms, and structure. John Wiley & Sons.
3. Li, J.J. and Corey, E.J., 2007. Name Reactions of Functional Group Transformations (Vol. 1). John Wiley & Sons.
4. Clayden, J., Greeves, N. and Warren, S., 2012. Organic chemistry. Oxford university press.
5. Norman, R. and Coxon, J.M., 2017. Principles of organic synthesis. Routledge.
6. Carey, F.A. and Sundberg, R.J., 2007. Advanced organic chemistry: part A: structure and mechanisms. Springer Science & Business Media.
7. Lin, G.Q., Li, Y.M. and Chan, A.S., 2001. Principles and applications of asymmetric synthesis. John Wiley & Sons.

22CHY306 Molecular Symmetry and Group Theory 2 1 0 3

Unit 1: Introduction to Molecular Point Groups [11 h]

Definition of a mathematical group. Symmetry in molecules- elements of symmetry, matrix representation of symmetry operations. Molecular point groups- abelian group, cyclic group, symmetry operations as group elements, similarity transformation and classes, group multiplication table, symmetry classification of molecules into pointgroups (Schoenflies symbol).

Unit 2: Construction and Interpretation of Character Tables [8 h]

Reducible and irreducible representations. Great Orthogonality Theorem and its consequences. Character tables-reduction formula, construction of character tables for point groups with order ≤ 6, interpretation of character tables.

Unit 3: Applications of Group theory - I (vibrational and electronic spectroscopy) [12 h]

Infrared and Raman activity of molecular vibrations in H_2O, N_2F_2, BF_3, AB_4 type molecules (Td and D_4h) and AB_6 type (Oh) of molecules, selection rules. Group theory to explain electronic structure of free atoms and ions- splitting of terms in a chemical environment, construction of energy level diagrams, estimations of orbital energies, selection rules and polarizations, double groups. Group theory to interpret electronic spectra of transition metal complexes – selection rules, Orgel diagrams, Tanabe-Sugano diagrams.

Unit 4: Applications of Group theory-II (Chemical bonding - Hybridization and Molecular Orbital Formation) [10 h]

Group theory to explain hybridization - wave functions as bases for irreducible representations, construction of hybrid orbitals for AB_3 (planar), AB_4 (Td), AB_5 (D_{3h}) and AB_6 (O_h) type of molecules. Symmetry adapted linear combinations- projection operators, application of projection operators to pi-bonding in ethylene, cyclopropenyl systems and benzene. Application of symmetry to predict polar and chiral compounds.

Unit 5: Symmetry in Solid State [4 h]

Symmetry elements and operations in solid state – proper axis of rotation, mirror planes of symmetry, roto- reflection and roto-inversion axes of symmetry, screw axes of symmetry, glide planes. A brief introduction to the crystallographic point groups and space groups.

Recommended Readings

1. Cotton, F.A., 2008. Chemical applications of group theory. John Wiley & Sons.
2. Carter, R.L., 1998. Molecular symmetry and group theory (p. 201). New York: Wiley.
3. Walton, D.P.H., 1998. Beginning group theory for chemistry. Oxford University Press.
4. Ramakrishnan V., Gopinathan M S, 2013, 'Group Theory in Chemistry (2nd reprint edition), Vishal Publications.
5. Salahuddin Kunju A, Krishnan G, 2015, Group theory and its application in chemistry (second edition), PHI Learning private LTD.

22CHY307 Molecular Spectroscopy 3 1 0 4

Unit 1: Rotational Spectroscopy [6 h]

Interaction of electromagnetic radiation with matter. Factors affecting intensities and band widths of spectral lines. Origin of pure rotational spectra - diatomic and polyatomic molecules, selection rules, intensities of spectral lines. Instrumentation of microwave spectroscopy. Microwave spectra in determination of structure of molecules. Applications in analysis of chemistry of space.

Unit 2: Vibrational and Vibration-Rotation Spectroscopy [13 h]

Vibration spectra of diatomic molecules - harmonic and anharmonic vibrations. Selection rules - classical, quantum mechanical and symmetry. Vibrating rotator - Born-Oppenheimer approximation, rotational character of vibration spectra, origin of vibration-rotation spectra. Different modes of vibrations. Vibration spectra of polyatomic molecules. Fermi resonance. Instrumentation of FTIR spectrophotometer. IR spectra of organic and inorganic compounds. Dependence of IR spectra on phase, temperature and solvents.

Unit 3: Raman Spectroscopy [11 h]

Classical and quantum mechanical theories on Raman scattering. Origin of rotational and vibrational Raman spectra. Instrumentation. Comparison between IR and Raman spectra - application of group theory - rule of mutual exclusion. Non-linear Raman spectroscopic techniques - stimulated, hyper, inverse and CARS. Resonance and surface enhanced Raman techniques. Applications of Raman spectroscopy in chemistry and biology.

Unit 4: Electronic Spectroscopy [12 h]

Electronic spectra of atoms - single and multi electron systems, j-j and L-S coupling. Electronic spectra of diatomic and polyatomic molecules - vibrational fine structure, Frank-Condon principle. Selection rules. Application of group theory in electronic spectra. Theory of fluorescence spectroscopy – quantum yield, lifetime.

Unit 5: Spin Resonance Spectroscopy [18 h]

Nuclear Magnetic Resonance - Classical and quantum mechanical approach - nuclear spin, magnetic moment, nuclear magnetic resonance, chemical shift, spin-spin coupling, relaxation processes. Dynamic NMR spectroscopy. Multiple resonance techniques. 2D and solid state NMR. Instrumentation of NMR – sampling. Spectra involving ^{1}H, ^{13}C, ^{19}F and ^{31}P nuclei. **Electron Spin Resonance -** Theory - electron spin, magnetic moment, electron spin resonance, hyperfine structure, line width and anisotropy. Dynamic ESR. Triplet state in ESR. Double resonance techniques. Instrumentation. ESR spectra of organic and inorganic compounds. **Nuclear Quadrupolar Resonance -** Theory - Nuclear quadrupolar moment, electric field gradient, the asymmetry parameter, nuclear quadrupolar transitions involving axially symmetric and axially non-symmetric molecules. Applications of NQR to analyze chemical bonding, molecular structure, solid state effects and hydrogen bonding.

Recommended Readings

1. Banwell, C.N. and McCash, E.M., 2017. Fundamentals of molecular spectroscopy. McGraw-Hill.
2. Hollas, J.M., 2004. Modern spectroscopy. John Wiley & Sons.
3. Sathyanarayana, D.N., 2020. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR. IK International Publishing House Pvt. Limited.
4. Sathyanarayana, D.N., 2015. Vibrational spectroscopy: theory and applications. New Age International.
5. Sathyanarayana, D.N., 2001. Electronic absorption spectroscopy and related techniques. Universities Press.
6. Sathyanarayana, D.N., 2020. Handbook of Molecular Spectroscopy: From Radio Waves to Gamma Rays. Wiley.
7. Drago, R.S., 2012. Physical methods in inorganic chemistry, Affiliated East.
8. Pavia, D.L., Lampman, G.M., Kriz, G.S. and Vyvyan, J.A., 2014. Introduction to spectroscopy. Cengage learning.
9. Kemp, W., 2017. Organic spectroscopy. Macmillan International Higher Education.
10. Silverstein, R M, F. X. Webster, F.X, Kiemle, D.J., Spectrometric identification of organic molecules (8^{th} edition). John Wiley
11. Skoog, D.A., Holler, F.J. and Crouch, S.R., 2007. Instrumental analysis (Vol. 47). Belmont: Brooks/Cole, Cengage Learning.

22CHY308 Analytical Chemistry 3 1 0 4

Unit 1: Errors, Statistics, and Sampling [10 h]

Theoretical principles of qualitative and quantitative analysis. Types of analytical methods - importance of analytical methods in qualitative and quantitative analysis - chemical and instrumental methods - advantages and limitations. Data analysis – average deviation, standard deviation, confidence limits, comparison of results - t-test and f-test, rejection of results, calibration curves, and correlation coefficient. Significant figures. Sampling - procedures and statistics.

Unit 2: **Aqueous and Solid Phase Extraction** [10 h]

Liquid-liquid extraction – theory and selection of solvents. Distillation - introduction, types of distillation, and applications. Solid phase extraction (SPE) – types, formats and apparatus, method of operation, solvent selection, factors affecting SPE, automation, and on-line SPE. Supercritical fluid extraction – instrumentation and applications.

Unit 3: **Chromatography** [13 h]

Thin layer chromatography - stationary phase, mobile phase, adsorbents, plate preparation, sample application, development, saturation of chamber, detection of spot, R_f values calculation, effect of adsorbent, solvent, solute, quantitative analysis and applications. Column chromatography – packing a column and application. Separation of biomolecules – electrophoresis, centrifugation of DNA and proteins. Gas chromatography (GC), high-performance liquid chromatography (HPLC), GC-MS and LCMS – instrumentation, working principle and application.

Unit 4: Thermal Analysis [10 h]

Principle of thermogravimetry (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC) - instrumentation and characteristics of TGA and DTA curves, factors affecting TGA and DTA curves. Applications - determination of purity of compounds by DSC, thermometric titrations, microthermal analyser – working principle and applications.

Unit 5: Surface Characterization Techniques [17 h]

Principle, instrumentation, working and applications of the following microscopic techniques-SEM, AFM, STM, STEM, TEM, confocal microscopy and fluorescence microscopy. Elemental composition - energy dispersive spectroscopy, UPS, XPS, Auger electron spectroscopy, selected area diffraction. Particle size analyzers, DLS, zeta potential, BET and electrochemical surface area analysis.

Recommended Reading

1. Karger, B.L., Snyder, L.R. and Horvath, C., 1973. Introduction to separation science.
2. Rousseau, R.W. ed., 1987. Handbook of separation process technology. John Wiley & Sons.
3. Skoog, D.A., West, D.M., Holler, F.J. and Crouch, S.R., 2013. Fundamentals of analytical chemistry. Cengage learning.
4. Skoog, D.A., Holler, F.J. and Nieman, T.A., 1998. Principles of instrumental analysis 5th edition. Saunders College Pub. Co.: Philadelphia.
5. Luo, Z., A Practical Guide to Transmission Electron Microscopy (Volume II).
6. Ul-Hamid, A., 2018. A beginners' guide to scanning electron microscopy. Cham, Switzerland: Springer International Publishing.

7. Thomas, S., Thomas, R., Zachariah, A.K. and Mishra, R.K. eds., 2017. Microscopy methods in nanomaterials characterization (Vol. 1). Elsevier.

22CHY385 Physical Chemistry Lab 0 0 5 2

1. Conductance measurements and verification of Onsager equation
2. Determination of solubility of sparingly soluble salt-application Kohlrausch law
3. Preparation of buffers-use of Henderson equation
4. Determination of molecular weight of coordination complex by partition coefficient method.
5. Effect of current density on the thickness of anodised aluminium films
6. pH metric estimation of strong acids
7. Spectrophotometric estimation of iron in a water sample
8. Conductometric estimation of weak and strong acids in a mixture
9. Construction of phase diagram for two-component systems
10. Construction of three-component phase diagrams
11. Determination of molecular weight of metal complexes by partition coefficient method
12. Estimation of halides in a mixture by potentiometry
13. Spectrophotometric determination of molecular formula and weight of metal complexes
14. Determination of efficiency of corrosion-resistant films using linear polarization (Tafel plots).
15. Flame photometric estimation of metal ions in water and soil.
16. Estimation of sugars using polarimetry

Recommended Readings

1. Das. R.C. and Behara. B., 1983. 'Experiments in Physical Chemistry', Tata McGraw-Hill.
2. Findly. A., 1972.' Practical Physical Chemistry', 9th edition, Wiley.
3. Yadav, J.B.2010. 'Advanced Practical Physical Chemistry', Krishna Prakashan Media, 29th edition.
4. Shoemaker, D.P., Garland, C.W. and Steinfeld, J.I., 2018. *Experiments in physical chemistry*. McGraw-Hill.
5. Malati, M.A., 1999. *Experimental inorganic/physical chemistry: an investigative, integrated approach to practical project work*. Elsevier.
6. Atkins, P., Atkins, P.W. and de Paula, J., 2014. *Atkins' physical chemistry*. Oxford university press.

SEMESTER 6

22CHY315 Equilibria, Dilute solutions, Surface and Photochemistry 3 1 0 4

Unit 1: Chemical Equilibrium [7 h]

Law of mass action, equilibrium constant – relation between K_p, K_c and K_x. Thermodynamic treatment of the law of mass action – van't Hoff reaction isotherm. Temperature dependence of the equilibrium constant – van't Hoff's equation. Pressure dependence of the equilibrium constant K_p and K_c. Factors that change the state of equilibrium – Le Chatelier's principle and its application to chemical and physical equilibria.

Unit 2: Phase Equilibria [10 h]

Phase, components and degrees of freedom. Derivation of Gibbs phase rule. Application of phase rule to one component system. Reduced phase rule. Two component system - simple eutectic. Pattinson's process. Phase diagram - steel, alloys, Fe-C system and zone refining. Thermal analysis and cooling curves - compound formation with congruent melting point - Zn–Mg and incongruent melting point – Na-K system. Continuous solid solutions of metals and solid solutions with minimum and maximum melting points.

Unit 3: Dilute Solutions [15 h]

Concept of activity and activity coefficients. Two component systems - completely miscible liquids – azeotropes, Duhem - Margules equation, partially miscible liquids - lower and upper CSTs - effect of impurities on CST. Three component system - completely immiscible and partially miscible liquids - triangular coordinates. Nernst distribution law – derivation and applications. Colligative properties – determination of molecular weight.

Unit 4: Surface Chemistry, Catalysis and Colloids [16 h]

Adsorption – physical and chemical - thermodynamics of adsorption, adsorption isotherms – Freundlich, Langmuir, and BET - positive, negative and electrostatic adsorption. Applications of adsorption. Catalysis - homogeneous catalysis – kinetics of acid–base catalysis and mechanism. Heterogeneous catalysis – kinetics – Langmuir-Hinshelwood mechanism, monolayer and multilayer adsorption. Enzyme catalysis - factors affecting enzyme-catalyzed reactions. Catalyst poisons. Catalysis in the chemical industry.

Colloidal state – properties, stability - zeta potential, isoelectric point. Protective colloids - Hofmeister series. Coagulation or flocculation - Hardy-Schulze law. Micelle and critical micelle concentration. Application of colloids.

Unit 5: Photochemistry [12 h]

Consequences of light absorption - Jablonski diagram. Laws of photochemistry - Beer-Lambert law, Grotthus-Draper law and Stark Einstein law. Quantum efficiency. Energy transfer in photochemical reactions – photosensitisation. Quenching - Stern-Volmer equation, Forster resonance energy transfer and Marcus theory. Photochemical reactions - kinetics, chemiluminescence and photoelectric cells.

Recommended Readings

1. Atkins, P., Atkins, P.W. and de Paula, J., 2014. Atkins' physical chemistry. Oxford university press.
2. House, J.E., 2007. Principles of chemical kinetics. Academic press.
3. Glasstone, S., 1951. Textbook of physical chemistry. Macmillan.
4. Laidler, K.J. and Keith, J., 2003. Chemical kinetics (Vol. 2). New York: McGraw-Hill.
5. Birdi, K.S., 2009. Surface and colloid chemistry: principles and applications. CRC press.

22CHY316 Electrochemistry 3 1 0 4

Unit 1: Quantitative Electrochemistry and Ionics [12 h]

Quantitative electrochemistry - review of Faraday’s laws. Conductivity of electrolytes, Kohlrausch law, solubility product and salt hydrolysis. Debye-Huckel-Onsager equation – Debye-Huckel limiting law and its testing and improvement – conductometric titrations. Aqueous and non-aqueous electrolytes. Mass transfer in electrolytes – convection,

diffusion and migration, general mass transfer equation – derivation - mixed migration and diffusion - effect of supporting electrolytes, microscopic view of diffusion, Ficks law, boundary conditions.

Unit 2: Electrified Interfaces [10 h]

Interfacial region – electrical double layers and their structure - electrode potential and its measurement, reversibility, polarizable and nonpolarizable electrodes. Electrochemical cells - cell resistance, standard electrode potentials, calculation of emf – variation of potential with concentration, pressure and temperature, liquid junction potential, measurement of interfacial surface tension, electrocapillary curves, electrokinetic phenomena, measurement of zeta potential and electrophoresis. Applications of potential measurements, reference electrodes, ion-selective electrodes, potentiometry, pH metry. Structure of semiconductor-liquid interface.

Unit 3: Kinetics of Electrochemical Reactions [14 h]

Transition state theory, essentials of electrode reactions, Butler-Volmer model, one step-one electron processes, transfer coefficient, exchange current, current over potential equation, Tafel plots, effects of mass transfer, multistep mechanisms, quasi reversible and irreversible processes, microscopic theories of charge transfer- Marcus model, distribution of energy states model, tunnelling and extended charge transfer. Faradaic and nonfaradaic processes, electrode reactions with coupled homogeneous chemical reactions. Theory for voltametric and chronopotentiometric methods, controlled potential and coulometric methods, rotating disc and ring disc electrodes.

Unit 4: Electroanalytical Techniques [10 h]

Potential sweep methods – linear sweep voltammetry and cyclic voltammetry - reversible, quasi-reversible and irreversible systems. Potential step methods – chronoamperometry, polarography-DME-Ilkovic equation, pulse voltammetry – normal and differential pulse. Electrochemical impedance spectroscopy – Bode and Nyquist plots.

Unit 5: Electrochemical Energy Storage Devices and Processes [14 h]

Electrochemical energy storage, principle of working of supercapacitors and batteries. Primary batteries – duracell, metal-air and lithium primary batteries. Secondary batteries - lead acid, lithium-ion and lithium polymer batteries. Fuel cells - PEMFC, direct methanol fuel cells. Industrial cathodic processes - electrodeposition of copper, nickel, zinc and chromium over mild steel. Industrial anodic processes - anodising of aluminium, electropolishing – electrochemical machining. Electroless deposition.

Recommended Readings

1. Allen, J. and Bard, R.L., 2000. Faulkner. Electrochemical Methods: Fundamentals and Applications, John Wiley and Sons. Inc. New York.
2. Bockris, J.O.M. and Reddy, A.K., 1998. Ion-solvent interactions. Modern Electrochemistry 1: Ionics, Springer.
3. Bockris, J.O.M., Reddy, A.K. and Gamboa-Aldeco, M., 2000. Electrodics. Modern Electrochemistry 2A: Fundamentals of Electrodics, 2nd Edition, Springer.
4. Pletcher, D. and Walsh, F.C., 1990. Industrial electrochemistry. Springer Science & Business Media.
5. Beard, K.W., 2019. Linden's handbook of batteries. McGraw-Hill Education.
6. Brenner, A., 2013. Electrodeposition of alloys: principles and practice. Elsevier.

22CHY317 **Coordination Chemistry** **3 1 0 4**

Unit 1: Theories and Concepts on *d*-block Coordination Compounds. [15 h]

Werner's coordination theory, valence bond theory (VBT), crystal field theory (CFT) – CFSE - effects of CFSE, types of ligands. Spectrochemical series, spectral and magnetic properties, and nephelauxetic effect. Crystal field splitting - O_h, T_d, square planar, square pyramidal and trigonal pyramid geometries, factors affecting the magnitude of CFSE, isomerism in coordination complexes, Jahn-Teller (JT) distortion - manifestation on spectral properties. Limitations of CFT. Molecular orbital theory and ligand field theory.

Unit 2: Spectral and Magnetic Properties [15 h]

Russell-Saunders coupling schemes, term symbols for various d^n ions, Orgel diagrams for d^n systems, ligand field parameters, *Dq*, Racah parameter *B* and nephelauxetic constant. Tanabe-Sugano diagrams - applications. Charge-transfer transitions – MLCT and LMCT. Selection rules - spin-orbit and vibronic coupling effects. Spectral behaviour of *f*-block coordination complexes. Magnetic properties of coordination complexes - magnetic susceptibility - the contribution of spin-orbit coupling on μ_{eff}, types of magnetic behaviour - para, ferro, anti-ferro and ferri-magnetic systems. Curie and Curie-Weiss laws. Guoy, Faraday and SQUID methods. Kotani plots - effects of temperature on magnetic behaviour, multinuclear homo- and heterometallic 3*d, 4d and 5d* systems and mixed 3*d*-4*f* systems.

Unit 3: Reaction Mechanism [13 h]

Complex equilibrium - formation constants, factors affecting stability, stability constants. Mechanisms of ligand displacement and addition reactions, *cis*- and *trans*-effect and substitution reactions. Kinetic and thermodynamic consequences on reaction pathways. Mechanism - dissociation, interchange, association and conjugate base. Stereochemical aspects. Isomerisation of chelate rings, sigma and pi bonding effects. Oxidation-reduction reactions, inner and outer sphere electron transfer reactions.

Unit 4: Complexes of Inner Transition Elements [8 h]

Oxidation states, shapes of *f*-orbitals (4*f* and 5*f*), nature of bonding of *f*-orbitals with ligands, ligand preferences, coordination numbers and the geometry of the complexes. Influence of lanthanide and actinide contraction in their coordination behaviour. Various types of coordination compounds of lanthanides and actinides.

Unit 5: Application of Coordination Compounds [9 h]

Medicinal applications - sodium nitroprusside complex for hypertension treatment. Cancer therapy – platinum and palladium anticancer agents, nonplatinum anticancer agents – mechanism of action. Vanadium compounds - mechanism of action. Electrochemical application - mechanism of an electrochemical process involving labile complexes, electrochemical process in a real system – copper cyanide and gold cyanide system, electro reduction of tin(II) and zinc(II) complexes. Electrochemical deposition of alloys.

Recommended Readings

1. Cotton, F.A., Wilkinson, G., Murillo, C.A. and Bochmann, M., 1999. Advanced inorganic chemistry. John Wiley and Sons, Inc.
2. Huheey, J.E., Keiter, E.A., Keiter, R.L. and Medhi, O.K., 2006. Inorganic chemistry: principles of structure and reactivity. Pearson Education India.

3. Lee, J.D., 2008. Concise inorganic chemistry. John Wiley & Sons.
4. Douglas, B.E., McDaniel D. and Alexander J. 2000. Concepts and models of inorganic chemistry. Wiley.
5. Atkins, P. and Overton, T., 2010. Shriver and Atkins' inorganic chemistry. Oxford University Press, USA.
6. J. E. House, “Inorganic Chemistry”, Academic Press, 2008.
7. Gopalan, R., 2001. Concise coordination chemistry. Vikas publishing house.
8. Jones, C.J. and Thornback, J.R., 2007. Medicinal applications of coordination chemistry. Royal Society of Chemistry.
9. Day, M.C. and Selbin, J., 1969. Theoretical inorganic chemistry.

22CHY318 Organic Synthesis - II 3 1 0 4

Unit 1: Organometallic Reagents and Catalysts [14 h]

Application of organometallic compounds of lithium, magnesium, boron, silicon and tin in organic synthesis. Applications of organo platinum-group metals, organonickel, organocobalt, organocopper, organozinc, organocadmium and organomercury in organic synthesis.

Unit 2: Synthetic Strategies - I: Functional Group Interconversions [14 h]

Functional group interconversions, the importance of the order of events in organic synthesis, chemoselectivity, regioselectivity, and Umpolung concept. The concept of protection and deprotection of functional groups in synthesis. Protection of amino, hydroxy, diol, carbonyl and, double and triple bonds.

Unit 3: Synthetic Strategies – II: Retro Synthesis [9 h]

Disconnection Approach - synthons and synthetic equivalents, donor and acceptor synthons, disconnection, alternating polarity disconnection and steps in planning the synthesis. One and two groups C-X and C-C disconnections. Control of relative stereochemistry and enatioselectivity in carbonyl condensations. 1-5 disfunctionalised compounds.

Unit 4: Rearrangement and Transformation Reactions [14 h]

Classification of rearrangements. General mechanistic consideration, nature of migration, migratory aptitude, stereochemical aspects and memory effects in rearrangements. Rearrangement to electron deficient carbon - pinacol-pinacolone, Wagner-Meerwein, benzillic acid, Wolf, Rupe and Demjanov rearrangements. Rearrangement to electron deficient nitrogen - Hofman, Curtius, Schmidt, Lossen and Beckmann rearrangements. Rearrangement to electron deficient oxygen - Baeyer-Villiger rearrangement. Rearrangement to electron rich carbon - Fovorskii, Wittig, Neber and Stevens rearrangements. Aromatic rearrangement - Fries, Claisen and benzidine rearrangements.

Unit 5: Asymmetric Synthesis [9 h]

Principles and applications of asymmetric synthesis. Stereoselectivity in cyclic compounds, enantio-selectivity, diastereo-selectivity, enatiomeric and diastereomeric excess, stereoselective aldol reactions. Cram’s rule, Felkin Anh rule and Cram’s chelate model.

Asymmetric synthesis - use of chiral auxiliaries, chiral reagents and catalysts. Asymmetric hydrogenation, epoxidation and dihydroxylation.

Recommended Readings

1. Warren, S., 1991. Designing organic syntheses: a programmed introduction to the synthon approach. John Wiley & Sons.
2. Li, J.J. and Corey, E.J., 2007. Name Reactions of Functional Group Transformations (Vol. 1). John Wiley & Sons.
3. Norman, R.O.C., and Coxon, J.M., 2014. Principles of organic synthesis. CRC press,
4. Gawley, R.E. and Aubé, J., 2012. Principles of asymmetric synthesis. Elsevier.
5. Carey, F.A. and Sundberg, R.J., 2007. Advanced organic chemistry: part B: reaction and synthesis. Springer Science & Business Media.
6. Li, J.J., 2020. Name reactions: a collection of detailed mechanisms and synthetic applications. Springer Science & Business Media.
7. Rojas, C.M., 2015. Molecular Rearrangements in Organic Synthesis. John Wiley & Sons.

22CHY386 Advanced Organic Chemistry Lab 0 0 6 3

Students are expected to try various approaches in organic synthesis and characterization. The assessment is based on the practical skills in the lab, originality and the written report at the end of the course. Topics include but are not restricted to the below points.

1. Multicomponent reactions
2. Multi-step synthesis
3. Metal free catalysis
4. Bio active molecules synthesis

SEMESTER 7

22CHY521 Statistical and Irreversible Thermodynamics 2 1 0 3

Unit 1: Fundamental Statistics for Thermodynamics [4 h]

Probability. Permutations and combinations. Probability distributions - discrete and continuous binomial, Poisson and Gaussian distributions. Combinatorial analysis for statistical thermodynamics - distinguishable objects and indistinguishable objects.

Unit 2: Statistical Thermodynamics - I [9 h]

Thermodynamic probability. Entropy and probability. Phase space. Ensembles and ensemble average - microcanonical ensemble, entropy of a perfect gas, entropy of mixing of ideal gases and Gibbs paradox, canonical ensemble, grand canonical ensemble. General formulations of Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics.

Unit 3: Statistical Thermodynamics - II [12 h]

Partition function for poly atomic molecules - partition function for free linear motion, free motion in a shared space, linear harmonic vibrations, translational, rotational and vibrational partition functions, molecular partition functions, partition functions and thermodynamic

properties, calculation of equilibrium constant. Heat capacity - classical and quantum statistical theory of specific heat residual entropy.

Unit 4: Irreversible Thermodynamics [10 h]

Examples for irreversible process. Steady state and near equilibrium conditions. Linear relations - phenomenological coefficients, Onsager reciprocal relations. One component system with heat and mass transport - entropy production. Heat and mass transport in multicomponent systems. Principle of macroscopic reversibility and Onsager's reciprocal relations. Verification of Onsager relations.

Unit 5: Irreversible Thermodynamics [10 h]

Application of irreversible thermodynamics - thermoelectricity, electro-kinetic phenomena, thermomolecular pressure difference, mechanocaloric effects, transference in aqueous solutions of electrolytes. Stationary non-equilibrium state. Irreversible thermodynamics for the non-linear regime. Chemical reactions and molecular machines. Applications of irreversible thermodynamics to biological systems.

Recommended Readings

1. Atkins, P., Atkins, P.W. and de Paula, J., 2018. Atkins' physical chemistry. Oxford university press.
2. Laurendeau, N.M., 2005. Statistical thermodynamics: fundamentals and applications. Cambridge University Press.
3. Glasstone, S., 1947. Thermodynamics for chemists (No. 541.369). D. Van Nostrand,.
4. Rastogi, R.P., 2009. An Introduction To Chemical Thermodynamics. Vikas Publishing House.
5. Rajaram, J., 2013. Chemical thermodynamics: Classical, statistical and irreversible. Pearson Education India.
6. Lebon, G., Jou, D. and Casas-Vázquez, J., 2008. Understanding non-equilibrium thermodynamics (Vol. 295, p. 15). Berlin: Springer.
7. Prigogine., 1968. Introduction to Thermodynamic Irreversible Processes, Interscience Publishers.
8. Sears, F.W., Salinger, G.L. and Lee, J.E., 1975. Thermodynamics, kinetic theory, and statistical thermodynamics. Addison-Wesley.
9. B. R. Puri, B.R., Pathania, M.S., L. R. Sharma, L.R., 2020, Principles of physical Chemistry, Vishal Publishing Co.
10. Hill, T.L., 2003. An introduction to statistical thermodynamics. Courier Corporation.
11. Swendsen, R., 2020. An introduction to statistical mechanics and thermodynamics. Oxford University Press, USA.

22CHY522 Physical Methods in Chemistry 3 0 1 4

Unit 1: UV-Visible and Fluorescence Spectroscopy [10 h]

Laws of absorption. Type of electronic transitions – allowed and forbidden transitions. Chromophore and auxochromes. Factors governing absorption maximum and intensity. Woodward Fieser and Fieser-Kuhn's rules - calculation of λ_{max} for simple organic molecules.

Fluorescence and phosphorescence - principles, Stokes shift, quantum yield and application. Instrumentation of UV-Visible and fluorescence spectroscopy.

Unit 2: Infrared Spectroscopy [8 h]

Hook's law, vibrational frequency, modes of vibrations, and selection rules. Instrumentation - sampling techniques. Fingerprint and functional group region. Factors influencing vibrational frequency. Interpretation of the IR spectra of organic molecules with various functional groups.

Unit 3: ^{1}H NMR Spectroscopy [12 h]

Theory, relaxation effects, NMR active nuclei. Instrumentation – magnetic shimming. Chemical shift, magnetic anisotropic effect, spin-spin splitting, n+1 rule, j-j coupling, measurement of J. Karplus relationship, first and second order spectra, double resonance, spin tickling and chemical shift reagents. Spectra of conformational isomers - homotopic, enantiotopic and diastereotopic systems. Nuclear Overhauser effect (NOE). Variable temperature NMR. Application of ^{1}H NMR for the structural elucidation of organic compounds. MestReNova – Introduction and data analysis.

Unit 4: ^{13}C, 2D and 3D NMR spectroscopy [16 h]

^{13}C NMR – theory. ^{1}H coupled and decoupled ^{13}C spectra, chemical shift values. Attached proton test (APT), distortionless enhancement by polarization transfer (DEPT), incredible natural abundance double quantum transfer experiment (INADEQUATE). ^{13}C NMR spectroscopy for the structural elucidation of organic compounds. ^{11}B, ^{15}N, ^{19}F and ^{31}P NMR spectra. 2D-NMR- examples and interpretation of homonuclear (COSY, NOESY, TOCSY) and heteronuclear (HMQC, HSQC) NMR. Introduction to 3D NMR.

Unit 5: Mass Spectrometry [14 h]

Instrumentation – methods of ionisation - EI, CI, APCI, ESI, MALDI and FAB. Mass analyser – magnetic and electrostatic sector, time of flight and quadrupole. Molecular ion, base peak, multicharged ion, metastable ions and isotope ratio. Fragmentation patterns of saturated, unsaturated and aromatic hydrocarbons, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, amines, nitro, nitrile and halides. McLafferty rearrangement. Quantitative analysis using mass spectra.

Structural elucidation using UV-Visible, IR, ^{1}H NMR, ^{13}C NMR and MS

Recommended Readings

1. D. L. Pavia, G. M. Lampman, G. A. Kriz, and J. R. Vyvyan, 2009. Introduction to Spectroscopy, 5th Edition, Brooks-Cole.
2. W. Kemp, 1988. Organic Spectroscopy, 3rd Edition, McMillan International Higher Education.
3. Silverstein, R.M. and Bassler, G.C., 2015. Spectrometric identification of organic compounds, 8th edition. Wiley
4. Hollas, J.M., 2004. Modern spectroscopy. John Wiley & Sons.
5. Günther, H., 2013. NMR spectroscopy: basic principles, concepts and applications in chemistry. John Wiley & Sons.
6. Dyer, J.R., 1965. Applications of absorption spectroscopy of organic compounds. Prentice Hall India Learning Private Limited
7. Hoffmann, E., and Stroobant. V. 2001. Mass spectrometry-principles and applications.

8. Fleming, I. and Williams, D.H., 2007. Spectroscopic methods in organic chemistry. New York: McGraw-hill.

22CHY523 Organometallic Chemistry 3 1 0 4

Unit 1: Concepts and Metal Carbonyls [12 h]

History and overview of organometallic compounds. Classification and nomenclature, classes of ligands, hapticity. 18-electron and 16-electron organometallic compounds. Metal carbonyls – synthesis and bonding, donor and acceptor properties of CO, binding modes of CO, polynuclear carbonyls, metal-metal bonding in M-CO clusters. Cluster valence electron (CVE) count - Wade-Mingos' rule, capping rule, Mingos' rule - CVE based structure prediction. IR spectral features of metal carbonyls. Reactions and activation of metal carbonyls. Metal nitrosyl (M-NO) compounds - bonding and structural features – comparison with metal carbonyl.

Unit 2: Structure and Bonding in Organometallic Compounds [12 h]

Fragment molecular orbitals (FMO) of various organic and inorganic moieties like CH_3, CH_2, CH, BH_2, BH, NH_2 and NH. Walsh's diagram of hetero di and triatomic molecule. Inorganic fragments MLn with varying number of L. Symmetry and shape of their FMO's. Isolobal concept, isoelectronic and isolobal relationships between various organic and inorganic fragments. Structure and bonding between various organic and inorganic fragments based on MO level diagrams.

Unit 3: Metal with Phosphine, Alkyl, Aryl and π-donor Ligands [10 h]

Metal phosphines compounds-bonding and structural features. Organometallic compounds with π-donor ligands like olefins, acetylenes and allyl moieties. Structure and bonding of metal derivatives of cyclic π-donors - metallocenes, sandwich/half-sandwich compounds, bent metallocenes, metal carbenes – Fischer carbenes and Schrock carbenes. Metal alkyl and aryl derivatives.

Unit 4: **Stereochemistry and Reactions of Organometallic Compounds** [12 h]

Stereochemically non-rigid molecules, fluxional nature of organometallic compounds, characterization of non-rigidity by spectroscopic methods. Reactions involving various organometallic compounds - oxidative addition, reductive elimination, migratory insertion -1,1 and 1,2-type insertion, elimination reactions, cyclometalation and ortho-metalation reactions and agostic interactions. Ligand substitution processes, nucleophilic and electrophilic additions – regioselectivity, and abstraction reactions. Coupling reactions, Pauson-Khand reaction and olefin oxidation.

Unit 5: **Industrial Applications of Organometallic Compounds** [14 h]

Homogeneous and heterogeneous organometallic catalysis - principle, mechanism and their applications. Alkene hydrogenation using Wilkinson's catalyst, water-gas shift reaction, Monsanto process and Cativa Process. Hydro-formylation reactions, Wacker process, Ziegler-Natta polymerization of alkenes, Fischer-Tropsch process, olefin-metathesis - Grubbs, Hoveyda–Grubbs and Schrock catalysts. Palladium based catalysts - Heck, Stille, Negishi, Suzuki-Miyaura, Sonogashira, Kumada, Hiyama and Buchwald-Hartwig couplings. Organometallic compounds as drugs, sensors, radiopharmaceuticals and tracers.

Recommended Readings

1. Crabtree, R.H., 2019. The organometallic chemistry of the transition metals. John Wiley & Sons.

2. Bochmann, M., 2000. Organometallics: Complexes with Transition Metal-carbon [sigma]-bonds. Oxford University Press on Demand.
3. Gupta, B.D. and Elias, A.J., 2010. Basic Organometallic Chemistry.
4. Atwood, J.D., 1997. Inorganic and organometallic reaction mechanisms. John Wiley & Sons.
5. Jack, R., Finke, R.G., Collman, J.P. and xanne Stehr, R., 1987. Principles and applications of organotransition metal chemistry. University Science Books.
6. Huheey, J.E., Keiter, E.A., Keiter, R.L. and Medhi, O.K., 2006. Inorganic chemistry: principles of structure and reactivity. Pearson Education India.
7. Gates, B. C., 1992. Catalytic chemistry. Wiley
8. Elschenbroich, C. and Salzer, A., 1992. A Concise Introduction. VCH.

22CHY524 Frontiers in Organic Chemistry 3 1 0 4

Unit 1: Pericyclic Reactions – I [12 h]

Molecular orbital symmetry. Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Electrocyclic reactions – con rotation and dis rotation in 4n, 4n+2, allyl systems and secondary effects. Electrocyclization of charged species and heteroatomic trienes.

Unit 2: Pericyclic Reactions – II [14 h]

Cycloaddition reactions - antrafacial and suprafacial additions, 4n and 4n+2 systems with (2+2) and (4+2) cycloadditions. Effect of stereochemistry and substituents on the rate of cycloadditions, 1,3-dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements - suprafacial and antrafacial shifts - [1,2]-sigmatropic shifts involving carbon moieties. [m,n] and [m,m] sigmatropic hydrogen shifts. Claisen, Cope, Wittig and aza–Wittig rearrangements, fluxional tautomerism. Ene reactions.

Unit 3: Photochemistry – I [10 h]

Photochemistry of alkenes- intramolecular reactions, geometrical isomerism, cyclisation reactions. Photochemical rearrangements - 1,4 and 1,5- dienes. Photochemistry of aromatic compounds - isomerizations, additions, substitutions and photo reduction.

Unit 4: Photochemistry – II [12 h]

Photochemistry of carbonyl compounds - Norrish type I and type II, and Patterno–Buchi reactions. Intramolecular reactions of carbonyl compounds – saturated cyclic and acyclic, α,β and β,γ- unsaturated compounds, cyclohexanone, cyclohexadienones. Intermolecular cycloaddition reactions and dimerisations. Photo-Fries reactions and rearrangements, Lumiketone rearrangement and Barton reaction. Photo reduction of carbonyl compounds. Singlet molecular oxygen reactions. Photostabilizers.

Unit 5: Heterocyclic Compounds [12 h]

Nomenclature, general characteristics, synthesis and reactions of three, four, five and six membered ring heterocycles containing one and two hetero atoms. Fused ring compounds – synthesis and reactions of indole, quinoline, isoquinoline, coumarin, flavones. Antibiotics containing heterocycles - structure and synthesis of penicillin and cephalosporin-C.

Recommended Readings

1. Carey, F.A. and Sundberg, R.J., 2007. Advanced organic chemistry: part A: structure and mechanisms. Springer Science & Business Media.
2. Carey, F.A. and Sundberg, R.J., 2007. Advanced organic chemistry: part B: reaction and synthesis. Springer Science & Business Media.
3. Smith, M.B., 2020. March's advanced organic chemistry: reactions, mechanisms, and structure. John Wiley & Sons.
4. Sankararaman, S., 2005. Pericyclic Reactions-A Textbook: Reactions, Applications and Theory. Wiley-VCH.
5. Singh, N.D., 2014. Organic photochemistry and pericyclic reactions.
6. Klán, P. and Wirz, J., 2009. Photochemistry of organic compounds: from concepts to practice. John Wiley & Sons.
7. Steed, J.W. and Atwood, J.L., 2022. Supramolecular chemistry. John Wiley & Sons.
8. Balzani, V., Credi, A. and Venturi, M., 2008. Molecular devices and machines: concepts and perspectives for the nanoworld. John Wiley & Sons.
9. Lehn, J.M., 2011. Supramolecular Chemistry: Concepts and Perspectives. John Wiley & Sons

22CHY585 Advanced Inorganic Chemistry Lab 0 0 6 3

Students are expected to perform hands on synthesis, characterization and applications of inorganic materials. Topics include but are not restricted to the below points.

1. Nanomaterials
2. Co-ordination complexes
3. Mixed metal oxides
4. Organometallics
5. Biomimetics

The assessment is based on the practical skills in the lab, originality of the work and the written report, at the end of the course.

SEMESTER 8

22CHY525 Molecular Modeling and Simulations 3 0 2 4

Unit 1: General Concepts for Computational Chemistry [4 h]

Introduction to computational chemistry- co-ordinate systems, potential energy surfaces, molecular graphics and surfaces. Mathematical concepts - energy minimization methods, derivative minimization method- first order, second derivative. The Newton-Raphson method. Quazi newton methods.

Unit 2: Computational Quantum Chemistry [12 h]

Schrodinger equation - time independent. Approximations. Theory and applications of HMO and EHMO. Basis Sets. Theory and applications of *ab-initio* methods - Hartree and Hartree-Fock methods and SCF procedure. DFT- theory and applications.

Experimental component: Predict atomic/molecular properties by computational quantum chemistry - Tools such as ORCA and Quantum espresso.

Unit 3: Molecular Mechanics [10 h]

Classical mechanics formulations as applied to address motion associated with molecules.

Force fields in MM - terms for bond stretching, angle bending and torsional motion, improper torsions and out of plane bending motions, cross terms, class 1,2 and 3 force fields. Terms for nonbonded interactions - electrostatic interactions, van der Waals interactions - Lennard-Jones potential. Many body effects in empirical potentials. Effective pair potentials. Forcefield models for simulation of liquid water. United atom force fields and reduced representations. Derivatives of molecular mechanics energy function. Calculation of thermodynamic properties using a force field. Forcefield parameterization - transferability of forcefield parameters, treatment of delocalized pi electrons. Force fields for inorganic molecules, solid state systems. Empirical potentials for metals and semiconductors.

Unit 4: Molecular Simulations- MD and MC [10 h]

Molecular dynamics – simple models, MD with continuous potentials, setting up and running an MD simulation, constraint dynamics, time dependent properties, MD at constant temperature and pressure. Solvent effects with MD - potentials of mean force and stochastic dynamics. MD simulations for analyzing molecular conformations. MD simulations of chain amphiphiles. Monte Carlo simulations - properties by integration method, basics and implementation of Metropolis MC method. MC simulations of small molecules and polymers. Biased MC method. Quazi-ergodicity. Calculation of chemical potential. The configurational bias MC method. Simulating phase equilibria by Gibbs Ensemble MC method

Experimental component: Predict atomic and molecular properties by MD and MC simulation techniques.

Unit 5: Molecular Modeling and Simulations – Applications [9 h]

Conformational analysis - exploring the conformational space, finding the global energy minimum, evolutionary algorithms and simulated annealing. Solving protein structures using restrained MD and simulated annealing. Molecular fitting, clustering algorithms and pattern recognition techniques. Optimization of crystal structures. Computations for free energy, solvation, modeling of chemical reactions and defects in solids. A review on IT integrated computational techniques for material discovery - drugs and a few special effect materials.

Experimental component: Predict atomic and molecular properties by comprehensive combination of modeling and simulation techniques.

Recommended Readings

1. Leech, A.R., 2017. Molecular modeling – Principles and Applications. Pearson
2. Lewars, E., 2011. Computational chemistry- Introduction to the theory and applications of molecular and quantum mechanics. Springer
3. Christopher, J.C., 2004. Essentials of computational chemistry: theories and models. Wiley
4. Atkins, P.W. and Friedman, R.S., 2011. Molecular quantum mechanics. Oxford university press.

5. Bonomi, M. and Camilloni, C., 2019. Biomolecular Simulations. Methods Mol. Biol. Springer.
6. Leech., A.R, Gillet, V.J., 2009. An Introduction to Chemoinformatics. Springer.

22CHY526 Bioorganic and Natural Products Chemistry 3 1 0 4

Unit 1: Amino Acids, proteins and Peptides [12 h]

Amino acids – classification and synthesis. Peptides and proteins - structure and synthesis. Solid phase synthesis – choice of resin, classification and reactions leading to peptide formation - Boc and Fmoc strategies. Enzymes – classification. Enzyme inhibition and poisoning. Enzymes in organic synthesis.

Unit 2: Enzymes [10 h]

Enzymes – classification. Enzyme inhibition and poisoning. Enzymatic reactions with group transfer - hydrolysis, phosphorylation and transamination. Bio-catalyzed C-C bond formation and bond breaking reactions. Redox reactions – transfer of hydride. Monooxygenases and dioxygenases.

Unit 3: Carbohydrates and Nucleic Acids [14 h]

Nomenclature, classification and structure of mono and disaccharides, and mutarotation. Glucose and fructose - synthesis and reactions. Killiani synthesis, interconversions and Amadori rearrangement. Stereoisomerism – epimers and anomers. Disaccharides – properties and reactions of maltose, sucrose and lactose. Glycosides – classification and preparation. Oligo- and polysaccharides – structure, properties, reactions and applications of cellulose, starch and cyclodextrins. Synthesis of shikimic acid. Artificial sweeteners. Structure and synthesis of nucleic acids, deoxy sugars, genetic code and sequencing.

Unit 4: Steroids and Vitamins [10 h]

Steroids - classification, structural elucidation of cholesterol. Conversion of cholesterol to progesterone, androsterone, testosterone and vitamin D. Classification, structure, and synthesis of prostaglandins. Vitamins – classification, structure, source, uses, deficiency symptoms and diseases.

Unit 5: Alkaloids, Terpenoids and Flavonoids [14 h]

Alkaloids – classification, source and application. General methods of structural elucidation of alkaloids. Total synthesis of reserpine and quinine. Terpenes and terpenoids – isoprene rule, classification, structure and application of myrcene, limonene, geraniol and menthol. Biosynthesis and synthesis of menthol, camphor and β-carotene. Flavonoids - source and function in plants. Structure and synthesis of flavones, flavanols and flavanones.

Recommended Readings

1. Finar, I.L., 2002. Organic Chemistry, Volume 2: Stereochemistry and The Chemistry Natural Products, 5/E. Pearson Education India.
2. Bhat, S.V., Nagasampagi, B.A. and Sivakumar, M., 2009. Natural products: chemistry and applications. Alpha Science International.
3. Nicolaou, K.C. and Sorensen, E.J., 1996. Classics in total synthesis: targets, strategies, methods. John Wiley & Sons.

4. Kar, A., 2018. Chemistry of Natural Products, (Volume I and II), CBS
5. Voet, D. and Voet, J.G. 2010. Biochemistry, 4th Edition. John Wiley and Sons.

22CHY527 Solid State Chemistry 2 1 0 3

Unit 1: Crystal structure and symmetry [10 h]

Elements of symmetry in crystal systems, proper rotation, mirror planes, inversion, improper axis symmetry elements, Schoenflies and Hermann-Mauguin notations, unit cells, glide plane, screw axis, atom occupancy in cubic unit cells, Space groups. Spinel and inverse spinel, perovskite structures, ionic radii, crystal radii, radius ratio. Extended covalent array, diamond, graphite.

Unit 2: Electronic properties of solids [12 h]

Free electron theory, density of states, electronic conductivity, molecular orbital theory, overlap and bonding, linear chain of H atoms, LCAO, Fermi Level, conductors, insulators and semiconductors, n- and p-type semiconductors, bands in compounds, band-gap energy, direct and indirect band gaps in semiconductors, band-gap measurements, electrical conductivity. Organic conductors, preparation, mechanism of conduction in organic semiconductors - applications, photoconductivity of polymers. Superconductivity- mechanism - BCS theory – examples – high temperature superconductors. Electronic properties of nanosolids.

Unit 3: Magnetic properties of solids [7 h]

Behavior of substances in a magnetic field, magnetic moments, Types of magnetic materials - paramagnetism, diamagnetism, ferro- and anti-ferromagnetism, ferri-magnetism, effects of temperature of magnetism, Curie & Curie-Weiss laws; mechanism of ferro- and anti-ferromagnetic ordering, super exchange.

Unit 4: Optical properties of solids [6 h]

Luminescence and phosphorescence of solid materials, phosphors, materials for lighting, doping in crystals and colour features, ruby, diamond. Optical properties of nano solids.

Unit 5: Characterization tools for solids [10 h]

X-ray diffraction - Bragg's equation and experimental methods (powder method and rotating crystal technique), phase identification and analysis of crystallite size. Magnetic characterization: Vibration Sample Magnetometer Application of spectroscopic Techniques: DRS, FT-IR spectroscopy, Raman spectroscopy, XPS, Solid state NMR. Microscopy techniques: SEM, TEM, Energy dispersive X-ray analysis

Recommended Readings

1 Woodward, P.M., Karen, P., Evans, J.S. and Vogt, T., 2021. Solid State Materials Chemistry. Cambridge University Press.
2 Azaroff, L.V., 2017. Introduction to solids. Tata Mcgraw hill publishing company.
3 Smart, L.E. and Moore, E.A., 2021. Solid state chemistry: an introduction. CRC press.
4 West, A.R., 2014. Solid state chemistry and its applications. John Wiley & Sons.
5 Ooi, L.L., 2010. Principles of X-ray Crystallography. Oxford University Press.
6 Egerton, R.F., 2005. Physical principles of electron microscopy. New York: Springer.
7 Kuzmany, H., 2009. Solid-state spectroscopy: an introduction. Berlin: springer.

8 Müller, K. and Geppi, M., 2021. Solid State NMR: Principles, Methods, and Applications. John Wiley & Sons.

9 Franco, V. and Dodrill, B. eds., 2021. Magnetic Measurement Techniques for Materials Characterization. Springer International Publishing.

10 Dann, S.E., 2000. Reactions and characterization of solids (Vol. 2). Royal Society of Chemistry.

11 Bhushan, B., Luo, D., Schricker, S.R., Sigmund, W. and Zauscher, S. eds., 2014. Handbook of nanomaterials properties. Springer Science & Business Media.

22CHY528 Bioinorganic Chemistry 2 1 0 3

Unit 1: Reactive Oxygen Species and Macrocyclic Ligands [7 h]

Essential elements in biological systems, transport of ions across biological membranes, active and passive transport. Reactive oxygen species (ROS), generation and function of free radicals, action of ROS in biological systems, oxidative stress and antioxidants. Structure of macrocyclic ligand (porphine and corrin). Hydroporphyrins (H_2P) and metalloporphyrins (MP) - spectral, fluorescence and redox properties. Chemistry of Chlorophyl.

Unit 2: Uptake, Transport and Storage of Oxygen and Iron [10 h]

Myoglobin (Mb) and haemoglobin (Hb) - prosthetic groups and functions, mechanism for reversible binding of O_2. Cooperative effect in Hb and its consequences. Behaviour of bound O_2 to Fe(II). Difference between O_2 and CO binding to Hb and Mb and CN^- poisoning. Sickle-cell anaemia. 'Picket-fence' porphyrin and its special features. Haemerythrin and haemocyanin – structure, functions, O_2 binding and electron transfer. Fe-S and other non-haeme iron proteins, ferredoxins - structure and special properties. Uptake, transport and storage of iron - transferrin, ferritin, siderophores and enterobactin.

Unit 3: Metalloenzymes – I [12 h]

Structure, properties and reaction mechanism of catalases, peroxidases - glutathione peroxidase, HRP and cytochrome C peroxidase, cytochromes - cytochrome P-450, cytochrome C-oxidase and monooxygenases. Electron transport in biology, electron transport chain. Structure and enzymatic reaction mechanisms of superoxide dismutase and tyrosinase. Copper containing enzymes - azurin, plastocyanin - structure and function. Type I, II and III copper proteins. Zinc containing enzymes - carbonic anhydrase, carboxy peptidase - structure and enzymatic reactions. Vitamin B_{12} – nomenclature, structure, enzymatic reaction and its model compounds.

Unit 4: Metalloenzymes – II [7 h]

N_2 fixation, nitrogenase enzyme, Fe-S clusters, Fe-protein structure, Mo-Fe protein structure, P-cluster and M-centre. Bioinorganic Chemistry of photosynthesis (PS-I and PS–II). Role of Mn, Ni, Mo and Cr in biological systems.

Unit 5: Metals in Medicine [9 h]

Metal ion based (V, Fe, Au and Pt) drugs and anticancer agents. Cis-platin and its properties. Chelation therapy, macrocyclic antibiotics, therapeutic complexes, DNA intercalators and

diagnostic agents. Photodynamic therapy - principles and applications. Natural and synthetic ionophores and crown ethers - interaction and uptake of alkali metal and alkaline earth metal ions with crown ethers, cryptands, cryptates, calixarenes and cyclodextrins. Metal toxicity and homeostasis. Diseases caused by both excess and deficiency of metal ions, thalassaemia, Wilson disease. Heavy metal toxicity – mercury, arsenic and chromium poisoning.

Recommended Readings

1. Bertini, I., Gray, H.B., Lippard, S.J. and Valentine, J.S., 2007. Bioinorganic chemistry. University science books.
2. Stephen J. L, Jeremy M. B, 1994. Principles of bioinorganic Chemistry, University Science Books.
3. Greenwood, N.N. and Earnshaw, A., 2012. Chemistry of the Elements. Elsevier.
4. Bertini, G., Gray, H.B., Gray, H., Valentine, J.S., Stiefel, E.I. and Stiefel, E., 2007. Biological inorganic chemistry: structure and reactivity. University Science Books.
5. Da Silva, J.F. and Williams, R.J.P., 2001. The biological chemistry of the elements: the inorganic chemistry of life. Oxford University Press.
6. Berg, J.M., Tymoczko, J.L. and Stryer, L., 2002. Biochemistry.

22CHY586 Advance Physical Chemistry Lab 0 0 6 3

This course involves the analysis of various physical chemistry parameters of materials and the study of their applications. This will provide hands-on skills in synthesis, characterization, reaction kinetics, interpretation, statistical treatment, and documentation of experimental data. Topics include but are not restricted to the below points.

1. Synthesis of nanomaterials and their characterization by various electroanalytical techniques for energy storage, corrosion, and biosensing applications
2. Spectrophotometric estimations of environmental pollutants
3. Surface functionalization of nanomaterials and their characterization for various applications
4. Study of spectrophotometric, electrochemical, and catalytic applications of transition metal complexes

22RM500 Research Methodology 2 0 0 2

Unit 1: Ethics in Research

Ethics, moral philosophy, nature of moral judgements and reactions. Scientific conduct - ethics with respect to science and research. Intellectual honesty and research integrity. Scientific misconducts - falsification, fabrication and plagiarism. Redundant publications - duplicate and overlapping publications. Selective reporting and misrepresentation of data.

Unit 2: Literature Survey

Importance of literature survey, planning a literature search, identifying key concepts and key words, locating relevant literature and reliability of a source.

Unit 3: Design of Experiments and Data Analysis

Aim, objectives, expected outcome, and methodology to be adopted. Importance of reproducibility of results. Objectives and basic principles of designs of experiments. Data presentation - using graphs, in tables, schemes and figures. Software for drawing. Bibliography using Mendeley and Zotero.

Unit 4: Publication Ethics

Best practices and standards, conflicts of interest, publication misconduct, unethical behaviour and related problems. Authorship and contributorship. Identification of publication misconduct, complaints and appeals.

Unit 5: Research Communication

General aspects of scientific writing - reporting practical and project work, writing literature survey and reviews, organizing a poster display, oral presentation. Guidelines for manuscript writing - abstract, introduction, methodology, results and discussion, conclusion, acknowledgement, references and citation. Intellectual property (IP) and intellectual property rights (IPR).

Recommended Readings

1. Bird, A., 2006. Philosophy of science. Routledge.
2. MacIntyre, A., 2017. A short history of ethics: A history of moral philosophy from the Homeric age to the twentieth century. University of Notre Dame Pess.
3. Chaddah, P., 2018. Ethics in Competitive Research: Do not get scooped; do not get plagiarized.
4. Bordens, K.S. and Abbott, B.B., 2002. Research design and methods: A process approach. McGraw-Hill.
5. Kothari C.R., 2020. Research methodology methods and Techniques. New Age International Publishers.
6. Thomas, C.G., 2021. Research methodology and scientific writing. Thrissur: Springer.

CORE ELECTIVES

22CHY531 Chemical Biology 3 0 0 3

Unit 1: The Fundamentals of Chemical Biology

The central dogma of molecular biology, genes, genomes, source of diversity beyond genomes. Diversity through combinatorial assembly, Prebiotic chemistry, non-bonding interaction, power of modular design.

Unit 2: Nucleic Acids

DNA - forms of DNA, the ribonucleotide subunits of DNA, elementary forces in DNA, superstructure, biological synthesis of DNA by polymerase enzyme, chemical synthesis, separation of DNA by electrophoresis, recombinant DNA technology, nucleic acid photochemistry, DNA as target for cytotoxic drugs. RNA - structure, RNA synthesis, transcription control, mRNA processing in eukaryotes, controlled degradation of RNA, ribosomal translation of mRNA into proteins, oligonucleotide libraries to protein libraries.

Unit 3: Peptides and Proteins

Amino acids and peptides, solid phase peptide synthesis, secondary structure of protein, disulfide cross links, domains with structural and functional roles, protein structure, receptor-ligand interaction. Quantitative view of enzyme function, mechanistic view of enzyme catalyzed multiple reactions. Organic cofactors. Engineering improved protein function.

Unit 4: Glycobiology and Polyketides

Structure of carbohydrate building blocks, chemistry and enzymology of the glycosidic bond, polysaccharides, glycoproteins, glycolipids, glycosylation in the cytosol, proteins. Carbohydrate binding, glucose homeostasis and diabetes. The Claisen reaction in polyketide biosynthesis, biosynthesis of fatty acids, biological role of human polyketide, nonhuman polyketide, nonribosomal peptide synthases, human terpenes.

Unit 5: Chemical Control of Signal Transduction

Signal transduction, signal transduction in human cells, nuclear receptors, receptor tyrosine kinase, cell surface receptors, receptor tyrosine kinases, G protein coupled receptors, ion channels receptors, trimeric death receptors, pathways controlled by small diffusible gas molecules.

Recommended Reading

1. Van Vranken, D. and Weiss, G.A., 2018. Introduction to bioorganic chemistry and chemical biology. Garland Science.
2. Waldmann, H. and Janning, P., 2004. Chemical Biology-A practical course. Wiley-VCH.
3. Schreiber, S.L., Kapoor, T. and Wess G. 2007. Chemical Biology: From Small Molecules to Systems Biology and Drug Design, Volume 2, Wiley-VCH.

22CHY532 **Medicinal Chemistry** **3 0 0 3**

Unit 1:Medicinal Chemistry

Drugs – classification, modes of administration. Mechanism of drug action – drug receptor interactions, agonist and antagonist. Physicochemical properties of drugs - solubility**,** partition coefficient, dissociation constant, hydrogen bonding, ionization, drug shape, surface activity, complexation, protein binding, molar refractivity and bioisosterism. Stereochemical aspects of drug action.

Unit 2:Essentials of Drug Design

Molecular mimetics, drug-lead modification, drug design using QSAR and computer assisted design. Use of software's - drug likeness, Lipinski rule, predicting ADME properties.

Unit 3:Natural Products as Medicinal Agents

Role of natural products in drug discovery. Medicinal agents belonging to alkaloids, steroids, polypeptides and modified nucleic acid bases – its source and purification. Structure and application of taxol, cardiac glycosides, vinca alkaloids, morphine, and quinine. Modern developments on natural product based immunomodulators, memory enhancers, anti-inflammatory agents and anti-parasitics. Lipids and prostaglandins.

Unit 4: Synthetic Medicinal Agents

Classification and application of Sulphonamides, antihistamins, non-steroidal antiinflammatory drugs (NSAID), diuretics, antipyretics, anticonvulsants and cardiovascular agents. Anaesthetics – general anaesthetics, local anaesthetics, muscle relaxants and sedatives – classification and mode of action. Antiseptics and disinfectants.

Unit 5 Infectious and Non-infectious Diseases

Malaria – life cycle of parasite. Antimalarial agents – artemisinin class of compounds. AIDS – introduction, mechanism of action. Cancer – introduction – recognition of cancer cells, types of neoplasms. Treatment of cancer – taxol, and vinblastine. Drugs targeting DNA.

Recommended readings

1. Ahluwalia, V.K. and Chopra, M., 2008. Medicinal chemistry. Ane Books Pvt Ltd.
2. Kothekar, V., 2005. Essentials of drug designing. Dhruv Publications.
3. Kar, A., 2007. Medicinal chemistry. 4th edition, New Age International.
4. Nadendla, R.R., 2008. Medicinal Chemistry. PharmaMed Publication

22CHY533 **Biosensors** **2 0 2 3**

Unit 1: Basic Principles

Ideal characteristics. Classification – enzymatic and non-enzymatic sensors, DNA and protein-based sensors-immunosensors. chemiluminescence and electroluminescence, FRET in biosensing. Electrochemical and optical principles in biosensing: Principles of potentiometry, voltammetry, amperometry and impedimentary in biosensing. Fabrication and testing of optical and electrochemical biosensors.

Unit 2: Biosensing using Nanomaterials

Surface to volume ratio, quantum confinement. Application of surface plasmon resonance in biosensing. Biofunctionalisation of nanomaterials. Application of conducting polymers, metal nanoparticles, semiconducting quantum dots, metal organic framework, carbon nanotubes, graphenes, and carbon dots in biosensing. Nanomaterials for signal amplification.

Unit 3: Applications of Biosensors

Clinical applications – monitoring of diabetes, cancer, cardiovascular, kidney diseases. Biosensors for metabolites, proteins, DNA, pathogens. Environmental and forensic applications - pesticides, narcotics and poisonous gases.

Unit 4: Lab-on-a-Chip Devices

Importance of Lab-on-a-chip. Fabrication – components - fabrication of microfluidics-lithography – Integration of sensors and microfluidics. Testing of lab-on-a-chip devices. Paper analytical devices – Liver function biomarkers and urinalysis.

Unit V: Wearable Sensors

Importance of continuous monitoring. Wearable sensors for continuous monitoring. Epidermal electronic system, lab-on-skin-devices - Fabrication and testing.

Recommended Readings

1. Xueji Zha Zhang, X., Ju, H. and Wang, J. eds., 2011. Electrochemical sensors, biosensors and their biomedical applications. Academic Press.
2. Ju, H., Zhang, X. and Wang, J., 2011. NanoBiosensing: principles, development and application. Springer Science & Business Media.
3. Wang, J., 2006. Analytical electrochemistry. Wiley, New York, USA.

4. Merkoçi, A. ed., 2009. Biosensing using nanomaterials. John Wiley & Sons.
5. Perret, B., 2008. Peter Gründler: Chemical sensors. An introduction for scientists and engineers. Springer-Verlag, Berlin Heidelberg

22CHY534 Nanomaterials for Biological Applications 2 0 2 3

Unit 1: Introduction to Nanomaterials

Size dependence of properties – Surface to volume ratio and quantum confinement. Characterisation techniques - microscopic techniques to study nano structures - SEM, AFM, TEM and STM. Spectroscopic techniques to characterize nanostructures - Raman, XPS, Auger, EDAX. Size and charge distribution - DLS, Zeta potential, size exclusion chromatography, electrophoretic separation and protein staining.

Unit 2: Synthetic Approaches

Colloidal, Self-assembly, electrochemical methods, sol-gel, Langmuir-Blodgett (LB), chemical vapour deposition, plasma arcing, ball milling, and lithography.

Unit 3: Nanomaterials

Synthesis, properties and characterization of fullerenes, carbon nanotubes, graphenes and carbon quantum dots. Metallic and semiconducting quantum dots, metal organic framework and MXenes.

Unit 4: Biofunctionalisation of Nanomaterials

Noncovalent and covalent assembly. Biofunctionalisation of CNTs, graphene, metal and semiconducting nanoparticles. Biological applications of nanomaterials - cell and tissue imaging, cell delivery vehicles, drug delivery, gene delivery, sensing, targeted therapies - hyperthermia for cancer using magnetic nanoparticles, regenerative medicine, tissue engineering, biomimetics, nanomedicine and nanozymes.

Unit 5: Biological Nanostructures

DNA nanostructures – 3D DNA nanostructures, self-assembly. Programmed patterning – DNA programmed self-assembly of biomolecules. DNA - protein conjugates. Peptide nanostructures – self-assembly, applications – regenerative medicine, drug delivery.

Recommended Readings

1. Nabok, A., 2005. Organic and inorganic nanostructures. Artech House Publishers.
2. Wang, Z.L., 2001. Characterization of nanophase materials. Particle & Particle Systems Characterization: Measurement and Description of Particle Properties and Behavior in Powders and Other Disperse Systems, 18(3), pp.142-165.
3. Ju, H., Zhang, X. and Wang, J., 2011. NanoBiosensing: principles, development and application. Springer Science & Business Media.
4. Mozafari, M.R. ed., 2007. Nanomaterials and nanosystems for biomedical applications. Springer Science & Business Media.
5. C. M. Niemeyer and C. A. Mirkin (Editors), Nanobiotechnology" WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

22CHY535 Biomaterials 3 0 0 3

Unit 1: Metals and Ceramics

Metals - properties - thermal treatments - strengthening by alloying, work hardening, thermal treatments, and order disorder transformation. Ceramics - properties - bioactive ceramics - ceramic and polymeric carbons - biological glasses – coatings.

Unit 2: Composites

Classifications – properties –testing on composite materials - ultrasonic techniques, sensing of deformation and damage - environmental effects - applications of composites.

Unit 3: Biomaterials

Definition - classification, metallic implants, Co-Ti-based alloys, ceramic implant materials, aluminum oxides, hydroxyapatite - glass ceramics - medical applications. Implementation problems - inflammation, rejection, corrosion, structural failure. Surface modifications. Materials for bone and joint replacement, dental metals and alloys, dental restorative materials and dental amalgams. Cardiovascular materials – cardiac prosthesis, vascular graft materials, cardiac pacemakers, cardiac assist devices. Materials for ophthalmology contact lens. Materials for drug delivery. Nano biomaterials - matrix and filler materials

Unit 4: Biomaterial Properties and Structural Characterization

Mechanical properties, visco-elasticity, wound-healing process, application of biomaterial for the human body, body response to implants, blood compatibility. Structural characterization of biomaterials through various techniques.

Unit 5: Biomaterials for Point of Care Applications

Nanopharmacology and drug targeting - cellular uptake. In vitro methods to study antibacterial and anticancer properties of nanomaterials. Point-of-care diagnostics – applications of nanomaterials, biocompatibility of nanomaterials.

Recommended readings:

1. Black, J., 2005. Biological performance of materials: fundamentals of biocompatibility. CRC Press.
2. Rodney Cotterill, 2002. Biophysics: An Introduction. John Wiley & sons Ltd.

22CHY536 Introduction to Bioinformatics 2 0 2 3

Unit 1: Biological Databases

Bioinformatics - goal, scope, applications. Biological databases - types of databases, pitfalls of biological databases, information retrieval from biological databases.

Unit 2: Sequence Alignment

Pairwise sequence alignment. Database similarity searching - multiple sequence alignment, profiles and hidden Markov models. Protein motifs and domain prediction - motif and domain databases using regular expressions, statistical models. Protein family databases. Motif discovery in unaligned sequences - sequence logos.

Unit 3: Gene and Promoter Prediction, Phylogenetics

Categories of gene prediction programs - gene prediction in prokaryotes and eukaryotes, promoter and regulatory element prediction, prediction algorithms. Molecular Phylogenetics-

molecular evolution and molecular phylogenetics, gene phylogeny versus species phylogeny, forms of tree representations, phylogenetic tree construction methods and programs - distance based methods, character-based methods, phylogenetic tree evaluation, phylogenetic programs.

Unit 4: Structural Bioinformatics

Basic ideas on protein structure - protein structure database, protein structural visualization, comparison, and classification. Secondary structure prediction - globular proteins, transmembrane proteins, coiled coil prediction. Protein tertiary structure prediction - methods-homology modelling, threading and fold recognition. *ab initio* protein structure prediction, CASP, RNA structure prediction - types of RNA structures, RNA secondary structure prediction methods, *ab initio* approach, comparative approach, performance evaluation.

Unit 5: Genomics and Proteomics

Genome - mapping, sequencing, sequence assembly, annotation, comparative genomics. Functional genomics – sequence based approaches, microarray-based approaches, comparison of SAGE and DNA microarrays. Proteomics - technology of protein expression analysis, post translational modification, protein sorting, protein–protein interactions.

Addendum: Details of a case study in connection with the application of bioinformatics in drug discovery.

Recommended Readings

1. Xiong, J., 2006. Essential bioinformatics. Cambridge University Press.
2. Lesk, A. M., 2014. Introduction to bioinformatics. Oxford University Press.
3. Choudhuri, S., 2014. Bioinformatics for beginners: genes, genomes, molecular evolution, databases and analytical tools. Elsevier.
4. Matthew He, Sergey Petoukhov., 2011. Mathematics of Bioinformatics -Theory, Practice, and Applications. Wiley
5. Selzer, P.M., Marhöfer, R.J. and Rohwer, A. eds., 2008. Applied bioinformatics: an introduction. Berlin, Heidelberg: Springer Berlin Heidelberg.

22CHY537 Bioelectrochemistry 3 0 0 3

Unit 1: Electron Transport in Biological Systems

Biological cells, proton motive force, electron transport chains-mitochondrion-cytochrome c complexes, electron transport chain in bacteria, electron transfer in photosynthesis - redox components- quinones, flavins, NADPH, heme, iron-sulfur, and copper centers, redox potentials. Kinetics of electron transport reactions.

Unit 2: Electrochemistry of Redox Enzymes

Mediated enzyme electrochemistry, protein film voltammetry, wiring with redox polymers - conducting polymers, metallopolymer systems. Oxidoreductase enzymes, nicotinamide cofactors, regeneration of NAD(P)H from $NAD(P)^+$. Direct electrochemistry of enzymes on electrodes, voltammetry of enzymes, self-assembly of enzymes, covalent binding on electrodes. Enzyme cross-linking to electrodes.

Unit 3: Membrane Electrochemistry

Structure of biomembranes, membrane lipids, membrane proteins, lipid bilayer membranes-liposomes. Membrane potentials-diffusion and electrostatic potentials-surface potential and its measurement. Dielectric relaxation and its determination. Transport of ions and molecules

through the membranes, ionic channels, passive and active transport systems. Membrane receptors and cell signaling. Analytical applications of membrane coated electrodes.

Unit 4: Bioelectrosyntheis

Electrolytic production of organic compounds, enzymes in organic synthesis, mechanisms-homogeneous systems, oxidation of alcohols, diols and phenols, site-specific oxidation of sugars, reduction of carbonyl compounds.

Unit 5: Applications of Bioelectrochemistry

Microbial fuel cells, oxidoreductase, coated electrodes for fuel cells. Electrochemical immunoassays - labelled and label free assays, DNA assays, DNA markers-DNA-drug interactions-DNA hybridization. Glucose sensors.

Recommended Readings

1. Bartlett, P.N., 2008. Bioelectrochemistry: fundamentals, experimental techniques and applications. John Wiley & Sons.
2. Milazzo, G. and Bach, M.F. eds., 2013. Bioelectrochemistry I: Biological Redox Reactions. Springer Science & Business Media.
3. Milazzo, G. ed., 2013. Bioelectrochemistry II: Membrane Phenomena (Vol. 32). Springer Science & Business Media.
4. Lenaz, G. ed., 1997. Bioelectrochemistry of Biomacromolecules (Vol. 5). Springer Science & Business Media.

22CHY538 Bio microfluidics 2 0 2 3

Unit 1: Basics of Fluid Mechanics

Microfluidics - origin, definition, benefits, challenges, commercial activities. Physics of miniaturization, scaling laws. Intermolecular forces, states of matter, continuum assumption, governing equations, constitutive relations - gas and liquid flows, boundary conditions, transition to turbulence, low Re flows, pressure driven flows, Couette flow, Poiseuille flow, Stokes drag on a sphere, time-dependant flows, two-phase flows.

Unit 2: Microfabrication techniques

Photolithography, soft lithography, dip-pen lithography, nanoimprint lithography. Milling and machining- bulk and surface micromachining, CNC, electric discharge machining, 3D printing. Wafer bonding, polymer microfabrication, PMMA/COC/PDMS substrates, micromolding, hot embossing, fluidic interconnections.

Unit 3: Microfluidic components for fluid manipulation

Micromixers - Physics of mixing, Pe-Re diagram of micromixers Active and passive micromixers- lamination mixers, serpentine mixers, acoustic mixers. Micropumps-piezoelectric pumps, peristaltic pumps, infusion pumps. Microvalves - active and passive microvalves - thermopneumatic valves, piezoelectric valves, electrostatic valves, electromagnetic valves, capillary force valves. Serial dilution networks - hydraulic resistance and circuit analysis, linear, logarithmic and combinatorial networks. Microfluidic cell culture and cellular assays.

Unit 4: Droplet microfluidics and microfluidic separation

Droplet generations, kinetics of a droplet, dynamics of a droplet, in-channel dispensers, T-junction and cross-junction, droplet formation, breakup and transport. Microparticle separator, principles of separation and sorting of microparticles, design and biological applications.

Unit 5: Microreactors and Microfluidic applications

Microreactors, design considerations, liquid phase reactors, design consideration for on-chip polymerase chain reactions. Applications of biomicrofluidics - drug delivery, diagnostics, biosensing. Organ-on-a-Chip devices - design and engineering- Lung-on-a-Chip, Heart-on-a-Chip.

Recommended Readings

1. Nam-Trung Nguyen and Steven T. Wereley, "Fundamentals and Applications of Microfluidics", Artech House, 2006
2. Albert Folch "Introduction to BioMEMS", CRC Press, 2013
3. Patrick Tabeling "Introduction to Microfluidics", Oxford University Press, 2005

22CHY541 Electroanalytical Techniques 2 0 2 3

Unit 1: Fundamentals

The electrolyte double layer, the mechanism of electron transfer - exchange current – kinetics and transport – reversible and irreversible reactions.

Unit 2: Study of Electrode Reactions

Cyclic voltammetry – reversible, irreversible and quasi reversible processes – study of reaction mechanism, adsorption, quantitative applications – spectroelectrochemistry – scanning electrochemical microscopy.

Unit 3: Controlled Potential and Current Techniques

Chronoamperometry –pulse voltammetry - square wave and staircase voltammetry - AC voltammetry - stripping voltammetry - bulk electrolysis – chronopotentiometry - Tafel polarisation - electrogravimetry - flow analysis.

Unit 4: Electrochemical impedance spectroscopy

Faradaic impedance – equivalent circuits – AC impedance - Bode and Nyquist plots – applications.

Unit 5: Electrochemical instrumentation

Operational amplifiers – current and voltage feedback - potentiostat and galvanostat – troubleshooting in electrochemical systems.

Recommended Readings

1. Wang, J., 2006. Analytical electrochemistry. New York, USA: Wiley.
2. Brett, C.M., Brett, O. and Electrochemistry, A.M., 1993. Principles, methods and applications.
3. Bard, A.J. and Faulkner, L.R., 1983. Electrochemical Methods: Fundamentals and Applications. Surface Technology, 20(1), pp.91-92.
4. Bagotsky, V.S. ed., 2005. Fundamentals of electrochemistry. John Wiley & Sons.
5. Barsoukov, E. and Macdonald, J.R., 2005. Impedance Spectroscopy Theory, Experiment, and. Applications, 2nd ed.(Hoboken, NJ: John Wiley &Sons, Inc., 2005).

22CHY542 Photoelectrochemistry 3 0 0 3

Unit 1: Fundamental of semiconductor

Fundamentals of semiconductors. Energy band diagram, Fermi energy, semiconductor surfaces, solar radiation, air mass, AM1.5, Light mater interaction, Optical absorption, Semiconductor light interaction, carrier generation and recombination

Unit 2: Basics of Photoelectrochemistry

Basic electrochemistry, solid-liquid interface, Semiconductor electrolyte interface, semiconductor–inert electrolyte junction. semiconductor–redox electrolyte junction. semiconductor–electrolyte junction under illumination, Quasi-Fermi levels (QFLs), band bending, Fermi level pinning, Surface recombination.

Unit 3: Photoelectrochemical cell

Electron transfer processes between excited molecules and semiconductor electrodes. Nanostructuring of semiconductor electrodes, fabrication of semiconducting electrode. Materials engineering, photoelectrochemical solar cells (PEC), kinetic aspects in photoelectrochemical solar cells, DSSC, general considerations, choosing a photoelectrode. Photostorage of solar energy in colloidal semiconductor systems, redox catalysis in photochemical and photoelectrochemical solar energy conversion systems, effect of organized assemblies on electron transfer reactions and charge separation processes.

Unit 4: Advanced Application of Photoelectrochemistry

Photocatalytic decontamination of water, photocatalytic reactions of organic compounds. Heterogenous photocatalysis, photocatalyst for waste treatment, plasmonic photocatalysis. Basic principles of photosynthesis, photoelectrochemical CO_2 reduction and dinitrogen reduction.

Unit 5: Photoelectrochemical Water Splitting

Overview on the water splitting, electrocatalyst, photoelectrocatalyst, OER, HER, standalone overall solar water splitting. Hydrogen generation from organics and waste, Economic overview of solar water splitting, future prospect of solar water splitting.

Recommended Readings

1. Viswanathan, B. and Scibioh, M.A., 2014. Photoelectrochemistry: Principles and Practices. Alpha Science International Limited.
2. Yuri, P., and Yuri, G. Semiconductor photoelectrochemistry, Consultants Bureau,NewYork, 198611
3. Schiavello, M. ed., 2013. Photoelectrochemistry, Photocatalysis and Photoreactors Fundamentals and Developments (Vol. 146). Springer Science & Business Media.

22CHY543 Electrochemical Energy Storage Systems 2 0 2 3

Unit 1: Basic Principles

Review of Faradays laws, thermodynamics of electrochemical cells and kinetics of electrochemical reactions. Performance evaluation of energy storage devices - cell voltage – capacity - specific and volumetric energy and power densities, Peukert curves, Ragone plot, discharge profiles. Factors affecting the performance. Design and classification of electrochemical storage devices, importance of nanotechnology. Battery components - current collector, separator, electrolyte and active materials.

Unit 2: Primary Batteries

The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries - zinc-carbon - Leclanche type, zinc alkaline - duracell, zinc/air, zinc-silver oxide batteries, lithium primary cells - liquid cathode - solid cathode and polymer electrolyte types.

Unit 3: Secondary Batteries

Fabrication, performance characteristics, electrode and electrolyte materials of the following batteries: Lead acid and VRLA, nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, silver peroxide, lithium-ion batteries, lithium polymer cells. Advanced Batteries for electric vehicles, specifications - sodium-beta and redox batteries.

Unit 4: Reserve Batteries and Fuel Cells

Reserve batteries - water activated, electrolyte activated and thermally activated batteries - remote activation - pyrotechnic materials. Fuel Cells-Principle, chemistry and functioning - carbon, hydrogen-oxygen, proton exchange membrane (PEM), direct methanol (DMFC), molten carbonate electrolyte (MCFC) fuel cells, solid oxide fuel cells and outline of biochemical fuel cells. Fuel cell stack technology.

Unit 5: Supercapacitors

Types - double layer, hybrid and pseudo capacitors, symmetric and asymmetric capacitors. Mechanism of energy storage, materials for supercapacitors, carbon materials-activated carbon, carbide-derived carbon, CNT, graphene, mesoporous carbon, metal oxides, metal sulphides, conducting polymers. Effect of ratio of ion and molecule sizes and pore sizes. Electrolytes- aqueous, organic and ionic liquid. Determination of capacitor performance-cyclic voltammetry, galvanostatic charge-discharge, impedance spectroscopy. Flexible and wearable supercapacitors.

Recommended Readings

1. Beard, K.W., 2019. Linden's handbook of batteries. McGraw-Hill Education.
2. Bagotsky, V.S., Skundin, A.M. and Volfkovich, Y.M., 2015. Electrochemical power sources: batteries, fuel cells, and supercapacitors. John Wiley & Sons.
3. Allen, J. and Bard, R.L., 2000. Faulkner. Electrochemical Methods: Fundamentals and Applications, John Wiley and Sons. Inc. New York.
4. Conway, B.E., 2013. Electrochemical supercapacitors: scientific fundamentals and technological applications. Springer Science & Business Media.

22CHY544 Industrial Electrochemistry 2 0 2 3

Unit 1: Metal finishing and Processing

Review of kinetics, thermodynamics and quantitative aspects of electrochemical reactions. Industrial cathodic processes - electrodeposition of copper, nickel and chromium over mild steel – zinc plating on MS, electrodeposition of alloys - brass, bronze, effect of complexation. Industrial anodic processes - anodization of aluminium and its alloys-electropolishing - electrochemical etching of ferrous and non-ferrous metals - electrochemical machining.

Electroless deposition-electroforming - making of waveguides and plated through-hole boards. Surface passivation and corrosion control.

Unit 2: Industrial Electrolysis

Hydrogen production by electrolysis - HER and OER, water splitting cells - PEM electrolysis-alkaline water electrolysis-high temperature steam electrolysis. Chlor alkali process - general principles of brine electrolysis - chlorine cell technologies - synthesis of sodium hydroxide. Production of fluorine, sodium chlorate, per acids, permanganate, potassium dichromate and chromic acid -Neue Bitter Felder cell.

Unit 3: Metal Extraction

Electrorefining and electrowinning, extraction of aluminium, lithium, sodium, magnesium and calcium by electrolysis, Down's cell. Hydrometallurgy - extraction of copper, zinc, cobalt, nickel, cadmium, thallium, indium. Aqueous electrorefining of copper, nickel, cobalt, lead and tin. Molten salt electrorefining.

Unit 4: Electrochemical Synthesis

Galvanostatic and potentiostatic methods, electrospinning, Monsanto hydrodimerization of acrylonitrile, electrodeposition of polyphenols, electropolymerization of conducting polymers, aqueous and non-aqueous synthesis of L-Cysteine, electro-catalytic hydrogenation, electrocatalytic oxidation. Electrochemical synthesis of nanomaterials-graphene-metal chalcogenides-bimetallic nanomaterials-intercalation of metal ions-core shell nanomaterials-porous materials and thin films.

Unit 5: Water Treatment and Environmental Protection

Metal ion removal and metal recovery, treating wash water from plating industry, metal recovery from effluents, hypochlorite and low tonnage chlorine electrolyzers, electrodialysis, treatment of wastewater organic pollutants, decomposition of organic and inorganic pollutants, domestic and industrial water disinfection, phase separation - electroflotation, electrocoagulation, ion-selective electrodes for water analysis - glass-solid state membranes, heterogeneous and liquid membranes, gas sensors.

Recommended Readings

1. Pletcher, D. and Walsh, F.C., 1990. Industrial electrochemistry. Springer Science & Business Media.
2. Brenner, A., 2013. Electrodeposition of alloys: principles and practice. Volume I and II, Elsevier.
3. Godula-Jopek, A., 2015. Hydrogen production: by electrolysis. John Wiley & Sons.
4. Kanani, N., 2004. Electroplating: basic principles, processes and practice. Elsevier.
5. Aliofkhazraei, M. and Makhlouf, A.S.H. eds., 2015. Handbook of nanoelectrochemistry. Springer International Publishing.
6. Martínez-Huitle, C.A., Rodrigo, M.A. and Scialdone, O. eds., 2018. Electrochemical water and wastewater treatment. Butterworth-Heinemann.
7. Fuchigami, T., Atobe, M. and Inagi, S., 2014. Fundamentals and applications of organic electrochemistry: synthesis, materials, devices. John Wiley & Sons.

22CHY545 Nanomaterials for Electrochemical Applications 2 0 2 3

Unit 1: Introduction to Nanomaterials

Size dependence of properties – Surface to volume ratio and quantum confinement. Characterisation techniques - microscopic techniques to study nano structures - SEM, AFM, TEM and STM. Spectroscopic techniques to characterize nanostructures - Raman, XPS, Auger, EDAX. Size and charge distribution - DLS, Zeta potential.

Unit 2: Synthetic approaches

Colloidal, Self assembly, electrochemical methods, sol-gel, Langmuir-Blodgett (LB), chemical vapour deposition, plasma arcing, ball milling, and lithography.

Unit 3: Nanomaterials

Synthesis, properties and characterization of fullerenes, carbon nanotubes, graphenes and carbon quantum dots. Metallic and semiconducting quantum dots, metal organic framework, MXenes.

Unit 4: Nanomaterials for Energy

Semiconductor nanostructures - electronic structure and physical process. Material aspect of solar cells, fuel cells, lithium-ion batteries, supercapacitors, and hydrogen storage systems. Zero-dimensional nano materials - graphene and carbon quantum dots, fullerenes, inorganic quantum dots. One dimensional material - nanotubes, nanorods, and nanowires. Two dimensional nanomaterials - graphene, hexagonal boron nitride, metal dichalcogenides and MXene.

Unit 5: Nanomaterials in Hydrogen Energy

Hydrogen Energy - hydrogen production methods, hydrogen storage methods - metal hydrides, metallic alloy hydrides and carbon nanotubes. Size effects - hydrogen storage capacity - hydrogen reaction kinetics.

Recommended Readings

1. Nabok, A., 2005. Organic and inorganic nanostructures. Artech House Publishers.
2. Wang, Z.L., 2001. Characterization of nanophase materials. Particle & Particle Systems Characterization: Measurement and Description of Particle Properties and Behavior in Powders and Other Disperse Systems, 18(3), pp.142-165.
3. Lu, W., Baek, J.B. and Dai, L. eds., 2015. Carbon nanomaterials for advanced energy systems: advances in materials synthesis and device applications. John Wiley & Sons.
4. Li, F., Bashir, S. and Liu, J.L., 2018. Nanostructured Materials for Next-Generation Energy Storage and Conversion. Fuel Cells. Springer.

22CHY546 Electro organic Chemistry 3 0 0 3

Unit 1: Basic Principles

Fundamental concepts and principles in organic electrochemistry – cell reaction. Thermodynamic and kinetic aspects - free energy of cell reaction and cell potential.

Unit 2: Anodic Reactions

Anodic Reactions of – Saturated, unsaturated and aromatic hydrocarbons, hydroxy, carbonyl, carboxylic acids, amines, amides, ethers, esters, halides and organosuphur compounds

Unit 3: Cathodic Reactions

C-H bond formation. Reactions of carbonyl, carboxylic acids and esters, organohalides, nitrocompounds, organosulphur and nitriles. Cathodic addition and elimination reactions.

Unit 4: Reductive Cyclisation

Electrohydrocyclisation, electroreductive cyclisation, tandem cyclisation, cyclisations of halides. Electroreductive coupling using transition metal catalysts.

Unit 5: Anodic Synthesis of Heterocyclic Compounds

Mechanistic aspects – inter and intra molecular cyclisations. Anodic synthesis of heterocyles – formation of C-N, C-O, C-S, N-N, N-O and N-S bonds.

Recommended Readings

1. Kyriacou, D., 1994. Modern electroorganic chemistry. Berlin: Springer-Verlag.
2. Shono, T., 2012. Electroorganic chemistry as a new tool in organic synthesis (Vol. 20). Springer Science & Business Media.
3. Steckhan, E., and Little, R.D., 1997. Electrochemistry VI Electroorganic Synthesis: Bond Formation at Anode and Cathode. Springer Berlin Heidelberg.

22CHY547 Corrosion Science 3 0 0 3

Unit 1: Introduction to Corrosion

Corrosion - causes, classification. Chemical and electrochemical corrosion and their mechanism. Factors influencing corrosion. Pilling-Bedworth ratio - types of oxide film, electrochemical and galvanic series and their significance. Electrochemical and thermodynamic principles of corrosion, Pourbiax diagram. Forms of corrosion - pitting corrosion, intergranular corrosion, waterline corrosion, stress corrosion cracking, cavitation damage, caustic embrittlement, hydrogen damages, corrosion fatigue, fretting corrosion, exfoliation, stray current corrosion, microbial corrosion and soil corrosion.

Unit 2: Corrosion Kinetics

Faradays laws of electrolysis and its application in determining corrosion rates, corrosion kinetics, Evan's diagram, three electrode system, over potential - concentration and diffusion over potential, passivity. Mixed potential theory and its application. Corrosion measurement and monitoring, resistance polarization, determination of corrosion rates by electrochemical measurements - linear polarisation, Tafel and AC impedance.

Unit 3: Corrosion Prevention

Cathodic protection, mechanism of cathodic protection - sacrificial anodic, impressed current cathodic protection, design parameters in cathodic protection, cathodic protection interferences, advantages and disadvantages of cathodic protection. Anodic protection, inhibitors - types and mechanism of inhibition.

Unit 4: Materials and Design in Corrosion Prevention

Corrosive environment, stages in design processes, soldering and threading, crevices, flowing water systems, design for liquid containers, design in packaging. Material selection, factors affecting the performance of materials, materials classification, materials and fluid corrosivity, corrosion behaviour materials, alloying.

Unit 5: Corrosion Resistant Coatings

Organic coatings - polymer coatings, metallic coatings - anodization, tinning, galvanization, sherardizing, cladding, ceramic and nano coatings, and inorganic coatings-oxides, phosphate and chromate coatings, chemical conversion coatings. Methods of coating - electroplating and electroless plating, CVD, PVD, sol gel method, spin coating, spray coating, dip coating. Methods of measuring the coating thickness. Measurement of coating performance.

Recommended Readings

1. Fontana, M.G. and Greene, N.D., 2005. Corrosion Engineering. Tata Mcgraw-Hill.
2. Philip. P.E, Schieitzer, A. 1996. Corrosion Engineering Handbook, 2nd edition, Inco alloys International.

3. Uhlig, H.H. and Revie, R.W., 1985. Corrosion and corrosion control.
4. Ahmad, Z., 2006. Principles of corrosion engineering and corrosion control. Elsevier.
5. Pletcher, D. and Walsh, F.C., 1990. Industrial electrochemistry. Springer Science & Business Media.

22CHY548 **Sustainable Chemical Sciences** **3 0 0 3**

(for Applied Electrochemistry Stream)

Unit 1: Green Chemistry as a Protocol Toward Sustainability

History of green chemistry, chemical composition of the environment, the twelve principles of green chemistry, green chemistry as an expression of environmental ethics - thrift chemistry, the concept of sustainability, from green to sustainable chemistry, sustainable use of chemical feedstock, water and energy, quantifying greenness of a chemical reaction, green chemistry metrics- mass-based, energy, and environmental metrics designing greener process, life cycle assessment.

Unit 2: Sustainability Framework and Matrices

Integrated pollution prevention and control - best available techniques reference documents (BREFs), from industrial emissions directive (IED) to voluntary systems, policy drivers for sustainable chemistry - transition concept, development of a CSR management system framework. Sustainability assessment methods and tools - sustainability assessment framework, impact indicators, and assessment methodologies, environmental impact assessment, economic impact assessment, social impact indicators, sustainability matrices in chemical process, environment, energy and chemistry

Unit 3: Successful Example of Sustainable Industrial Chemistry

Detailed process chemistry of the current technologies and routes for the following chemicals in industry. Propene oxide production (CHPO (chlorohydrin) technology, PO/TBA technology, PO/SM technology, PO-only routes). Synthesis of adipic acid. Ecofining - new process for green diesel production from vegetable oil. Direct oxidation of benzene to phenol, Friedel–Crafts acylation of aromatic ethers using zeolites, sustainable chemistry in the production of nicotinates. Homogeneous catalysis - Shell higher olefin process (SHOP) and Du Pont synthesis of adiponitrile. Heterogeneous catalysis - BP AVADA ethyl acetate process

Unit 4: Green Electrochemistry and Organic Synthesis

Green electrochemistry, electrochemistry and energy sustainability, hydrogen economy. Green electro-organic synthesis - principles of synthetic organic electrochemistry. Electrochemical procedures for Shomo oxidation, electrochemical Birch reduction, electrosynthesis of adiponitrile, clean synthetic route for electro reduction of tribromothiophene to 3-bromo thiophene. Electrochemical reduction of carbon dioxide.

Unit 5: Electrochemical Synthesis of Inorganic Materials

Chemicals from the electrolysis of halides - chlorine and sodium hydroxide production (chlor-alkali) industry - membrane cells, diaphragm cells, mercury cells, oxygen cathodes, hypochlorite, and chlorate, perchlorate, and perchloric acid, bromate, iodate, and periodate.

Electrowinning of metals - aqueous electrolytes, molten salt electrolytes, aluminium production, electrosynthesis of peroxidisulphate, permanganate, hydrogen peroxide and ozone.

Recommended Reading

1. Azapagic, A., Perdan, S. and Clift, R. eds., 2004. Sustainable development in practice: case studies for engineers and scientists. John Wiley & Sons.
2. Cavani, F., Centi, G., Perathoner, S. and Trifirò, F. eds., 2009. Sustainable industrial chemistry: Principles, tools and industrial examples. John Wiley & Sons.
3. Ameta, S.C. and Ameta, R. eds., 2013. Green Chemistry: Fundamentals and Applications. CRC press.
4. Marteel-Parrish, A. E., Abraham, M. A. 2014. Green chemistry and engineering: A Pathway to Sustainability. John Wiley & Sons, Inc.
5. Dicks, A.P. and Hent, A., 2014. Green chemistry metrics: a guide to determining and evaluating process greenness. Springer.
6. Scott, K., 2017. Sustainable and Green Electrochemical Science and Technology. John Wiley & Sons.
7. Protti, S. and Palmieri, A. eds., 2021. Sustainable Organic Synthesis: Tools and Strategies. Royal Society of Chemistry.

Courses offered under the framework of

Amrita Values Programmes I and II

22AVP201 Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

22ADM211 Leadership from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

22ADM201 Strategic Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

22AVP204 Lessons from the Upanishads

Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

22AVP205 Message of the Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

22AVP206 Life and Message of Swami Vivekananda

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

22AVP207 Life and Teachings of Spiritual Masters India

Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

22AVP208 Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

22AVP209 Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

22AVP210 Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability

Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma's words "it is a big step in restoring the lost harmony of nature".

Benefits of Indian Medicinal Systems

Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognized as a viable and sustainable medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

22AVP213 Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

22AVP214 Principles of Worship in India

Indian mode of worship is unique among the world civilizations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realization of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

22AVP215 Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendor of our temples makes art enthusiast spellbound, warmth and grandeur of color combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the Vasthupurusha.

22AVP218 Insights into Indian Classical Music

The course introduces the students into the various terminologies used in Indian musicology and their explanations, like Nadam, Sruti, Svaram – svara nomenclature, Stayi, Graha, Nyasa, Amsa, Thala,- Saptatalas and their angas, Shadangas, Vadi, Samavadi, Anuvadi. The course takes the students through Carnatic as well as Hindustani classical styles.

22AVP219 Insights into Traditional Indian Painting

The course introduces traditional Indian paintings in the light of ancient Indian wisdom in the fields of aesthetics, the Shadanga (Sixs limbs of Indian paintings) and the contextual stories from ancient texts from where the paintings originated. The course introduces the painting styles such as Madhubani, Kerala Mural, Pahari, Cheriyal, Rajput, Tanjore etc.

22AVP220 Insights into Indian Classical Dance

The course takes the students through the ancient Indian text on aesthetics the Natyasastra and its commentary the AbhinavaBharati. The course introduces various styles of Indian classical dance such as Bharatanatyan, Mohiniyatton, Kuchipudi, Odissy, Katak etc. The course takes the students through both contextual theory as well as practice time.

22AVP221 Indian Martial Arts and Self Defense

The course introduces the students to the ancient Indian system of self-defense and the combat through various martial art forms and focuses more on traditional Kerala's traditional KalariPayattu. The course introduces the various exercise technique to make the body supple

and flexible before going into the steps and techniques of the martial art. The advanced level of this course introduces the technique of weaponry.

Social Awareness Campaign

The course introduces the students into the concept of public social awareness and how to transmit the messages of social awareness through various media, both traditional and modern. The course goes through the theoretical aspects of campaign planning and execution.

21SSK301	Life Skills III	1 0 2 2

Team Work: Value of Team work in organisations, Definition of a Team, Why Team, Elements of leadership, Disadvantages of a team, Stages of Team formation. Group Development Activities: Orientation, Internal Problem Solving, Growth and Productivity, Evaluation and Control. Effective Team Building: Basics of Team Building, Teamwork Parameters, Roles, Empowerment, Communication, Effective Team working, Team Effectiveness Criteria, Common characteristics of Effective Teams, Factors affecting Team Effectiveness, Personal characteristics of members, Team Structure, Team Process, Team Outcomes.

Facing an Interview: Foundation in core subject, Industry Orientation/ Knowledge about the company, Professional Personality, Communication Skills, activities before interview, upon entering interview room, during the interview and at the end. Mock interviews.

Advanced Grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc.

Syllogisms, Critical reasoning: A course on verbal reasoning. Listening Comprehension advanced: An exercise on improving listening skills.

Reading Comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Specific Training: Solving campus recruitment papers, National level and state level competitive examination papers; Speed mathematics; Tackling aptitude problems asked in interview; Techniques to remember (In Mathematics). Lateral Thinking problems. Quick checking of answers techniques; Techniques on elimination of options, Estimating and predicting correct answer; Time management in aptitude tests; Test taking strategies.

TEXTBOOKS:

1. A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
2. Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.

3. Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa& Co.
4. The Hard Truth about Soft Skills, by Amazon Publication.

REFERENCES:

1. Speed Mathematics, Secrets of Lightning Mental Calculations, by Bill Handley, Master Mind books;
2. The Trachtenberg Speed System of Basic Mathematics, Rupa& Co., Publishers;
3. Vedic Mathematics, by Jagadguru Swami Sri BharatiKrsnaTirthayi Maharaja, MotilalBanarsidass Publ.;
4. How to Ace the Brainteaser Interview, by John Kador, Mc Graw Hill Publishers.
5. Quick Arithmetics, by Ashish Agarwal, S Chand Publ.;
6. Quicker Maths, by M tyra& K Kundan, BSC Publishing Co. Pvt. Ltd., Delhi;
7. More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
8. The BBC and British Council online resources
9. Owl Purdue University online teaching resources
10. www.thegrammarbook.com online teaching resources
11. www.englishpage.com online teaching resources and other useful websites.