ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Code Format:

A1	A2	B3	C4	C5	C6
School/ Dept. (Offering)		**Level**	**0:** AC	**Serial Number (01 to 99)**	
BH: Basic Sciences and Humanities		**1:** UG/ Int. MSc. (1st Year)	**1:** PC	01/ 03/…/ 19: Odd Sem. (CHEM)	
CS: Computer Sciences		**2:** UG/ Int. MSc. (2nd Year)	**2:** PE	21/ 23/…/ 39: Odd Sem. (HUM)	
EE: Electrical Sciences		**3:** UG/ Int. MSc. (3rd Year)	**3:** OE	41/ 43/…/ 59: Odd Sem. (MATH)	
EI: Electronic Sciences		**4:** UG/ Int. MSc. (4th Year)	**4:** MC	61/ 63/…/ 79: Odd Sem. (PHY)	
IP: Infrastructure and Planning		**5:** UG/ Int. MSc. (5th Year)	**5:** LC	81/ 83/…/ 99: Odd Sem. ()	
MS: Mechanical Sciences		**6:** PG (1st Year)	**6:** PR		
BT: Biotechnology		**7:** PG (2nd Year)	**7:** SE	02/ 04/…/ 20: Even Sem. (CHEM)	
TE: Textile Engineering		**8:** Ph.D.	**8:**	22/ 24/…/ 40: Even Sem. (HUM)	
			9:	42/ 44/…/ 60: Even Sem. (MATH)	
				62/ 64/…/ 80: Even Sem. (PHY)	
				82/ 84/…/ 98: Even Sem. ()	

Abbreviation used:

I:	Integrated Program	PC:	Professional Core	SE:	Seminar
P:	Postgraduate Program	PE:	Professional Elective	L:	Lecture
GE:	Generic Elective/ Interdisciplinary	CC:	Core Course	T:	Tutorial
AECC:	Ability Enhancement Compulsory Course	CE:	Core Elective	P:	Practical
SEC:	Skill Enhancement Course	OE:	Open Elective	PH:	Physics
DSE:	Discipline Specific Elective	MC:	Mandatory Course	CY:	Chemistry
IA*:	Internal Assessment	LC:	Lab Course	MH:	Mathematics
EA:	End-Semester Assessment	AC:	Audit course	HS:	Humanities
PA:	Practical Assessment	PR:	Project	CS:	Computer Science

1st SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
AECC-1	BH1431	English For Communication	2	0	0	2	40	60	-	100
AECC-1 Lab	BH1531	English For Communication Laboratory	0	0	2	1	-	-	100	100
SEC-1	CS1481	Fundamentals Of Computers & Programming In C	3	0	0	3	40	60	-	100
SEC-1 Lab	CS1581	Programming In C Laboratory	0	0	2	1	-	-	100	100
GE-1	BH1371	Physics-I	3	0	0	3	40	60	-	100
GE-1 Lab	BH1571	Physics Laboratory-I	0	0	2	1	-	-	100	100
GE-2	BH1341	Mathematics-I	2	1	0	3	40	60	-	100
PC-1	BH1101	Inorganic Chemistry-I	4	0	0	4	40	60	-	100
PC Lab-1	BH1501	Inorganic Chemistry Laboratory-I	0	0	3	2	-	-	100	100
PC-2	BH1103	Organic Chemistry-I	4	0	0	4	40	60	-	100
PC Lab-2	BH1503	Organic Chemistry Laboratory-I	0	0	3	2	-	-	100	100
		Total credit	18	1	12	**26**	**240**	**360**	**500**	**1100**

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2nd SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
AECC-2	BH1432	Communication In Practice	2	0	0	2	40	60	-	100
AECC Lab-2	BH1532	Communication In Practice Lab	0	0	2	1	-	-	100	100
SEC-2	CS1482	Oops Using C++	3	0	0	3	40	60	-	100
SEC-2 Lab	CS1582	Oops Using C++ Laboratory	0	0	2	1	-	-	100	100
GE-3	BH1372	Physics-II	3	0	0	3	40	60	-	100
GE-3 Lab	BH1572	Physics Laboratory-II	0	0	2	1	-	-	100	100
GE-4	BH1342	Mathematics-II	2	1	0	3	40	60	-	100
PC-3	BH1102	Physical Chemistry-I	4	0	0	4	40	60	-	100
PC Lab-3	BH1502	Physical Chemistry Laboratory-I	0	0	3	2	-	-	100	100
PC-4	BH1104	Organic Chemistry-II	4	0	0	4	40	60	-	100
PC Lab-4	BH1504	Organic Chemistry Laboratory-II	0	0	3	2	-	-	100	100
		Total credit	18	1	12	**26**	**240**	**360**	**500**	**1100**

3rd SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
GE-5	BH2371	Physics-III	3	0	0	3	40	60	-	100
GE-5 Lab	BH2571	Physics Laboratory-III	0	0	2	1	-	-	100	100
GE-6	BH2341	Mathematics-III	2	1	0	3	40	60	-	100
PC-5	BH2101	Physical Chemistry-II	4	0	0	4	40	60	-	100
PC Lab-5	BH2501	Physical Chemistry laboratory-II	0	0	3	2	-	-	100	100
PC-6	BH2103	Organic Chemistry-III	4	0	0	4	40	60	-	100
PC Lab-6	BH2503	Organic Chemistry Laboratory-III	0	0	3	2	-	-	100	100
PC-7	BH2105	Molecular Spectroscopy And Photochemistry	4	0	0	4	40	60	-	100
PC Lab-7	BH2505	Spectroscopy Laboratory	0	0	3	2	-	-	100	100
		Total credit	17	1	11	**25**	**200**	**300**	**400**	**900**

4thSEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
AECC-3	BH2402	Environmental Science	2	0	0	2	40	60	-	100
SEC-3	BH2432	Organizational Behavior	2	0	0	2	40	60	-	100
GE-7	BH2342	Mathematics-IV	2	1	0	3	40	60	-	100
PC-8	BH2102	Physical Chemistry-III	4	0	0	4	40	60	-	100
PC Lab-8	BH2502	Physical chemistry Laboratory-III	0	0	3	2	-	-	100	100
PC-9	BH2104	Inorganic Chemistry-II	4	0	0	4	40	60	-	100
PC Lab-9	BH2504	Inorganic Chemistry Laboratory-II	0	0	3	2	-	-	100	100
PC-10	BH2106	Introduction To Quantum Chemistry	4	0	0	4	40	60	-	100
PC Lab-10	BH2506	Computational Chemistry Laboratory-I	0	0	3	2	-	-	100	100
		Total credit	18	1	9	**25**	**240**	**360**	**300**	**900**

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5thSemester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-11	BH3101	Inorganic Chemistry-III	4	0	0	4	40	60	-	100
PC Lab-11	BH3501	Inorganic Chemistry Lab-III	0	0	3	2	-	-	100	100
PC-12	BH3103	Analytical Chemistry	4	0	0	4	40	60	-	100
PC Lab-12	BH3503	Analytical Chemistry Laboratory	0	0	3	2	-	-	100	100
DSE-1	BH3201	Elecrtochemistry	4	0	0	4	40	60	-	100
DSE Lab-1	BH3505	Electrochemistry Laboratory	0	0	3	2	-	-	100	100
DSE-2	BH3203	Polymer Chemistry	4	0	0	4	40	60	-	100
DSE Lab-2	BH3507	Polymer Chemistry Laboratory	0	0	3	2	-	-	100	100
		Total credit	16	0	12	**24**	**160**	**240**	**400**	**800**

6thSemester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-13	BH3102	Green Chemistry	4	0	0	4	40	60	-	100
PC Lab-13	BH3502	Green Chemistry Laboratory	0	0	3	2	-	-	100	100
PC-14	BH3104	Materials Chemistry	4	0	0	4	40	60	-	100
PC Lab-14	BH3504	Materials Chemistry Lab	0	0	3	2	-	-	100	100
DSE-3	BH3202	Heterocyclic Chemistry	4	0	0	4	40	60	-	100
DSE Lab-3	BH3506	Heterocyclic Chemistry Laboratory	0	0	3	2	-	-	100	100
DSE-4	BH3204	Advanced Analytical Chemistry	4	0	0	4	40	60	-	100
DSE Lab-4	BH3508	Advanced Analytical Chemistry Laboratory	0	0	3	2	-	-	100	100
		Total credit	16	0	12	**24**	**160**	**240**	**400**	**800**

7th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-15	BH4101	Inorganic Chemistry-IV	4	0	0	4	40	60	-	100
PC-16	BH4103	Organic Chemistry-IV	4	0	0	4	40	60	-	100
PE-1	BH4201	Quantum Chemistry	3	0	0	3	40	60	-	100
PE-2	BH4203	Group Theory And Molecular Spectroscopy	3	0	0	3	40	60	-	100
PC Lab-15	BH4501	Inorganic Chemistry Lab-IV	0	0	3	2	-	-	100	100
PC Lab-16	BH4503	Organic Chemistry Lab-IV	0	0	3	2	-	-	100	100
PE Lab-1	BH4505	Medicinal Chemistry Lab	0	0	2	1	-	-	100	100
		Total credit	14	0	8	**19**	**160**	**240**	**300**	**700**

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8th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-17	BH4102	Inorganic Chemistry-V	4	0	0	4	40	60	-	100
PC-18	BH4104	Organic Chemistry-V	4	0	0	4	40	60	-	100
PC-19	BH4106	Physical Chemistry-IV	4	0	0	4	40	60	-	100
PE-3	BH4202	Biochemistry	3	0	0	3	40	60	-	100
PC Lab-17	BH4502	Inorganic Chemistry Laboratory-V	0	0	3	2	-	-	100	100
PC Lab-18	BH4504	Organic Chemistry Laboratory-V	0	0	3	2	-	-	100	100
PC Lab-19	BH4506	Physical Chemistry Laboratory-IV	0	0	3	2	-	-	100	100
		Total credit	15	0	9	**21**	**160**	**240**	**300**	**700**

9th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PE-4	BH5201	Organic Spectroscopy	3	0	0	3	40	60	-	100
PE-5	BH5203	Elective-I	3	0	0	3	40	60	-	100
PE-6	BH5205	Elective -II	0	0	3	3	40	60	-	100
PC-20	BH5101	Physical Chemistry-V	4	0	0	4	40	60	-	100
Seminar	BH5701	Literature Review And Seminar	0	0	4	2	-	-	100	100
PC Lab-20	BH5501	Physical Chemistry Laboratory-V	0	0	3	2	-	-	100	100
PE Lab-2	BH5503	Biochemistry Laboratory	0	0	3	2	-	-	100	100
PE Lab-3	BH5505	Computational Chemistry Lab-II	0	0	3	2	-	-	100	100
		Total credit	10	0	16	**21**	**160**	**240**	**400**	**800**

10th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-21	BH5102	Inorganic Chemistry-VI	4	0	0	4	40	60	-	100
PC-22	BH5104	Bioinorganic And Supramolecular Chemistry	3	0	0	3	40	60	-	100
PC-23	BH5106	Organic Chemistry-VI	3	0	0	3	40	60	-	100
PE-7	BH5202	Elective-III	3	0	0	3	40	60	-	100
Project	BH5602	Project	0	0	6	6	-	-	100	100
		Total credit	13	0	6	**19**	**160**	**240**	**100**	**500**

Students have to opt electives either from group-A or B or C

ELECTIVE	Group-A	Group-B	Group-C
I	Spectral Techniques in Inorganic Chemistry	Natural Product Chemistry	Advanced Chemical Kinetics
II	Chemistry of Materials	Pharmaceutical Chemistry	Biophysical Chemistry
III	Nuclear And Radiochemistry	Newer Synthetic Reactions and Reagents	Advanced Electrochemistry

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1st SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-1	BH1101	INORGANIC CHEMISTRY-I	4	0	0	4

Course Outcomes: Upon completion of this course, the students will be able to

1. learn about atomic theory, wave function, and quantum numbers.
2. get extended ideas about variation of physical and chemical properties of elements across the periodic table.
3. predict atomic structure, chemical bonding and molecular geometry based on accepted models.
4. know the importance of hydrogen and metallic bonding.

Unit- I

Atomic Structure

Bohr's theory and its limitations. Atomic spectrum of hydrogen atom. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and$|\psi|^2$. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Unit-II

Periodicity of Elements

Modern periodic table, detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules

(b) Atomic radii (vander Waals), Ionic and crystal radii, covalent radii

(c) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(d) Electron gain enthalpy, trends of electron gain enthalpy and its application.

(e)Electronegativity (Pauling, Mullikan, Allred Rachow scales) and its trend, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron density ratio.

Unit- III

Chemical Bonding: Basic idea about octet rule and Lenard-Jones potential.

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

Covalent bond: Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, σ *and* π-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and d atomic orbitals, Bents rule, Resonance and resonance energy,

Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple di, tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, Covalent character in ionic compounds, polarizing power and polarizability. Fajans' rule, polarization. Bond moment and dipole moment. Ionic character from dipole moment and electronegativities.

Unit- IV

Metallic bonding and Weak chemical forces

Metallic Bond: Basic idea of free electron model, Semiconductors, and Insulators.

Weak Chemical Forces: Vander Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution.

Suggested Readings:

1. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, 2008, Wiley (India).
2. B. E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts & Models of Inorganic Chemistry, 3rd Edition, 1999, John Wiley & Sons.
3. P. W. Atkins, and J. De Paula, Physical Chemistry, 10th Edition, 2014, Oxford University Press.
4. G. E. Rodger, Descriptive Inorganic, Coordination & Solid State Chemistry, 3rd Edition, 2012, Brooks/Cole, Cengage Learning.
5. F.A. Cotton, and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition, 1999, Wiley-VCH GmbH.
6. C. E. Housecroft, and A. G. Sharpe, Inorganic chemistry, 5th Edition, 2018, Pearson Publication.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-1	**BH1501**	**INORGANIC CHEMISTRY LABORATORY-I**	**0**	**0**	**3**	**2**

Course Outcomes: Upon completion of this course, the students will be able to

1. gain laboratory skills in handling various types of glassware's and preparation of stock solutions of different concentrations.
2. develop knowledge of concepts on quantitative analysis using common laboratory techniques.
3. understand the principles behind acid/base titrations and redox titration.

(A) Titrimetric Analysis

(i) Calibration and use of apparatus.
(ii) Preparation of solutions of different Molarity/Normality of titrants.
(iii) Use of primary and secondary standard solutions.

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe (II) and oxalic acid using standardized Potassium permanganate solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe (II) with Potassium dichromate using internal (diphenylamine, anthranilic acid) and external indicator.

Suggested Readings:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, 6th Edition, 2009, Pearson.
2. G. Svehala, and B. Sivasankar, Vogel's Qualitative Inorganic Analysis, 7th Edition, 2012, Pearson.

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Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-2	BH1103	ORGANIC CHEMISTRY-I	4	0	0	4

Course Outcomes: Upon completion of this course students will be able to

1. review some fundamental concepts of organic chemistry, ranging from nomenclature to their properties.
2. comprehend the formation, stability, and structure of various reaction intermediates, as well as their applicability to various organic reactions.
3. understand the structural and conformational analysis of organic molecules, their stability and application towards various organic reactions.
4. have a comprehensive understanding of the synthesis, stability, and corresponding reactions associated with specific hydrocarbons.

Unit-I

Basics of Organic Chemistry: Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes).

Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Unit-II

Stereochemistry: Concept of asymmetry, Fischer Projection, Newman and Sawhorse projection formulae and their inter conversions; Geometrical isomerism: cis–trans and, syn-anti isomerism, *E/Z* notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral centers, Diastereoisomers, meso structures, racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

Cycloalkanes and Conformational Analysis: Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

Unit-III

Chemistry of Aliphatic Hydrocarbons:

A. Carbon-Carbon sigma bonds: Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

B. Carbon-Carbon pi-bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff and Anti-Markownikoff addition), mechanism of oxymercuration demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, *e.g.* propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions.

Unit-IV

Aromatic Hydrocarbons: Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups.

Suggested Readings:

1. R. N. Morrison, and R. N. Boyd, Organic Chemistry, 7th Edition, 2011, Pearson India Pvt. Ltd.
2. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Edition, 2012, Oxford University Press.

3. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 4th Edition, 2020, New Age International Publishers.
4. T.W.G Solomons, C. B. Fryhle, and S.A. Snyder, Organic Chemistry, 12th Edition, 2016, Willey Singapore
5. P.Y. Bruice, Organic Chemistry, 8th Edition, 2016, Pearson Education.
6. R. Macomber, Organic Chemistry (Vol. I and II), 4th Edition, 2004, University Science Books.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-2	BH1503	ORGANIC CHEMISTRY LABORATORY-I	0	0	3	2

Course Outcomes: Upon completion of this course, the students will be able to

1. familiarize with identification of organic compounds by preliminary methods.
2. learn various methods to identify elemental composition as well as some basic functional groups of organic materials.
3. gain hands on experiences on purification of organic compound by crystallization technique utilizing various solvent & solvent mixture.

Syllabus

1. Detection of elements including physical tests such as state, colour, solubility, ignition, acidity, alkalinity.
2. Detection of functional groups containing C, H, X (X= N, O, S and halides) in known organic compounds.
3. Detection of functional groups containing C, H, X (X= N, O, S and halides) in unknown organic compounds.
4. Purification of organic compounds by crystallization using the following solvents:
   (i) Water (ii) Alcohol (iii) Alcohol-Water.

Suggested Readings:

1. F.G. Mann, and B.C. Saunders, Introduction to Practical Organic Chemistry, 4th Edition, 2009, Pearson Education.
2. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, and A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, 2005, Pearson Education.

2nd SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-3	BH1102	PHYSICAL CHEMISTRY-I	4	0	0	4

Course Outcomes: The students will be able to
1. Familiarize with various laws governing gas, liquid, solids.
2. Analyze different physical properties and their interrelations.
3. Accustom with basic concepts of ionic equilibria.
4. Summarize detailed classification among acid, base and salts.

Unit-I

Gaseous state: Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; gas laws, ideal gas equation, collision frequency; collision diameter; mean free path and viscosity of gases, variation of viscosity with temperature and pressure, relation between mean free path and coefficient of viscosity. Maxwell distribution, types of molecular velocities and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Reasons of deviation from ideal behavior, vander Waals equation of state, its derivation and application, virial equation, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

Unit-II

Liquid state: Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

Unit-III

Ionic equilibria: Types of electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids. Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product. Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.

Unit-IV

Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals, Glasses and liquid crystals.

Suggested Readings:

1. P. W. Atkins, and J. De Paula, Physical Chemistry, 8th Edition, 2006, Oxford University Press.
2. D. W. Ball, Physical Chemistry, 2nd Edition, 2017, Cengage Learning India Pvt. Ltd.
3. G. W. Castellan, Physical Chemistry 4th Edition, 2004, Narosa India Pvt. Ltd.
4. R. G. Mortimer, Physical Chemistry, 3rd Edition, 2009, Elsevier.
5. G. M. Barrow, Physical Chemistry, 5th Edition, 2007, Tata McGraw Hill.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-3	BH1502	PHYSICAL CHEMISTRY LABORATORY-I	0	0	3	2

Course Outcomes: The students will be able to

1. Gain skills to handle precise glassware's such as viscometer, stalgamometer *etc*. for determination of physical properties of various mixtures.
2. Develop knowledge on operation and maintenance of pH meter.
3. Expertise preparation of solutions and mixtures of different concentrations.

Syllabus

1. Surface tension measurements.

a. Determine the surface tension by (i) drop number (ii) drop weight method.

b. Study the variation of surface tension of detergent solutions with concentration.

2. **Viscosity measurements using Ostwald's viscometer**.

a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

b. Viscosity of sucrose solution with the concentration of solute.

3. pHmetry

a. Effect on pH of addition of HCl / NaOH to solutions of acetic acid, sodium acetate and their mixtures.

b. Preparation of buffer solutions of different pH.

i. Sodium acetate-acetic acid.

ii. Ammonium chloride-ammonium hydroxide.

c. pH metric titration of (i) strong acid *vs.* strong base, (ii) weak acid *vs.* strong base.

d. Determination of dissociation constant of a weak acid.

Suggested Readings:

1. B. D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, 18th Edition, 2020, R. Chand & Co.
2. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, 2003, McGraw-Hill Education.
3. A. M. Halpern, and G. C. McBane, Experimental Physical Chemistry, 3rd Edition, 2003, W.H. Freeman & Co.
4. V. D. Athawale and P. Mathur, Experimental Physical Chemistry, 1st Edition, 2001, New Age International Publishers.

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Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-4	BH1104	ORGANIC CHEMISTRY-II	4	0	0	4

Course Outcomes: Upon completion of this course students will be able:

1. understand various substitution reaction and their application towards synthesis of diverse organic moieties.
2. comprehend the formation and properties of various organic compound having different functionalities (alcohol, phenol, ether, carbonyl etc.).
3. cultivate a fundamental understanding of heterocyclic compounds and their applications.
4. familiarize with some well-known organic reagent and their application.

Unit-I

Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation, nucleophilic substitution reactions: S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent *etc*.; nucleophilic substitution *vs*. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li and their use in synthesis.

Unit-II

Alcohols, Phenols, Ethers and Epoxides

Alcohols: Preparation, properties and relative reactivity of primary, secondary and tertiary alcohols, Bouvealt-Blanc Reduction; Preparation and properties of glycols: Oxidation by per-iodic acid and lead tetraacetate, Pinacol Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids, Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

Unit-III

Carbonyl Compounds: Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer-Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Unit-IV

Carboxylic Acids and their Derivatives: Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement.

Sulphur containing compounds: Preparation and reactions of thiols, thioethers and sulphonic acids.

Suggested Readings:

1. T.W.G Solomons, C. B. Fryhle, and S.A. Snyder, Organic Chemistry, 12th Edition, 2016, Willey Singapore
2. J. E. McMurry, Fundamentals of Organic Chemistry, 7th Edition, 2013, Cengage Learning India Pvt. Ltd.
3. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Edition, 2003, Pearson Education.
4. R. N. Morrison, and R. N. Boyd, Organic Chemistry, 7th Edition, 2011, Pearson India Pvt. Ltd.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-4	BH1504	ORGANIC CHEMISTRY LABORATORY-II	0	0	3	2

Course Outcomes: Upon completion of this course, the students will be able to

1. learn various methods to identify elemental composition as well as some basic functional groups of organic materials.
2. gain hands on experiences to prepare of various organic compounds by following some well-known organic reactions.
3. familiarize characterization of the synthesized compound adopting some basic methods.

1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.
2. Organic compound preparations:
i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidine and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method and using green chemistry approach)
ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.
iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).
iv. Bromination (any one)
a. Acetanilide by conventional methods
b. Acetanilide using green approach (Bromate-bromide method)
v. Nitration: (any one)
a. Acetanilide/nitrobenzene by conventional method
b. Salicylic acid by green approach (using ceric ammonium nitrate).
vi. Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline.
vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
viii. Hydrolysis of amides and esters.
ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
xi. Aldol condensation with either conventional or green method.
xii. Benzil-Benzilic acid rearrangement.
Collected solid samples may be used for recrystallization, melting point and TLC.

Suggested Readings:

1. F.G. Mann, and B.C. Saunders, Introduction to Practical Organic Chemistry, 4th Edition, 2009, Pearson Education.
2. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, and A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, 2005, Pearson Education.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

3rd SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-5	BH2101	PHYSICAL CHEMISTRY-II	4	0	0	4

Course Outcomes: The students will be able to

1. Accumulate glossary of thermodynamics in detailed manner.
2 Formulate relations between thermodynamic properties
3. Utilize various laws of thermodynamics to predict nature of reactions
4. Determine effect of solute concentration on physical properties of solution

Unit-I

Introduction to thermodynamics:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat (q), work (w), internal energy (U), and statement of first law; enthalpy (H), relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry:

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.

Unit-II

Second Law:

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Free Energy Functions:

Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations: thermodynamic equation of state.

Unit-III

Partial molar quantities:

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases

Third law of thermodynamics:

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

Unit-IV

Solutions and Colligative properties:

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution

Suggested Readings:

1. P. W. Atkins, and J. De Paula, Physical Chemistry, 8th Edition, 2006, Oxford University Press.
2. G. W. Castellan, Physical Chemistry 4th Edition, 2004, Narosa India Pvt. Ltd.
3. T. Engel, and P. Reid, Physical Chemistry 3rd Edition, 2012, Prentice Hall India Pvt. Ltd.
4. D.A. McQuarrie, and J.D. Simon, Molecular Thermodynamics, 2nd Edition, 2004, Viva Books.
5. B. N. Roy, Fundamentals of Classical and Statistical Thermodynamics, 1st Edition, 2002, John Wiley& Sons Inc.
6. I .N. Levine, Physical Chemistry, 6th Edition, 2010, Tata McGraw Hill.
7. C.R. Metz, Physical Chemistry, Schaum's Outline Series, 2nd Edition, 2006, Tata McGraw Hill.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-5	**BH2501**	**PHYSICAL CHEMISTRY LABORATORY-II**	**0**	**0**	**3**	**2**

Course Outcomes: The students will be able to
1. Determine heat capacity of calorimeter of different volume
2. Concepts of thermochemistry for various applications.
3. Determine the heat of solution and change in enthalpy.

Syllabus

1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of integral enthalpy (endothermic and exothermic) solution of salts.
4. Determination of basicity of a polyprotic acid by the thermochemical method.
5. Determination of enthalpy of hydration of copper sulphate using a thermal analyzer
6. Study of the solubility of benzoic acid in water and determination of ΔH.

Suggested Readings:

1. B. D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, 18th Edition, 2020, R. Chand & Co.
2. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, 2003, McGraw-Hill Education.
3. A. M. Halpern, and G. C. McBane, Experimental Physical Chemistry, 3rd Edition, 2003, W.H. Freeman & Co.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-6	BH2103	ORGANIC CHEMISTRY-III	4	0	0	4

Course Outcomes: Upon completion of this course students will be able:

1. understand preparation, structure and reactivity of nitrogen containing functional groups.
2. gain knowledge on nomenclature, structure and preparation of various poly-nuclear hydrocarbon.
3. understand nomenclature, structure and reactivity of heterocyclic compounds.
4. gain a rudimentary understanding of various natural compounds, including their structural elucidation and therapeutic significance.

Unit-I

Nitrogen Containing Functional Groups: Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann elimination reaction; Distinction between primary, secondary and tertiary amines with Hinsberg reagent and nitrous acid. Diazonium salts: Preparation and synthetic applications

Unit-II

Polynuclear Hydrocarbons: Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

Unit-III

Heterocyclic Compounds: Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan, Furfural and Furoic acid.

Unit-IV

Alkaloids: Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, EMDE modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

Terpene: Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α-terpineol.

Suggested Readings:

1. R. N. Morrison, and R. N. Boyd, Organic Chemistry, 7th Edition, 2011, Pearson India Pvt. Ltd.
2. R. M. Acheson, An Introduction to the Chemistry of Heterocyclic Compounds, 3rd Edition, 2008, John Wiley & Sons.
3. T.W.G Solomons, C. B. Fryhle, and S.A. Snyder, Organic Chemistry, 12th Edition, 2016, Willey Singapore
4. J. E. McMurry, Fundamentals of Organic Chemistry, 7th Edition, 2013, Cengage Learning India Pvt. Ltd.
5. P.S. Kalsi, Organic Reactions and Their Mechanisms, 5th Edition, 2020, New Age International Publishers.
6. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Edition, 2012, Oxford University Press.
7. J. Singh, S.M. Ali, and J. Singh, Natural Products Chemistry, 1st Edition, 2010, Pragati Prakashan.
8. R. K. Bansal, Heterocyclic Chemistry, 6th Edition, 2019, New Age International Publishers.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-6	BH2503	ORGANIC CHEMISTRY LABORATORY-III	0	0	3	2

Course Outcomes: Upon completion of this course students will be able

1. gain knowledge about preparation of organic dye.
2. identify various functional group present in an organic-compounds and their characterization by adopting different spectroscopic techniques.
3. gain a comprehensive understanding of the process of extraction of organic raw materials from natural resources.

Syllabus

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g., salicylic acid, cinnamic acid, nitrophenols, etc.
2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy.
3. Preparation of methyl orange.
4. Extraction of caffeine from tea leaves.
5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple lab procedures.

Suggested Readings:

1. A. I. Vogel, Quantitative Organic Analysis, Part 3, 2nd Edition, 2012, Pearson Education.
2. F.G. Mann, and B.C. Saunders, Introduction to Practical Organic Chemistry, 4th Edition, 2009, Pearson Education.
3. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, and A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, 2005, Pearson Education.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-7	BH2105	MOLECULAR SPECTROSCOPY AND PHOTOCHEMISTRY	4	0	0	4

Course Outcomes: The students will be able to
1. Attain basic idea about electromagnetic radiation and their principles to construct spectrometric techniques.
2. Utilize rotational, vibrational and electronic spectroscopy to determine structure of complex compounds.
3. Summarize elementary idea of photochemistry.

Unit-I

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.
Rotational spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Unit-II

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.
Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Unit-III

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.
Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation.

Unit-IV

Photophysical and Photochemical processes: Laws of photochemistry, quantum yield. Jablonski diagrams: Franck-Condon principle, Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency. Kinetics of photochemical reactions ($H_2 + Br_2 = HBr$, $2HI = H_2 + I_2$), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and its applications).

Suggested Readings:

1. K. J. Laidler and J.M. Meiser, Physical Chemistry, 2nd Edition, 2006, CBS Publishers.
2. I. N. Levine, Physical Chemistry, 6th Edition, 2011, McGraw-Hill (International).
3. D. A. McQuarrie, and J.D. Simon, Physical Chemistry- A Molecular Approach, 1st Edition, 2019, Viva Books.
4. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, 4th Edition, 2021, New age International Publishers.
5. C. N. Banwell, and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edition, 2006, Tata McGraw-Hill.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-7	**BH2505**	**SPECTROSCOPY LABORATORY**	**0**	**0**	**3**	**2**

Course Outcomes: The students will be able to

1. Gain knowledge on indicators and their significance.
2. Obtain basic operation and maintenance of various analytical instruments.
3. Accustom with graphical representation and analysis of experimental data set.

Syllabus

(i) Determination of indicator constant - colorimetry.

(ii) Verification of Beer's Law - Determination of concentration of solution by colorimetry.

(Instructor may explain the principle of using colorimeter, its handling drawing standard calibration curve, and its application in finding unknown concentration of dyes, concentration of metal solutions (*e.g*. Ni, Cu using appropriate reagent) from standard calibration curve.

Suggested Readings:

1. P. S. Sindhu, Practicals in Physical Chemistry- A Modern Approach, 1st Edition, 2005, Macmillan.
2. J. M. Wilson, R. J. Newcombe, A. R. Denaro, and R. M. W. Rickett, Experiments in Physical Chemistry, 2nd Edition, 1999, Pregamon Press.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

4TH SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-8	BH2102	PHYSICAL CHEMISTRY-III	4	0	0	4

Course Outcomes: The students will be able to

1. Gain knowledge on phase diagram and their industrial application.
2. Utilize chemical kinetics to understand the mechanism of reactions.
3. Acquire basics of catalysis and their kinetics.
4. Understand adsorption isotherms and their significance

Unit-I

Phase Equilibria:

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform acetic acid system, triangular plots. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

Unit-II

Chemical Kinetics:

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudo unimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Unit-III

Catalysis:

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces, effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Unit-IV

Surface chemistry:

Colloids, Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langmuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Suggested Readings:

1. P. W. Atkins, and J. De Paula, Physical Chemistry, 8th Edition, 2006, Oxford University Press.
2. G. W. Castellan, Physical Chemistry 4th Edition, 2004, Narosa India Pvt. Ltd.
3. T. Engel, and P. Reid, Physical Chemistry 3rd Edition, 2012, Prentice Hall India Pvt. Ltd.
4. I .N. Levine, Physical Chemistry, 6th Edition, 2010, Tata McGraw Hill.
5. C.R. Metz, Physical Chemistry, Schaum's Outline Series, 2nd Edition, 2006, Tata McGraw Hill.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-8	BH2502	PHYSICAL CHEMISTRY LABORATORY-III	0	0	3	2

Course Outcomes: The students will be able to

1. Gain hands-on experience in construction of phase diagram.
2. Apply kinetics to calculate different physical parameters of chemical reactions.
3. Validate adsorption isotherms to various systems.

Syllabus

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_{2\,(aq)} + I^- \rightarrow I_{3\,(aq)}^-$

(ii) $Cu_{(aq)}^{+2} + nNH_3 \rightarrow Cu(NH_3)_n$

3. Study the kinetics of the following reactions.

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

Adsorption

Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.

Suggested Readings:

1. B. D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, 18th Edition, 2020, R. Chand & Co.
2. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, 2003, McGraw-Hill Education.
3. A. M. Halpern, and G. C. McBane, Experimental Physical Chemistry, 3rd Edition, 2003, W.H. Freeman & Co.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-9	BH2104	INORGANIC CHEMISTRY-II	4	0	0	4

Course outcome: Upon completion of this course, the students will be able to

1. understand the basic principles of oxidation, reduction and redox reactions.
2. learn to apply principles of redox reaction in metallurgy and hydrometallurgy processes.
3. learn the Structure, bonding of s and p block materials and their oxides/compounds.
4. understand the chemistry of inorganic polymers, their structures and their applications.

Unit- I

Oxidation-Reduction and general principle of metallurgy:

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel- de Boer process and Mond's process, Zone refining.

Unit- II

Chemistry of *s* and *p* Block Elements:

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine, per and oxo acids of Sulphur inter-halogen compounds, polyhalide ions, pseudo-halogens, properties of halogens.

Unit- III

Noble Gases:

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of fluorides, oxides and oxo fluorides of Xenon; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory).

Unit- IV

Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

Suggested Readings:

1. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, 2008, Wiley (India).
2. N. N. Greenwood, and A. Earnshaw, Chemistry of the Elements, 2nd Edition, 1997, Butterworth-Heinemann, Elsevier.
3. F.A. Cotton, and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition, 1999, Wiley-VCH GmbH.
4. G. E. Rodger, Descriptive Inorganic, Coordination & Solid State Chemistry, 3rd Edition, 2012, Brooks/Cole, Cengage Learning.
5. G. L. Miessler, and D. A. Tarr, Inorganic Chemistry, 4th Edition, 2010, Pearson Education.
6. P.W. Atkins, and D.F. Shriver, Inorganic Chemistry 5th Edition, 2010, Oxford University Press.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-9	BH2504	INORGANIC CHEMISTRY LABORATORY-II	0	0	3	2

Course outcomes: Upon completion of this course, the students will be able to

1. get an overall idea about the quantitative and qualitative analysis of inorganic compounds.
2. understand the basic difference between an iodometric and an iodimetric process.
3. learn about the preparation of inorganic compounds like chrome alum and cuprous chloride.

Syllabus

(A) Iodometric / Iodimetric Titrations

(i) Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(ii) Estimation of (i) arsenite and (ii) antimony iodimetrically
(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2
(ii) Preparation of aluminium potassium sulphate (Potash alum) or Chrome alum.

Suggested readings:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, 6th Edition, 2009, Pearson.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-10	BH2106	INTRODUCTION TO QUANTUM CHEMISTRY	4	0	0	4

Course Outcomes: The students will be able to
1. Acquire basic mathematical methods and their applications in quantum chemistry.
2. Utilize quantum mechanics to derive the selection rules.
3. Imply the solutions of Schrodinger equation to obtain quantum numbers and their significance.
4. Envisage the molecular properties of small molecules based on quantum mechanical concepts.

Unit-I

Introduction to black-body radiation and distribution of energy, photo-electric effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, The wave function: wave function and its interpretation, Wave function of a particle - Schrodinger equation, Basic idea about operator, classical mechanics variables – quantum mechanical operators, eigen function and eigen values, conditions of normalization and orthogonality, Hermitian property of operators, postulates of quantum mechanics

Unit-II

Particle in a box: boundary conditions, wave functions and energies, degeneracy, Quantitative treatment of simple harmonic oscillator model, setting up of Schrodinger equation and discussion of solution of wave functions.

Unit-III

Rotational motion of a particle: Idea about transformation of Cartesian coordinate to spherical polar coordinates, Schrodinger equation in polar coordinates, Rigid rotator model and discussion of application of Schrodinger equation, spherical harmonics, radial and angular parts of the atomic orbitals of hydrogen and hydrogen like atoms, representations of hydrogen atomic orbitals.

Unit-IV

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression), Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches, LCAO-MO treatment of H2, $H2^+$; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H2 (only wave functions, detailed solution not required) and their limitations.

Suggested Readings:

1. K. J. Laidler and J.M. Meiser, Physical Chemistry, 2nd Edition, 2006, CBS Publishers.
2. I. N. Levine, Quantum Chemistry, 7th Edition, 2016, Person Education.
3. D. A. McQuarrie, and J.D. Simon, Physical Chemistry- A Molecular Approach, 1st Edition, 2019, Viva Books.
4. A. K. Chandra, Introductory Quantum Chemistry, 4th Edition, 2017, Tata McGraw-Hill.
5. J. E. House, Fundamentals of Quantum Chemistry, 2nd Edition, 2004, Elsevier.
6. J. E. Lowe and K. A. Peterson, Quantum Chemistry, 3rd Edition, 2006, Academic Press.
7. R.K. Prasad, Quantum Chemistry, 4th Edition, 2020, New Age International Publishers.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-10	BH2506	COMPUTATIONAL CHEMISTRY LABORATORY-I	0	0	3	2

Course Outcomes: The students will be able to

1. conversant with drawing the structures uniformly using ChemDraw software.
2. Acquainted with plotting of graphs using ORIGIN software.
3. Accustomed with analysis of results using mathematical and statistical tools.

Syllabus

1. Practicing ChemDraw software to draw the structures.
2. Use of ORIGIN software to plot different types of graphs.
3. Convolution, deconvolution, linear and non-linear fitting of data sets and their analysis in ORIGIN.

Essential Readings:

1. F. Jensen, Introduction to Computational Chemistry, 3rd Edition, 2017, John Wiley & Sons Ltd.
2. C. J. Cramer, Essentials of Computational Chemistry, 2nd Edition, 2004, John Wiley & Sons Ltd.
3. D. C. Young, Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems, 1st Edition, 2001, Wiley-Interscience, GmbH.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

5th SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-11	BH3101	INORGANIC CHEMISTRY-III	4	0	0	4

Course outcomes: After completion of the course, the learner shall be able to understand:

1. VBT, CFT and MOT of coordination compounds.
2. applications of CFSE in determining the structure of coordination complexes.
3. the separation of Lanthanides and Actinides, its color, spectra and magnetic behavior.
4. the basic knowledge on the various metal ions and their roles present in biological systems.

Unit- I

Coordination Chemistry:

Introduction to coordination compounds, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelate effect. Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments. Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, Qualitative aspect of Ligand field theory, MO diagrams of representative coronation complexes.

Unit- II

Transition Elements:

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and E.M.F (Latimer & Ebsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

Unit- III

Lanthanides and Actinides:

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Unit- IV

Bioinorganic Chemistry:

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on distribution of metals. Sodium / K-pump, carbonic anhydrase and Carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), toxicity, chelating agents in medicine. Iron and its application in biosystem, Hemoglobin; Storage and transfer of iron.

Suggested Readings:

1. K. F. Purcell, and J.C. Kotz, Inorganic Chemistry, 2nd Edition, 2010, Cengage Learning.
2. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry, 5th Edition, 2022, Pearson Education.
3. S.J. Lippard, and J.M. Berg, Principles of Bioinorganic Chemistry, 4th Edition, 2022, University Science Books.
4. F.A. Cotton, and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition, 1999, Wiley-VCH GmbH.
5. F. Basolo, and R. C. Pearson, Mechanisms of Inorganic Chemistry, 2nd Edition, 1967, John Wiley & Sons.
6. N. N. Greenwood, and A. Earnshaw, Chemistry of the Elements, 2nd Edition, 1997, Butterworth-Heinemann, Elsevier.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-11	BH3501	INORGANIC CHEMISTRY LABORATORY-III	0	0	3	2

Course Outcomes: Upon completion of this course, the students will be able to

1. analyse a mixture of inorganic salts and insoluble inorganic samples.
2. identify acid and basic radicals in a sample of unknown mixtures.
3. apply and handle air and moisture sensitive chemicals for the synthesis and study of complexes and inorganic reactions.

Syllabus

1. Qualitative semi-micro analysis of known acid radicals (Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate) and basic radicals (ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium).
2. Qualitative semi-micro analysis of mixture containing mixtures containing three anions and three cations. Following radicals may be analyzed: Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium.
3. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-}-and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br and $I^-$$NO_3^-$ and Br^-, NO_3^- and I^-. Spot analysis/tests should be done whenever possible.
4. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
5. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. (Also find the λmax of the prepared complex using instrument).
6. Synthesis of ammine complexes of Ni (II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Suggested Readings:

1. G. Svehala, and B. Sivasankar, Vogel's Qualitative Inorganic Analysis, 7th Edition, 2012, Pearson.
2. G. Marr, and D. W. Rockett, Practical Inorganic Chemistry, 1st Edition, 1972, John Wiley & Sons.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-12	BH3103	ANALYTICAL CHEMISTRY	4	0	0	4

Course Outcome: The students will be able to

1. Acquainted with fundamentals of analytical chemistry.
2. Understand different analytical tools and statistical methods applied in analytical chemistry.
3. Acumen fundamentals of spectroscopic techniques
4. Get insights of separation techniques and its applications.

Unit I

Qualitative and quantitative aspects of analysis: Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

Unit II

Spectroscopy: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra.

UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Unit III

Thermal analysis: TGA, DTA and DSC: Basic principles, instrumentation and their applications.

Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Determination of pKa values.

Unit IV

Separation techniques

Solvent extraction: Classification, principle and efficiency of the technique, Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions, Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC and HPLC.

Suggested Readings:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, 6th Edition, 2009, Pearson.
2. H. H. Willard, Instrumental Methods of Analysis, 7th Edition, 1988, Wordsworth Publishing Co.
3. G. D. Christian, Analytical Chemistry, 6th Edition, 2004, John Wiley & Sons.
4. D.C Harris, Exploring Chemical Analysis, 9th Edition, 2016, W.H. Freeman Co.
5. D. A. Skoog, and F. J. Holler, Principles of Instrumental Analysis, 7th Edition, 2017, Cengage Learning.
6. O. Mikes, Laboratory Hand Book of Chromatographic & Allied Methods, 1st Edition, 1979, John Wiley& Sons.
7. R. V. Dilts, Analytical Chemistry, 1st Edition, 1974, Van Norstrand Reinhold Company.
8. S. M. Khopkar, Basic Concepts of Analytical Chemistry, 3rd Edition, 2023, New International Publications.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-12	BH3503	ANALYTICAL CHEMISTRY LABORTAORY	0	0	3	2

Course outcomes: The students will be able to

1. Acquire hands on experience in different chromatographic techniques.
2. Utilize concepts of solvent extraction.
3. Get practical experience in operation and handling of UV-Vis, FTIR etc.

Syllabus

I. Chromatography:

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.
(iii). Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.
(iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.

II. Solvent Extractions:

(i) Separation of a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.
(ii) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
(iii) Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

III. Analysis of soil:

(i) Determination of pH of soil.
(ii) Total soluble salt
(iii) Estimation of calcium, magnesium, phosphate, nitrate

IV. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of metal ions from their binary mixture.
(iii) Separation of amino acids from organic acids by ion exchange chromatography.

V. Spectrophotometry:

(i). Determination of pKa values of indicator using spectrophotometry.
(ii) Structural characterization of compounds by infrared spectroscopy.
(iii) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Suggested Readings:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, 6th Edition, 2009, Pearson.
2. D.C Harris, Exploring Chemical Analysis, 9th Edition, 2016, W.H. Freeman Co.
3. O. Mikes, Laboratory Hand Book of Chromatographic & Allied Methods, 1st Edition, 1979, John Wiley& Sons.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE-1	BH3201	ELECRTOCHEMISTRY	4	0	0	4

Course Outcome: The students will be able to

1. Gain basic principles of electrochemistry.
2. Apprehend idea about electrochemical cells and their function
3. Understand concepts of electrodes, EMF measurement.
4. Acquire basics of potentiometric titrations and their applications.

Unit-I

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

Unit-II

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry, electrochemical cells, reversible and irreversible cells with examples, Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone, hydroquinone, glass and Sb_2O/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Unit-III

Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Unit-IV

Electrical & Magnetic Properties of Atoms and Molecules: Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mossotti equation, Lorentz-Lorenz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

Suggested Readings:

1. P. W. Atkins, and J. De Paula, Physical Chemistry, 8th Edition, 2006, Oxford University Press.
2. G. W. Castellan, Physical Chemistry 4th Edition, 2004, Narosa India Pvt. Ltd.
3. R. G. Mortimer, Physical Chemistry, 3rd Edition, 2009, Elsevier
4. G. M. Barrow, Physical Chemistry, 5th Edition, 2007, Tata McGraw Hill.
5. T. Engel, and P. Reid, Physical Chemistry 3rd Edition, 2012, Prentice Hall India Pvt. Ltd.
6. D.W. Rogers, Concise Physical Chemistry, 1st Edition, 2011, John Wiley & Sons Co.
7. R. J. Silbey, R. A. Alberty, and M. G. Bawendi, Physical Chemistry, 4th Ed., 2005, John Wiley & Sons, Inc.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE Lab-1	BH3505	ELECTROCHEMISTRY LABORATORY	0	0	3	2

Course Outcome: The students will be able to

1. Gain knowledge in handling and maintainace of electrochemical equipment's
2. Prepare buffer solutions at a required pH, given a choice of solutions of acid/conjugate base pairs.
3. Implement principle and mechanism of Conductometric and potentiometric titrations

Syllabus

1. Determination of pH of a given solution using glass electrode.
2. Determination of cell constant.
3. Determination of equivalent conductance, degree of dissociation, and dissociation constant of weak electrolyte.
3. Conductometric titrations: strong acid *vs*. strong base, weak acid *vs*. strong base.
4. Potentiometric titrations: strong acid *vs*. strong base, weak acid *vs*. strong base.

Suggested Readings:

1. B. D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, 18th Edition, 2020, R. Chand & Co.
2. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, 2003, McGraw-Hill Education.
3. A. M. Halpern, and G. C. McBane, Experimental Physical Chemistry, 3rd Edition, 2003, W.H. Freeman & Co.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE-2	BH3203	POLYMER CHEMISTRY	4	0	0	4

Course Outcome: After completion of the course, the learner can be able to understand:

1. The mechanism of polymer material formation.
2. Molecular weight and structure property relationship
3. Polymerization procedure and Ziegler-Natta catalysis.
4. Characterization of polymers

Unit-I

Introduction: Polymer, monomer, examples of polymers, biopolymers, classification, polymerization process, degree of polymerization, condensation, addition polymers, kinetics of addition polymerization process.

Unit-II

Polymeric Structure and Property Relationship: Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average, weight average, viscosity average) and distribution of molecular weight, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature, Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

Unit-III

Polymerization Chemistry: Industrial methods of polymerization such as a bulk, solution, emulsion, suspension. Stereochemistry of polymers and stereo-specific polymerization, Catalysts-their utility in polymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Ziegler-Natta, Metallocene and others.

Unit-IV

Characterization of Polymers: Molecular weight determination by Light Scattering, Osmometry, End-Group Analysis, Viscosity, Gel Permeation Chromatography; Application, of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification of polymers.

Suggested Readings:

1. D.W. Van Krevelen and P.J. Hoftyzen, Properties of Polymer, 3rd Edition, 1990, Elsevier.
2. S. K. Gupta and A. Kumar, Reaction Engineering of Step Growth Polymerization, 1st Edition, 1987, Plenum Press.
3. F. W. Billmeyer, Text book of Polymer Science, 3rd Edition, 2007, John Wiley & Sons.
4. J. R. Fried, Polymer Science and Technology, 2nd Edition, 2005, Prentice Hall (India) Limited.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE Lab-2	BH3507	POLYMER CHEMISTRY LABORATORY	0	0	3	2

Course outcome: The students will be able to

(i) Gain knowledge in synthesis of polymers by different method.
(ii) Learn handling and operation of viscometers.
(iii) Expertise various analytical instruments *e.g.*, FTIR, TGA etc. used for characterization.

Syllabus

1. Free radical solution polymerization of any one: Styrene, methylmethacrylate, methyl acrylate, methacrylic acid (using free radical initiators). (Purification of monomer should be instructed)
2. Preparation of phenol-formaldehyde resins
3. Emulsion polymerization of poly (methyl methacrylate).
4. Use of viscometer for molecular weight determination – (any known polymer, example: polyvinyl pyrrolidone in water/polyacrylamide in $NaNO_2$ solution) by viscometry (Ubblohde/Ostwald viscometer).
5. Estimation of amount of HCHO in a given solution by sodium bisulphite method.
6. Use of FTIR/TGA/DSC for polymer characterization.
7. Determination of exchange capacity of cation exchange resins and anion exchange resins.

Suggested Readings:

1. P. Munk, and T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd Edition, 2002, John Wiley & Sons.
2. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Edition, 2005, Oxford University Press.
3. L. H. Sperling, Introduction to Physical Polymer Science, 4th Edition, 2005, John Wiley & Sons.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

6th SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-13	BH3102	GREEN CHEMISTRY	4	0	0	4

Course Outcome: After completion of the course, the students will be able to
1. Green chemistry and its principles.
2. Green synthesis and reactions.
3. Understanding principles of green chemistry.
4. Atom economy and design of chemical reactions using the principle.

Unit-I:

Introduction and Principles of Green Chemistry: Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry. Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions).

Unit-II

Green Synthesis/ Reactions:
1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)
4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.
5. Designing of Environmentally safe marine antifoulant.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
7. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils.

Unit-III

Future Trends in Green Chemistry: Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C3S3); Green chemistry in sustainable development.

Suggested Readings:

1. V. K. Ahluwalia, and M. R. Kidwai, New Trends in Green Chemistry, 1st Edition, 2004, Kluwer Academic Publishers.
2. P. T. Anastas, and J. K. Warner, Green Chemistry- Theory and Practice, 2nd Edition, 2005, Oxford University Press.
3. J. Andraos, and A. S. Matlack, Introduction to Green Chemistry, 3rd Edition, 2022, CRC Press.
4. M. A. Ryan, and M. Tinnesand, Introduction to Green Chemistry, 1st Edition, 2002, American Chemical Society.
5. M. Lancaster, Green Chemistry: An Introductory Text, 2nd Edition, 2010, RSC Publishing.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-13	BH3502	GREEN CHEMISTRY LABORATORY	0	0	3	2

Course Outcome: After completion of the course, the students will be able to
(i) Design of chemical reactions/chemical synthesis using green chemistry principles.
(ii) Use of green chemistry principle and processes in laboratory reactions.

Syllabus

1. Preparation and characterization of nanoparticles of gold using tea leaves.
2. Preparation of biodiesel from vegetable/ waste cooking oil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates Green Chemistry.
4. Reactions like addition, elimination, substitution and rearrangement may also be studied for the calculation of atom economy.
5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide).
6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.
7. Mechanochemical solvent free synthesis of azomethine.
8. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu (II) complex.
9. Photo reduction of benzophenone to benzopinacol in presence of sunlight.

Suggested Readings:

1. P. T. Anastas, and J. K. Warner, Green Chemistry- Theory and Practice, 2nd Edition, 2005, Oxford University Press.
2. M. Kirchoff, and M. A. Ryan, M.A. Greener Approaches to Undergraduate Chemistry Experiment, 1st Edition, 2002, American Chemical Society.
3. R. K. Sharma, I. T. Sidhwani, and M. K. Chaudhari, Green Chemistry Experiment: A Monograph, 1st Edition, ISBN 978-93-81141-55-7.
4. D. L. Pavia, G.M. Lampman, G. S. Kriz, and R. G. Engel, Introduction to Organic Laboratory Techniques: A small scale approach, 1st Edition, 1995, McGraw Hill Higher Education.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-14	BH3104	MATERIALS CHEMISTRY	4	0	0	4

Course Outcome: The students will be able to

1. Gain basic parameters of crystalline solids, symmetry and crystal structures.
2. Acquire basics of functionalized porous materials (silicates, zeolites, organic frameworks *etc*.) and its applications.
3. Get insight on preparation of inorganic solids, ionic liquids and its significance
4. Get insights of self-assembled structures, nanostructured organic/inorganic materials, composites and their industrial applications.

Unit-I

Basics of crystalline solids

Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding, lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations , translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism, twinning.

Unit-II

Silica based materials

Introduction to Zeolites, metallosilicates, silicates and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organosilica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications.

Unit-III

Inorganic solids/ionic liquids of technological importance

Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium based ionic liquids. Host-guest chemistry (elementary ideas).

Unit-IV

Nanomaterials

Overview of nanostructures and nanomaterials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures, control of nanoarchitecture, one dimensional control. Carbon nanotubes and inorganic nanowires.

Composite materials

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fiber-reinforced composites, environmental effects on composites, applications of composites.

Suggested Readings:

1. P. Atkins, T. Overton, J. Rourke, M. Weller, and A. F. Shriver, Inorganic Chemistry, 5th Edition, 2012, Oxford University Press.
2. D. M. Adam, Inorganic Solids: An Introduction to Concepts in Solid-State Structural Chemistry, 1st Edition, 1974, John Wiley& Sons
3. C.P. Poole, and F. J. Owens, Introduction to Nanotechnology, 1st Edition, 2003, John Wiley & Sons.
4. G. E. Rodger, Inorganic and Solid State Chemistry, 1st Edition, 2002, Cengage Learning.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-14	BH3504	MATERIALS CHEMISTRY LABORATORY	0	0	3	2

Course Outcome: The students will be able to

1. Gain familiarity in preparation of nanomaterials using various methods.
2. Gain operation and handling of sophisticated analytical instruments (XRD, SEM, BET, FTIR, and NMR).
3. Utilize concepts of spectroscopy for data interpretation.

Syllabus

1. Preparation of urea-formaldehyde resin
2. Preparations of novalac resin/resol resin
3. Synthesis of materials/porous materials (Sol-gel, hydrothermal, microwave).
4. Preparation of silver nano material.
5. Analysis of XRD pattern of crystals.
6. Interpretation of FTIR, NMR and UV-Vis data of given material.
7. Estimation of particle size from the BET, SEM techniques.
8. Density measurement of ionic liquids
9. Determining dynamic viscosities of given ionic liquids
10. Determination of hydration number IR spectra.

Suggested Readings:

1. G., Svehla, Vogel's Qualitative Inorganic Analysis, 6th Edition, 1987, Orient Longman.
2. V.V. Ramanujam, Inorganic Semi-micro Qualitative Analysis, 3rd Edition, 1990, National Publishing Company.
3. J. Bassett, G. H. Jeffery, J. Mendham, and R. C. Denny, Vogel's Textbook of Quantitative Chemical Analysis, 5th edition, 1999, Orient Longman.
4. A. J. Elias, Collection of Interesting General Chemistry Experiments, 1st Edition, 2002, Universities Press.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE-3	BH3202	HETEROCYCLIC CHEMISTRY	4	0	0	4

Course Outcomes: Upon completion of this course students will be able:

1. Acquire broad knowledge on general synthesis of diverse heterocyclic moieties.
2. Gain a comprehensive understanding about properties and reactivity of various heterocyclic compounds.
3. Grasp knowledge about the general synthetic approaches and reactivity of three, four and five membered heterocyclic compounds.
4. Accumulate knowledge about various natural product-derived heterocyclic compounds.

Unit-I

Three-membered rings with one heteroatom: Chemistry of Oxiranes, Aziridines and Episulfides - synthetic approaches and reactivities.

Three-membered heterocycles with two heteroatoms: Oxaziridine, Diaziridines and Diazirines- synthetic approaches and reactivities.

Unit-II

Four-membered heterocycles: Oxetane, Azetidine and Thietane - synthetic approaches and reactivities.

Natural products: Synthesis of Penicillin and Cephalosporin.

Unit-III

Five-membered aromatic heterocycles:

1. **with one heteroatom**: Furan, Pyrrole and Thiophene - general synthetic approaches, properties and reactivities.
2. **with two heteroatoms**: Oxazole, Isoxazole, Imidazole, Thiazole, Pyrazole and Isothiazole - general synthetic approaches and reactivities.
3. **with three and four heteroatoms**: Triazole and Tetrazole - synthetic approaches, properties and reactivity.

Unit-IV

Condensed five-membered Heterocycles: Benzofuran, indoles and Benzothiazole - general synthetic approaches, with greater emphasis on the chemistry of Indoles.

Suggested Readings:

1. J.A. Joule, and K. Mills, Heterocyclic Chemistry, 5th Edition, 2010, John Wiley& Sons.
2. A. R. Parikh, H. Parikh, and R. Khunt, The Essence of Heterocyclic Chemistry, 1st Edition, 2013, New Age International Publication.
3. A.R. Katritzky, and C. W. Rees, Comprehensive Heterocyclic Chemistry. The Structure, Reactions, Synthesis and use of Heterocyclic compounds, Volume 1-8, 1st Edition, 1984, Pergamon Press.
4. A. R. Katritzky, Handbook of Heterocyclic Chemistry, 1st Edition, 1985, Pergamon Press.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE Lab-3	BH3506	HETEROCYCLIC CHEMISTRY LABORATORY	0	0	3	2

Course Outcomes: Upon completion of this course students will be able to

1. learn identification of present of heteroatoms in an organic compound by different techniques.
2. identify various functional group present in an organic-compounds by adopting various spectroscopic techniques.
3. gain knowledge about preparation of some useful organic dye.

Syllabus

1. Identification of hetero atoms (S, N, X) in given organic compounds in lab.
2. Identification/separation of simple organic compounds containing hetero atoms using column chromatography/TLC) in lab.
3. Spectroscopic identification of simple organic compounds.
4. Melting point/boiling point of the compounds may be checked for its purity.
5. Preparation of Indigo (using Aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basic condition).

Suggested readings:

1. F.G. Mann, and B.C. Saunders, Introduction to Practical Organic Chemistry, 4th Edition, 2009, Pearson Education.
2. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, and A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, 2005, Pearson Education.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE-4	BH3204	ADVANCED ANALYTICAL CHEMISTRY	4	0	0	4

Course Outcome: The students will be able to

1. Acquainted with fundamentals of analytical chemistry.
2. Understand different analytical tools and statistical methods applied in analytical chemistry.
3. Acumen fundamentals of spectroscopic techniques
4. Get insights of separation techniques and its applications.

Unit-I

Statistical methods in chemical analysis

Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method).

Unit-II

Electroanalytical Methods: principles and applications of voltammetry, cyclic voltammetry, anodic stripping voltammetry.
Polarography: Current-voltage relationship, theory of polarographic waves, instrumentation, qualitative and quantitative applications.
Atomic spectroscopy: Atomic absorption spectroscopy, theory and application (with some examples).

Unit-III

Fluorescence Spectroscopy: Basic principles of fluorescence spectroscopy; quantum yield and lifetime; static & dynamic quenching; the Stern-Volmer equation, fluorescence anisotropy. Basic idea on green fluorescent protein.
Optical Activity and ECD Spectroscopy: Optical activity; absorption and dispersion; principles of circular dichroism; CD of small molecules.

Unit-IV

Analysis of fuel and drugs

Fuel analysis: Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel, Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point.
Drug analysis: Classification of drugs, Analysis of some standard drug using various chromatographic techniques.
Suggested Readings:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, 6th Edition, 2009, Pearson.
2. H. H. Willard, Instrumental Methods of Analysis, 7th Edition, 1988, Wordsworth Publishing Co.
3. G. D. Christian, Analytical Chemistry, 6th Edition, 2004, John Wiley & Sons.
4. D.C Harris, Exploring Chemical Analysis, 9th Edition, 2016, W.H. Freeman Co.
5. D. A. Skoog, and F. J. Holler, Principles of Instrumental Analysis, 7th Edition, 2017, Cengage Learning.
6. O. Mikes, Laboratory Hand Book of Chromatographic & Allied Methods, 1st Edition, 1979, John Wiley& Sons.
7. R. V. Dilts, Analytical Chemistry, 1st Edition, 1974, Van Norstrand Reinhold Company.
8. S. M. Khopkar, Basic Concepts of Analytical Chemistry, 3rd Edition, 2023, New International Publications.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
DSE Lab-4	BH3508	ADVANCED ANALYTICAL CHEMISTRY LABORATORY	0	0	3	2

Course Outcome: The students will be able to

1. Gain expertise in chromatographic techniques.
2. Use concepts of analytical chemistry in fuel and drug analysis.
3. Utilize basics of pH metric titrations in analysis of mixtures.

Syllabus

1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. Preparation of buffer solutions of different pH (i. Sodium acetate-acetic acid, ii. Ammonium chloride-ammonium hydroxide
2. Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:
i. Ni (II) and Co (II)
ii. Fe (III) and Al (III)
3. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.
4. IR/DSC analysis of known polymer sample (for students demonstration only)
5. Determination of flash point & fire point of given fuel sample.
6. Determination of viscosity index, cloud point, pour point of given fuel sample.
7. Determination of calorific value of given fuel sample/coal sample using bomb calorimeter.
8. Proximate analysis of given coal sample.
9. Determination of the iodine number of oil.
10. Determination of the saponification number of oil.

Suggested Readings:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, 6th Edition, 2009, Pearson Education.
2. P.C. Jain, and M. Jain, Engineering Chemistry, 16th Edition, 2005, Dhanpat Rai & Sons.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

7th SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-15	BH4101	INORGANIC CHEMISTRY-IV	4	0	0	4

Course Outcomes: Upon completion of this course students will be able to

1. understand structure and bonding of compounds involving main group elements.
2. predict the spectral properties of coordination compounds based on crystal field theory.
3. describe the stability of metal complexes through formation constants and able to calculate thermodynamic parameters from them.
4. demonstrate the reaction mechanism of selected substitution and electron transfer reaction of co-ordination compounds.

Unit- I

Stereochemistry and Bonding in Main Group Compounds

Wade's rule, STYX method, application to boron compounds and carboranes.

Structure and bonding in condensed phosphates, silicates, cyclo phosphazenes and S-N cyclic compounds.

Metal - Ligand Bonding

Limitation of CFT, MOT: energy level diagram of $\sigma -$ and $\pi -$ bonding in octahedral, tetrahedral and square planar complexes.

Unit- II

Electronic Spectra of Coordination Compounds:

Spectroscopic ground states, term symbols for d^n ions, Racah parameters, selection rules and intensities of bands, Orgel diagram, correlation and Tanabe-Sugano diagrams, spectra of 3d metal-aqua complexes of trivalent metal ions (d^1-d^6), divalent (Mn, Co and Ni), Calculation of Dq, B and β parameters for tetrahedral and octahedral complexes, CT spectra. Spectral properties of lanthanide and actinide metal complexes.

Unit- III

Metal-ligand Equilibria in Solution

Stability of metal complexes, compositions of metal complexes by Job's method. Stepwise and overall stability constant, factors affecting the stability constant, Determination of stability constants by (pHmetry and spectroscopic methods) and their applications.

Unit- IV

Inorganic Reaction Mechanism

Inert and labile complexes, factors affecting the reactivity of complexes, mechanisms of substitution (acid, base hydrolysis and anation) reactions of octahedral complexes, substitution reactions of square planar complexes, trans-effect – theories and applications in synthesis of metal complexes, redox reactions: mechanism of one election transfer reaction (inner sphere and outer-sphere), Marcus theory for outer-sphere reactions.

Essential Readings:

1. P.W. Atkins, and D.F. Shriver, Inorganic Chemistry 5th Edition, 2010, Oxford University Press.
2. N. N. Greenwood, and A. Earnshaw, Chemistry of the Elements, 2nd Edition, 1997, Butterworth-Heinemann, Elsevier.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry,1st Indian Edition, 2006, Pearson Education.
4. F. A. Cotton, G. Wilkinson, C. A. Murillo, and M. Bochmann, Advanced Inorganic Chemistry, 6th Edition,1999, John Wiley & Sons.
5. A. K. Das and M. Das, Fundamental Concept of Inorganic Chemistry, Vol. 4 and 5, 2nd Edition, 2014, CBS Publisher & Distributor Pvt. Ltd.
6. G. L. Miessler, P. J. Fischer and D. A. Tarr, Inorganic Chemistry, 5th Edition, 2013 Pearson Education.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-15	BH4501	INORGANIC CHEMISTRY LABORATORY-IV	0	0	3	2

Course Outcomes: Upon completion of this course students will be able to

1. Identify the acid and basic radicals in a mixture of inorganic salts based on the principles of qualitative analysis.
2. Carry out synthesis of various types of simple inorganic complexes.
3. Students will learn the basic characterization of the synthesized complexes by spectroscopic technique (UV-Visible and IR).

Syllabus

I. Semi micro qualitative analysis of inorganic mixtures containing anions, common cations, less familiar element (W, Mo, Ce, Th, Zr, V and U), insoluble (sulphate, oxides, halide).

II. Preparation and characterization (UV-Visible and IR spectra) of complexes

- Hexaamminenickel (II) chloride
- Sodium tris-(oxalate)iron(III)
- Tris(thiourea) copper(I) complex
- Ammonium tetrathiocyanatocobaltate(II)
- Chrome alum

Suggested Readings:

1. G. Svehla, Vogel's Qualitative Inorganic Analysis, 6th Edition, l987, Orient Longman.
2. A. J. Elias, A Collection of Interesting General Chemistry Experiments, 1st Edition, 2002, Universities Press (India) Pvt. Ltd.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-16	BH4103	ORGANIC CHEMISTRY-IV	4	0	0	4

Course Outcomes: Upon completion of this course students will be able:

1. comprehend the organic reaction mechanism through the knowledge of structure, reactivity and rearrangement in organic molecules.
2. understand the basic mechanism of various organic substitution reactions and their application towards preparation of different organic compounds.
3. reveal the structural features of organic compounds and the genesis of the optical activity of chiral substances.
4. familiarize with some well-known organic reaction and its applications

Unit- I

Stereochemistry

Conformational analysis of cycloalkanes, decalin, effect of conformation on reactivity, conformation of sugars, Elements of symmetry, chirality, molecules with more than one chiral center, threo- and erythro- isomers, methods of resolution. Optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape.

Unit- II

Reaction Mechanism (Structure, Reactivity and Rearrangements)

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes, benzyne. Types of mechanisms: S_N2, S_N1, mixed S_N1 and S_N2, SN at an allylic, aliphatic trigonal and a vinyl carbon. Reactivity: effects of substrate, structure, attacking nucleophile, leaving group and reaction medium, ambient nucleophile and regioselectivity. Kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle, potential energy diagrams, transition states and intermediates. Methods of determining reaction mechanisms, isotope effects. Quantitative treatment, Hammett equation and linear free energy relationships, substituent and reaction constants, Taft equation. The NGP mechanism, NGP by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, norbornyl systems.

Unit- III

Aromatic Electrophilic Substitution Reactions

The arenium ion mechanism, orientation and reactivity, energy profile diagrams, the ortho/para ratio, ipso attack, orientation in other ring systems, quantitative treatment of reactivity in substrates and electrophiles, diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction. The S_NAr, SRN1 mechanisms, reactivity effect of substrate structure, leaving group and attacking nucleophile. Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance, reactivity of aliphatic and aromatic substrates at bridgehead, reactivity in the attacking radicals, effects of solvents on reactivity.

Unit- IV

Molecular rearrangements

General mechanistic considerations-nature of migration, Migratory aptitude, A detailed study of the following rearrangements: Pinacol-Pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Ester synthesis, The von Richter, Sommelet-Hauser and Smiles rearrangements, Neber, Beckmann, Hoffman, Curtius, Schmidt, Bayer-Villiger, Fries rearrangement, Shapiro reaction.

Suggested Readings:

1. M. B. Smith, Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition, 2013, John Wiley & Sons.
2. F. A. Carey, and R. J. Sundberg, Advanced Organic Chemistry Part A & B: Structure and Mechanisms, 5th Edition, 2007, Springer International Edition.
3. P. Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition, 1985, John Wiley & Sons Inc.
4. H. O. House, Modern Organic Reactions, 2nd Edition, 1972, Addison Wesley.
5. R. O. C. Norman, and J.M. Coxon, Principles of Organic Synthesis, 3rd Edition, 1993, Academic Press.
6. P.S. Kalsi, Stereochemistry of Organic Compounds, 8th Edition, 2015, New Age International Publication.
7. J. Clayden, N. Greeves, and S. Warren, Organic Chemistry, 2nd Edition, 2000, Oxford University Press.
8. S. N. Ege, Organic Chemistry: Structure and Reactivity, 5th Edition, 2001, Prentice Hall Macmillan.
9. D. Nasipuri, Stereochemistry,4th Edition, 2012, New Age International Publishers.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-16	BH4503	ORGANIC CHEMISTRY LABORATORY-IV	0	0	3	2

Course Outcomes: Upon completion of this course students will be able:

1. identify various functional group present in an organic-compounds by qualitative analysis and confirmation by various analytical techniques.
2. synthesize some organic compounds.
3. separate the organic compounds by adopting various separation techniques.

Syllabus

1. Qualitative Analysis: Identification of organic compounds.
2. Separation, purification and identification of compounds of binary mixture using TLC and column chromatography.
3. Preparation of Picric acid.
4. Interpretation of IR spectra for functional group identification.
5. Structure Drawing of various organic building blocks using ChemDraw software.

Suggested Readings:

1. D. J. Pasto, C. R. Johnson, and M. J. Miller, Experiments and Techniques in Organic Chemistry, 6th Edition, 1992, Prentice Hall India Pvt. Ltd.
2. H. Middleton, Systematic Qualitative Organic Analysis, 2nd Edition, 1982, Rupa Publishing House.
3. H. T. Clarke, Hand Book of Organic Analysis, Qualitative & Quantitative, 2nd Edition, 1967, E. Arnold Publication.
4. A. I. Vogel, Text book of Practical Organic Chemistry, 5th Edition, 1989, ELBS (London).
5. K. L. Williamson, Macro-scale and Micro-scale Organic Experiments, 2nd Edition, 1994, D. C. Heath & Co.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-1	BH4201	QUANTUM CHEMISTRY	3	0	0	3

Course Outcomes: The students will be able to

1. Utilize the mathematical methods for quantum mechanical calculations.
2. Derive the selection rules of electronic transitions based on postulates of quantum mechanics.
3. Design significance of quantum numbers based upon solutions of Schrodinger equation.
4. Predict the molecular properties of small molecules based on quantum mechanical concepts.

Unit-I

Matrix Algebra: Matrices, determinants, matrix rank, orthogonal and unitary transformations, eigenvalues and eigenvectors, diagonalization of matrices. Vectors and Tensors: Introduction to vectors; vector operations; coordinate system transformation; Vector spaces, inner products, linear independence, bases. Ordinary Differential Equations: Linear first and second order ODEs, homogeneous and inhomogeneous ODEs with constant coefficients, system of linear ODEs, power series solution of differential equations and special functions.

Unit-II

Operators in Quantum mechanics: Linear, Hermitian and Angular Momentum operators, Eigenvalue problem, particle in 3-dimensional box, degeneracy and tunneling. Derivation of selection rules for electronic transitions, Solution of the Schrodinger equation for hydrogen and hydrogen-like atoms, significance of n, l and m quantum numbers.

Unit-III

Approximation methods (variation method and perturbation theory), multielectron atoms (Helium and Li^+ ion), spin quantum number, ground and excited state of helium atom. Born-Oppenheimer approximation, Hückel Molecular Orbital Theory, Molecular term symbols, Homonuclear and heteronuclear diatomic molecules (HF, CO, NO).

Suggested Readings:

1. G. Doggett, M. Cockett, and E. Abel, Maths for Chemists: RSC (Tutorial Chemistry Texts),1st Edition, 2012, RSC.
2. P. Tebbutt, Basic Mathematics for Chemists, 1st Edition, 1998, Wiley-Blackwell.
3. D.A. McQuarrie, and J.D Simon, Physical Chemistry: A Molecular Approach, 2nd Edition, 2015, Viva Books.
4. Quantum Chemistry. D.A. McQuarrie and J.D Simon, 2nd Edition, 2015, Viva Books.
5. A. Szabo, and N. S. Ostlund, Modern Quantum Chemistry, 1st Edition, 1996, Dover Books.
6. I. N. Levine, Quantum Chemistry, 4th Edition, 2000, Prentice Hall India Pvt. Ltd.
7. A. K. Chandra, Introductory Quantum Chemistry, 4th Edition, 2009, Tata McGraw Hill.
8. P. W. Atkins, and R. S. Friedman, Molecular Quantum Mechanics, 3rd Edition, 1997, Oxford University Press.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-2	BH4203	GROUP THEORY AND MOLECULAR SPECTROSCOPY	3	0	0	3

Course Outcomes: Upon completion of this course students will be able to

1. acquire the fundamental knowledge on symmetry, point groups and their properties; construct the character tables and predict their applications.
2. predict the rotational, vibrational and Raman spectra of complex systems; apply symmetry considerations to vibrational and Raman spectra.
3. understand the theories of magnetic resonances and apply these to predict the structure of molecules/compounds/ions etc.
4. understand the functioning of Mossbauer spectra and their application to ascertain the oxidation states of Fe and Sn systems.

Unit-I

Group Theory

Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroup, conjugacy relation and classes, generators, Point group. Representations of group operators, The great orthogonality theorem (without proof) and its explanation, irreducible and reducible representation, bases of a representation, character of a representation, character table and its meaning, reduction formula, symmetry and selection rules for transitions between rotational, vibrational and electronic states, Symmetry and normal modes of vibration. Determination of normal modes from Symmetry for AB_2, AB_3, AB_4, AB_5 and AB_6 systems, symmetry of overtones and combination bands.

Unit-II

Rotational and Infrared Spectroscopy: Rotational spectra of simple polyatomic molecules (linear, non-linear- symmetric top and spherical top, prolate and oblate types) Stark effects on rotational spectrum. Fundamental and overtone bands. Isotope effects.

Unit-III

Spin Based Spectroscopy

Nuclear Magnetic Resonance Spectroscopy: Nuclear spin; nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant 'J'. Classification (ABX, AMX, ABC, A_2B_2 *etc*.), spin decoupling; basic ideas about instrument, 1-D NMR studies of nuclei other than proton– ^{13}C, ^{19}F and ^{31}P. FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.

Electron Paramagnetic (Spin) Resonance (EPR or ESR) Spectroscopy: Basic principles, zero field splitting and Kramer's rule, factors affecting the 'g' value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship.

Suggested Readings:

1. C. N. Banwell, and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edition, 1995, Tata McGraw Hill.
2. G. M. Barrow, Molecular Spectroscopy, 4th Edition, 1995, McGraw Hill.
3. P. F. Bernath, Spectra of Atoms and Molecules, 2nd Edition, 2005, Oxford University Press.
4. F. A. Cotton, Chemical Applications of Group Theory, 3rd Edition, 2003, John Wiley & Sons.
5. A. M. Lesk, Introduction to Symmetry and Group Theory for Chemists, 1st Edition, 2004, Springer.
6. A. Vincent, Molecular Symmetry and Group Theory, A Programmed Introduction to Chemical Applications, 2nd Edition, 2013, John Wiley & Sons.
7. R. L. Carter, Molecular Symmetry and Group Theory, 2nd Edition, 1997, John Wiley & Sons.
8. K. V. Reddy, Symmetry and Spectroscopy of Molecules, 2nd Edition, 2009, New Age International Publications.

9. J. M. Hollas, Modern Spectroscopy, 4th Edition, 2004, John Wiley & Sons.
10. D.C. Haris, and M.D. Bertolucci, Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy, 1st Edition, 1989, Dover Publications Inc.
11. J. A. Weil, J. R. Bolton, and J. E. Wertz, Electron Paramagnetic Resonance: Elementary Theory and Practical Applications, 1st Edition, 1994, Wiley-Interscience.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE Lab-1	**BH4505**	**MEDICINAL CHEMISTRY LABORATORY**	**0**	**0**	**2**	**1**

Course Outcomes: After completion of the course, students will be able to
(i) Expertise in designing and synthesis of various organic compounds
(ii) Apply concepts of chromatography in purification of compounds
(iii) Gain basics in evaluation of physiochemical properties of different compounds.

1. Purification Techniques of Solvents by Fractional Distillation and Vacuum Distillation
2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by Column Chromatography.
3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties. (Benzilic Acid & Sodium Benzoate)
4. Synthesis & Purification of following Compounds using:
(i) Precipitation or Recrystallization.
(ii) Synthesis of Benzimidazole.
(iii) Synthesis of Anthranilic Acid.
(iv) Synthesis of Sulfanilamide.
(v) Synthesis of benzoic acid from benzyl alcohol.
(vi) Synthesis of 1, 4 – Dihydropyridine

Suggested Readings:

1. J. Mendham, R.C. Denney, J. D. Barnes, M. J. K Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, 2001, Pearson Education.
2. A. Kar, Advanced Practical Medicinal Chemistry, 1st Edition, 2004, New Age International Publications.
3. B. S. Furniss, A. J. Hannaford, P.W.G. Smith, and A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th edition, 2008, Pearson Education.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

8th SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-17	BH4102	INORGANIC CHEMISTRY-V	4	0	0	4

Course Outcomes: Upon completion of this course students will be able to

1. derive the magnetic properties of coordination, lanthanide and actinide compounds.
2. employ concepts to comprehend presence of para, Ferro, Anti-Ferro magnetism *etc.* in various inorganic complexes.
3. get knowledge on organometallic and fluxional compounds, their classifications, bonding and structures.
4. realize the reactions and catalytic properties of organometallic compounds.

Unit-I

Magnetic properties of coordination compounds

Types of magnetic behaviour, magnetic susceptibility and its determination by Gouy, Faraday and VSM method, Pascal's constants and constitutive corrections, paramagnetism, Curie-Weiss law, van Vleck's equation (derivation excluded) and its applications, spin-orbit coupling, ferro- and anti-ferromagnetism coupling, super paramagnetism, high and low spin equilibria. Anomalous magnetic moments, magnetic exchange coupling and spin crossover. Magnetic properties of Lanthanide and Actinide metal complexes.

Unit-II

Organometallic Chemistry-I

Stability and 18 electron rules (covalent and ionic), Alkyls/aryl and hydrides: alkyls and aryls (metal alkyls stabilized carbanion, β-elimination, stable alkyls, Agostic alkyls, reductive elimination, preparation of metal allyls). Metal hydrides: synthesis, characterization, reactions, bridging hydrides.

Unit-III

Organometallic Chemistry-II

Synthesis, bonding, properties of Pi-complexes and applications of alkenes and alkynes, allyls, diene, cyclopentane, Dienyl, arenes. Introductory idea on transition metal-carbon multiple compounds: carbenes and carbyne.

Fluxional Organometallic Compounds

Fluxionality and dynamic equilibria in compounds such as η^{2-} olefin, η^{3-} allyl and Dienyl complexes.

Unit-IV

Organometallic chemistry-III

Reactivity of organo-transition metal complexes: Coordinative unsaturation, substitution reactions (nucleophilic and electrophilic addition and abstraction), oxidative addition and reductive elimination, insertion reactions (insertion of CO, SO_2 and alkenes). Catalysis by organo-transition metal complexes: Alkene isomerization, hydrogenation and hydroformylation; Zeigler-Natta polymerization of ethylene, reduction of carbon monoxide by hydrogen (Fischer-Tropsch reaction).

Essential Readings:

1. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals**,** 1st Edition, 2014, John Wiley & Sons.
2. J. F. Hartwig, Organo-transition Metal Chemistry: From Bonding to Catalysis, 1st Edition, 2009**,** University Science Books.
3. A. F. Hill, Organo-transition Metal Chemistry, 1st Edition, 2002, Royal Society of Chemistry.
4. C.H. Elshebroicn, and A Salzer, Organometallics: A Concise Introduction, 3rd Edition, 2006, John Wiley & Sons.
5. S. G. Davies, Organo-transition Metal Chemistry: Applications to Organic Synthesis, 1st Edition, 1982, Pergamon Inc.
6. A.K. Das and M. Das, Fundamental Concept of Inorganic Chemistry, Vol. 4 and 5, 2nd Edition, 2016, CBS Publisher & Distributor Pvt. Ltd.
7. R. C. Mehrotra, and A. Singh Organometallic Chemistry, 2nd Edition, 2000, New Age International Publishers.
8. R. L. Dutta, and A. Samal, Elements of Magnetochemistry, 2nd Edition, 2004, S. Chand & Company Ltd.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-17	BH4502	INORGANIC CHEMISTRY LABORATORY-V	0	0	3	2

Course Outcome: Upon completion of this course students will be able to

1 carry out synthesis of simple complexes and pursue the quantitative analysis of metals or the ligands in those complexes.
2 perform volumetric analysis of metals in a mixture of their salts.
3 Quantitatively analyze the metals in a mixture of their salts by volumetric methods.

I. Preparation and quantitative analysis of complexes
- Preparation of Pentaamminechlorocobalt (III) chloride.
- trans- Dicholorobis (ethylenediamine) cobalt (III) chloride
- sodium tris-(oxalate)iron(III)
- Tris(thiourea) copper(I) complex
- ammonium tetrathiocyanatocobaltate(II)
- Potassium tris-(oxalato)aluminate(III)
- Tetraaminecopper (II) sulphate.

II. Volumetric analysis
- Volumetric estimation of Fe & Cu in their mixture.
- Volumetric estimation of Zn & Cu in their mixture.
- Volumetric estimation of Ni and Zn in their mixture.

Suggested Readings:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, 6th Edition, 2009, Pearson.
2. G. Svehala, and B. Sivasankar, Vogel's Qualitative Inorganic Analysis, 7th Edition, 2012, Pearson.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-18	BH4104	ORGANIC CHEMISTRY-V	4	0	0	4

Course Outcomes: Upon completion of this course, students will be able:

1. To comprehend the science behind the creation of diverse natural products.
2. To grasp the reactivity pattern and fundamental reaction mechanism of distinct reducing and oxidizing agents.
3. To understand the utility of retrosynthesis towards formation of various organic species, selectively protecting and deprotecting organic functionalities.
4. To comprehend the use of coupling reaction in the creation of carbon-carbon and carbon-hetero atom bonds.

Unit- I

Organic transformations and reagents: Functional group interconversions including oxidations and reduction and stereochemistry.

Reductions: Catalytic hydrogenation, reduction by dissolving metals, Bio-reduction. Hydride transfer reagents: Sodium borohydride, Sodium cyanoborohydride, Lithium aluminium hydride, alkoxy substituted LAH reducing agents, DIBAL, Application of Hydroboration. Diborane, Disiamylborane, 9-Borabicyclo [3.3.1] nonane (9-BBN), isopinocamphenyl and diisopinocampheylborane. Homogeneous hydrogenation: Mechanism and applications using Rh, Ru and other metal complexes.

Oxidations: Scope of the following oxidizing agents with relevant applications and mechanism: DDQ, DCC, Chromium (VI) oxidants, Osmium tetroxide, Selenium dioxide, $KMnO_4$, tertiary-Butyl hydro peroxide. Manganese (IV) oxidants, Swern oxidation, Oxidation with per-acids. Oxidation with hypervalent organoiodines.

Unit- II

Coupling Reactions: Carbon-carbon bond formation through coupling reactions (Heck, Suzuki, Stille and Sonogashira, Negishi), Carbon-hetero atom bond forming reactions using transition metals (Cu, Pd, Rh, Ru, Ni, Fe etc.), Buchwald- Hartwig reaction, C-C bond forming reaction; Wittig reaction, Julia-Kocienski olefination, Peterson olefination, Metathesis reaction (Cross or ring closure).

Unit-III

Disconnection Approach: An introduction to synthon and synthetic equivalents, disconnection approach, functional group inter conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemo-selectivity.

Reversal polarity & protecting group: Umpolung approach, cyclisation reactions, amine synthesis. Protecting Groups*:* Principle of protection and deprotection of alcohol, amine, carbonyl and carboxyl groups and their application in organic synthesis.

Unit-IV

One Group -C Disconnection: Alcohols and carbonyl compounds, regioselectivity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

Two Group C-C Disconnections: Diels-Alder reaction, 1, 3–difunctionalised compounds, α, β-unsaturated carbonyl compounds, control in carbonyl condensations, 1, 5-difunctionalised compounds. Michael addition and Robinson annulation.

Ring Synthesis: Saturated heterocycles, synthesis of 3-, 4-, 5- and 6- membered rings, aromatic heterocycles in organic synthesis.

Synthesis of Some Complex Molecules: Application of the above protocols in the synthesis of following compounds: Camphor, Vitamin D and Cortisone.

Suggested Readings:

1. G. S. Zweifel, M. Nantz, P. Somfai, Modern Organic Synthesis and Introduction, 2nd Edition, 2014, John Wiley & Sons.
2. J. Fuhrhop, and G. Penzlin, Organic Synthesis: Concepts, Methods and Starting Materials, 2nd Edition, 1993, Wiley-VCH.
3. W. Carruthers, Some Modern Methods of Organic Synthesis, 4th Edition, 2004, Cambridge University Press.
4. H. O. House, Modern Synthetic Reactions, 2nd Edition, 1972, W. A. Benjamin & Co.
5. M. B. Smith, Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition, 2013, John Wiley & Sons.
6. R.O.C. Norman, and J. M. Coxon, Principles of Organic synthesis, 3rd Edition, 1993, CRC Press.
7. F. A. Carey, and R. J. Sundberg, Advanced Organic Chemistry Part B: Structure and Mechanism, 5th Edition, 2008, Springer.
8. S. Warren, and P. Wyatt, Organic Synthesis: The Disconnection Approach, 2nd Edition, 2008, Wiley India Pvt. Ltd.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-18	BH4504	ORGANIC CHEMISTRY LABORATORY-V	0	0	3	2

Course Outcomes: Upon completion of this course, students will be able:

1. To practice standard synthesis procedure for synthesis of some organic compounds.
2. To estimate organic compounds using standard methods.
3. To isolate some pharmaceuticals from a given mixture by distillation.

Syllabus

1. Application of steam distillation in isolation of essential oil (clove) and perfume (rose).
2. Preparation of paracetamol, aspirin, and some dyes and indicators.
3. Preparation of (i) o-iodobenzoic acid from anthranilic acid, furoic acid from furfural, (ii) Thiamine catalyzed benzoin condensation and (iii) benzil from benzoin.
4. Estimation of (i) phenol, aniline, ascorbic acid and glucose by Fehling's method & Bertrand's method.

Suggested Readings:

1. D. J. Pasto, C. R. Johnson and M. J. Miller, Experiments and Techniques in Organic Chemistry, 6th Edition, 1992, Prentice Hall.
2. H. Middleton, Systematic Qualitative Organic Analysis, 2nd Edition, 1982, Rupa Publishing House.
3. A. I. Vogel, Text book of Practical Organic Chemistry, 5th Edition, 1989, ELBS (London).
4. K. L. Williamson, Macro-scale and Micro-scale Organic Experiments, 2nd Edition, 1994, D. C. Heath & Co.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-19	BH4106	PHYSICAL CHEMISTRY-IV	4	0	0	4

Course Outcomes: The students will be able to

1. Utilize basics of classical thermodynamics to explain real systems.
2. Employ phase rule to explain processes of industrial importance.
3. Acquired knowledge on statistical mechanics and their application in chemistry.
4. Describe kinetics of complex reactions.

Unit- I

Classical Thermodynamics: Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient. Standard States for Gases, Liquids and Solids and its Applications. Free Energies, Enthalpies and Entropies of Ions in Solutions. Debye Hückel theory of activity coefficient. Activity, fugacity and mean Activity coefficients of Electrolytes and their Determinations, Debye-Hückel Limiting Law. Thermodynamics of Mixing–Mixtures of Volatile Liquids– ideal and Real Solutions and -Excess Functions.

Unit-II

Equilibrium Thermodynamics: Thermodynamic Derivations of Gibbs equation Phase Rule, Applications to two component (eutectic) & three component systems involving solids and liquids (Acetic Acid – Chloroform - Water, NaCl-Na_2SO_4-H_2O, NH_4NO_3-$(NH_4)_2SO_4$-H_2O.

Non Equilibrium Thermodynamics: Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the properties of and forces, non-equilibrium stationary states, phenomenological equations.

Unit- III

Statistical Thermodynamics: Distribution Laws: Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac model, Most probable configuration and concept of entropy. Principle of equipartition of energy, partition functions: Molecular partition functions-translational, rotational, vibrational and electronic partition functions. Derivation of thermodynamic functions (energy, enthalpy, entropy and free energy) for ideal monoatomic and diatomic gases.

Unit-IV

Chemical Kinetics: Complex reactions: opposing, parallel and consecutive reactions. Chain reactions (linear), branching chains–explosion limits; Rice Herzfeld scheme for photochemical reactions. Theories of reaction rates: Collision theory, Transition state theory (both thermodynamic and statistical mechanics formulations). Theory of unimolecular reactions, Lindemann mechanism, Hinshelwood treatment.

Solution Kinetics: Factors affecting reaction rates in solution, effect of solvent and ionic strength (primary salt effect) on the rate constant, secondary salt effect, isotope effect, Kramer's theory. Diffusion limited reactions. Study of fast reactions using stopped flow and relaxation techniques (T-jump and P-jump).

Suggested Readings:

1. D. A. McQuarrie, and J. D. Simon, Molecular Thermodynamics, 1st Edition, 2015, Viva Books.
2. R. S. Berry, S. A. Rice, and J. Ross, Physical Chemistry, 2nd Edition, 2000, Oxford University Press.
3. D. A. McQuarrie, and J. D. Simon, Physical Chemistry: A Molecular Approach, 1st Edition, 2015, Viva Books.
4. R. J. Silbey, R. A. Alberty, and M. G. Bawendi, Physical Chemistry, 4th Edition, 2005, John Wiley & Sons Inc.
5. P.W. Atkins, Physical Chemistry, 8th Edition, 1998, Oxford University Press.
6. A. W. Adamson, Physical Chemistry of Surfaces, 2nd Edition, 2012, Wiley (India) Pvt. Ltd.
7. D. A. McQuarrie, Statistical Mechanics, 2nd Edition, 2000, University Science Books.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-19	**BH4506**	**PHYSICAL CHEMISTRY LABORATORY-IV**	**0**	**0**	**3**	**2**

Course Outcomes: The students will be able to

1. Utilize basics of electrochemistry to explain titrations.
2. Experience operation of spectrophotometers and related data analysis
3. Acquire proficiency in handling various optical instruments

Syllabus

1. pHmetry / conductometric / potentiometric and precipitation titrations.
2. Determination of acid dissociation constant by spectrophotometric technique.
3. Determination of inversion of sucrose using polarimeter.
4. Determination of critical micellar concentration (CMC) of surfactants.
5. Determination of polarizability from refractive index measurements.
6. Determination of composition of a complex by Job's method.
7. Determination of polarity of solvent by dye absorption.

Suggested Readings:

1. D. P. Shoemaker, C. W. Garland, and J. W. Nibber, Experiments in Physical Chemistry, 5th Edition, 1989, McGraw Hill.
2. B. D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, 18th Edition, 2020, R. Chand & Co.
3. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, 2003, McGraw-Hill Education.
4. A. M. Halpern, and G. C. McBane, Experimental Physical Chemistry, 3rd Edition, 2003, W.H. Freeman & Co.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-3	BH4202	BIOCHEMISTRY	3	0	0	3

Course Outcomes: Upon completion of this course students will be able to

1. Understand the structure and function of selected biomolecules.
2. Get the knowledge on working of bioenergetics and metabolism of glucose.
3. Identify the ion-channel and transport phenomena on biosystem.
4. Get comprehensive knowledge on the enzymes, their functions and kinetics.

Unit- I

Introduction to Biomolecules: Structure and Function: Carbohydrates (Monosaccharide, oligosaccharides, polysaccharides (starch, Glycogen, Cellulose); Lipids: Saturated and unsaturated fatty acids, triacylglycerols, phosphoglycerides, sphingolipids, waxes and sterol; amino acids and peptides, proteins - hierarchy of protein architecture, Ramachandran plot; nucleic acids: DNA, RNA, double helix model of DNA, denaturation and renaturation of DNA; replication, transcription and translation of DNA; hormones and vitamins.

Unit- II

Principle of Bioenergetics: Bioenergetics and Thermodynamics; Phosphoryl group transfer and energy currency-ATP; Biological Oxidation and reduction reactions

Metabolic processes: Introduction to metabolism of carbohydrates: Glycolysis, TCA Cycle, Gluconeogenesis.

Unit- III

Transport Mechanism: Introduction to ion-channel, Na^+/K^+ transport (Ion pump); O_2 transport by hemoglobin, CO_2 transport by carbonic anhydrase.

Enzymes: Properties of enzyme, classification of enzymes, mechanism of enzyme action, kinetics of enzyme action, activation energy, enzyme inhibition, coenzyme, apoenzyme and holoenzyme.

Suggested Readings:

1. D. L. Nelson, and M. M. Cox, Lehninger Principles of Bio-Chemistry, 7th Edition, 2017, W. H. Freeman & Co. Ltd.
2. J. M Berg, J. L. Tymoczko, and L. Stryer, Biochemistry, 9th Edition, 2019, W. H. Freeman & Co. Ltd.
3. D. Voet, J. G. Voet, and C.W. Pratt, Fundamentals of Biochemistry, 2nd Edition, 2011, John Wiley & Sons.
4. C. B. Powar, & G. R. Chatwal, Biochemistry, 5th Edition, 2017, Himalaya Publishing House.
5. S. C. Rastogi, Biochemistry, 3rd Edition, 2010, Tata McGraw Hill.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

9th SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-4	BH5201	ORGANIC SPECTROSCOPY	3	0	0	3

Course Outcomes: Upon completion of this course students will be able to

- To gain knowledge on principles of various spectroscopic techniques and mass spectrometry.
- To envisage the spectral data for various organic and inorganic compounds based on these principles.
- To deduce the structure of organic and inorganic compounds based on various spectral data.

Unit-I

Introduction to spectroscopic techniques for structure elucidation. Electromagnetic radiation, absorption of energy by organic compounds, types of spectroscopic methods for structural elucidation of organic and inorganic molecules.

IR – Spectroscopy: Basic principles, characteristic frequencies of common functional groups.

UV-Visible Spectroscopy: Basic principles. Born-Oppenheimer approximation, Frank Condon principle, laws of photochemical equivalence. Application of UV – Visible spectroscopy to organic structure elucidation, Woodward – Fisher rules.

Unit-II

Nuclear Magnetic Resonance (NMR) Spectroscopy: JJ coupling, vicinal and germinal coupling and, Applications of ^{1}H and ^{13}C NMR spectroscopy in the structural determination of organic compounds. One-dimensional NMR of common heteroatoms present in organic compounds (N, F and P).

Unit-III

Mass spectrometry: Basic principles of mass spectrometry, fragmentation and rearrangements (including McLafferty rearrangement) of organic molecules, basics of high resolution mass spectrometry, ionization potential and isotopic distribution, experimental setup, application of mass spectrometry to organic and inorganic compounds in structural determination.

Unit-IV

Problem solving exercises involving UV, IR, NMR & MS data: Problems involving interpretation of spectral details of organic compounds.

Essential Readings:

1. E. A. O. Ebsworth, Structural Methods in Inorganic Chemistry, 2nd Edition, 1991, Blackwell Scientific Publications.
2. R. S. Drago, Physical Methods in Chemistry, 2nd Edition, 1992, Saunders Co.
3. R. M. Silverstein, and F. X. Webster, Spectrometric Identification of Organic Compounds, 6th Edition, 1997, John Wiley & Sons. Inc.
4. W. Kemp, Organic Spectroscopy, 3rd Edition, 1994, MacMillan.
5. L. Pavia, and V. Kriz, Introduction to Spectroscopy, 3rd Edition, 2000, Cengage Learning.
6. D. H. Williams, and I. Fleming, Spectroscopic Methods in Organic Chemistry, 6th Edition, 2014, Tata McGraw Hill.
7. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th Edition, 2006, New Age International Publishers.
8. J. A. Weil, J. R. Bolton, and J. E. Wertz, Electron Paramagnetic Resonance: Elementary Theory and Practical Applications, 1st Edition, 1994, Wiley Interscience.
9. H. Friebolin, Basic One and Two Dimensional NMR Spectroscopy, 1st Edition, 1991, Wiley-VCH.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-20	BH5101	PHYSICAL CHEMISTRY-V	4	0	0	4

Course Outcomes: The students will be able to

1. Apprehend ideas on surface science to explain various processes.
2. Develop theoretical understanding of electrochemistry.
3. Extend concepts of electrochemistry in technologies of commercial importance.
4. Impart basics of photochemistry to various applications (LASER, LED, *etc.*).

Unit-I

Surface Chemistry: (a) Adsorption: Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation). Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electrokinetic phenomenon), catalytic activity at surfaces.

(b) Micelles: Surface active agents, classification of surface-active agents, ionic and non-ionic micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants counter ion binding to micelles, thermodynamics of micellization, phase separation and mass action models, Solubilization, micro emulsion, reverse micelles.

Unit-II

Electrochemistry: Ionics- Non-structural treatment of ion solvent interaction, quantitative measure of ion solvent interactions. The Born model, Electrostatic potential at the surface of a charged sphere. The electrostatics of charging and discharging spheres. The Born expression for the free energy of ion-solvent interactions, the interaction of a single ionic species with the solvents and solvent, limitation of Born theory. Structural treatment of the ion-solvent interactions, structure of water near an ion, Ion dipole model of ion solvent interaction, limitation of ion-dipole theory of solvation, water molecule as electrical quadrupole, ion-quadrupole model of ion-solvent interaction, Ion-induced dipole interactions, primary and secondary solvation, Limitation of ion-quadrupole theory.

Unit-III

Electrodics: Thermodynamics of electrified interface equations. Derivation of electrocapiliarity; Lippmann equations (surface excess), methods of determination, Structure of electrified interfaces. Over potentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot, Interfaces-theory of double layer at semiconductor-electrolyte solution interfaces. Effect of light at semiconductor solution interface. Electrocatalysis-influence of various parameters. Diffusion layer. The limiting current density and its practical application. Corrosion, Battery and Fuel cell.

Unit-IV

Advanced Photochemistry:

Bimolecular Photophysical Processes: Photo-induced electron-transfer and charge transfer processes, excimer and exiplex, fluorescence quenching. Radiative, Forster type and Dexter type energy transfer.

Suggested Readings:

1. P. W. Atkins, and J. D. Paulo, Physical Chemistry,10th Edition, 2014, Oxford University Press.
2. T. Engel and P. Reid, Physical Chemistry, 1st Edition, 2006, Pearson Education.
3. A.W. Adamson and A.P. Gast, Physical Chemistry of the Surfaces, 6th Edition, 1997, John Wiley & Sons.
4. D.K. Chakraborty, Adsorption and Catalysis, 1st Edition, 1992, Narosa (India) Pvt. Ltd.
5. K. Holmberg, B. Jonsson, B. Kronberg and B. Lindman, Surfactants and Polymers in aqueous solution, 1st Edition, 2002, John Wiley & Sons.
6. J. Rajaraman and J. Kuriacose, Kinetics and Mechanism of Chemical Transformations, 3rd Edition, 2010, McMillan.
7. J.O.M. Bockris, and A. K. N. Reddy, Modern Electrochemistry Vol. I and II, 3rd Edition, 1997, Plenum Press.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC Lab-20	BH5501	PHYSICAL CHEMISTRY LABORATORY-V	0	0	3	2

Course outcomes: The students will be able to

1. Develop expertise for performing experiments to determine the physical properties/parameters of surfactants, solvents, acids etc.
2. Learn experimental techniques to validate photochemical laws.
3. Study thermo gravimetric analysis and fast reactions.

Syllabus

1. Determination of CMC of surfactants by different methods.
2. Adsorption isotherm studies.
3. pKa determination of tribasic acid by pH titration method
4. Iodination of acetone by spectrophotometric method
5. Fluorometry studies of naphthalene/anthracene.
6. Study of fast reactions by Stopped flow Spectrophotometry (reaction of Fe(III)thiocyanate and ascorbic acid).
7. Thermogravimetric analysis of calcium oxalate and copper sulphate.
8. Determination of surface tension by tensiometer.
9. Cyclicvoltametric study of Ferri-Ferrocyanide system

Suggested Readings:

1. D. P. Shoemaker, C. W. Garland, and J. W. Nibber, Experiments in Physical Chemistry, 5th Edition, 1989, McGraw Hill.
2. B. D. Khosla, V. C. Garg, and A. Gulati, Senior Practical Physical Chemistry, 18th Edition, 2020, R. Chand & Co.
3. C. W. Garland, J. W. Nibler, and D. P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, 2003, McGraw-Hill Education.
4. A. M. Halpern, and G. C. McBane, Experimental Physical Chemistry, 3rd Edition, 2003, W.H. Freeman & Co.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-5	BH5203	ELECTIVE-I (SPECTRAL TECHNIQUES IN INORGANIC CHEMISTRY)	3	0	0	3

Course Outcomes: Upon completion of this course students will be able to

1. learn about the applications of various spectroscopic techniques.
2. gain fundamental understanding on the principle of operation and interpretation of spectra of inorganic compounds for their structural characterization.
3. describe the electronic spectra of metal complexes for prediction of their properties.
4. understand Mössbauer spectrum, chemical shift, determine oxidation state, electric quadrupole interaction, determines the chemical structure and bonding, hyperfine interactions.

Unit-I

Vibrational spectroscopy: Vibrational spectra and symmetry, selection rules, symmetry of an entire set of normal vibrations, F and G matrix. Raman spectra and selection rules, polarized and depolarized Raman lines, resonance Raman spectroscopy, use of symmetry to determine the number of active infrared and Raman lines, Non-resonance overtones and difference bands. Application of Raman and Infrared selection rules to the determination of inorganic structures, bond strength frequency shift relations, changes in spectra of donor molecules on coordination, change in symmetry on coordination.

Unit-II

Electronic spectroscopy: *N*ephelauxetic effect, effect of σ and π bonding on the energy of t_{2g} orbitals and *Dq*, spectrochemical series, effect of distortion on the *d* orbital energy level (T_d, D_{2d}, D_{4h}), *cis*- and *trans*- isomers and bonding parameters from spectra of tetragonal complexes, bonding parameters, calculation of *Dq*, *Ds* and *Dt* for tetragonal complexes, intervalence electronic transition, structural evidence from electronic spectra.

Mossbauer spectroscopy: Basic principles, spectral line shape and natural line width, characteristics of Mossbauer nuclides, Doppler's effect, parameters to evaluate Mossbauer spectra: chemical shift or isomer shift and its interpretation, quadruple interaction, Magnetic field interaction. Application of Mossbauer spectra to Fe and Sn system with respect to oxidation states, Recoil energy, Partial quadrupole splitting and geometry of the complexes.

Unit-III

Nuclear Magnetic Resonance (NMR) spectroscopy: Effect of fast chemical reactions, coupling to quadrupole nuclei, NMR of paramagnetic substances in solution, nuclear and electron relaxation time, the expectation value of <Sz>, contact shift, pseudo contact shift, factoring contact and pseudo contact shift for transition metal ions. Contact shift and spin density, π delocalization, simplified M.O. diagram for Co(II) and Ni(II). Application to planar tetrahedral equilibrium, Contrast agents.

Nuclear Quadrupolar Resonance (NQR) Spectroscopy: Quadrupolar moment, energy bands of a Quadrupolar nuclease and effect of asymmetry parameters and energy lends. Effect of an external magnetic field, selected examples for elucidation of structural aspects of inorganic compounds using NQR spectroscopy.

Suggested Readings:

1. S. F. A. Kettle, Physical Inorganic Chemistry: A Coordination Chemistry Approach, 1st Edition, 1996, Springer.
2. R.S. Drago, Physical Methods for Chemists, 2nd Edition, 2016, East West Press Pvt. Ltd.
3. F. E. Mabbs, and D. J. Machin, Magnetism and Transition Metal Complexes. 2nd Edition, 2008, Dover Publications.
4. E. A. O. Ebsworth, Structural Methods in Inorganic Chemistry, 2nd Edition, 1991, Blackwell Scientific Publications.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-6	BH5205	ELECTIVE-II (CHEMISTRY OF MATERIALS)	3	0	0	3

Course Outcomes: After completion of course, the students will be able to

1. Learn the basic properties of materials & nanomaterials, role of size and shape in nanomaterials.
2. Acquire concepts on the dramatic changes in properties that occur by reducing the size and shape of materials.
3. To impart knowledge on how to perform the synthesis of such small sizes and shapes of materials.
4. Student will learn about the several characterization techniques for the elucidation of molecular structure and their composition.

Unit-I

Introduction: Properties of materials & nanomaterials, role of size and shape in nanomaterials. **Electronic Properties:** Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, Resistivity.

Magnetic Properties: Superparamagnetism, blocking. Important properties in relation to nano magnetism. **Optical Properties:** Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence. Thermal and Mechanical Properties.

Unit-II

Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Post synthetic size-selective processing, Sol-gel route, Micelles and microemulsions.

Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticles synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.

Unit-III

Characterization Techniques: X-ray diffraction, Scanning Probe Microscopy, SEM, TEM, Optical microscope, UV-Vis spectrophotometers, IR Spectrophotometers and their description, operational principle and application for analysis of nanomaterials.

Suggested Readings:

1. C. Dupas, P. Houdy, and M. Lahmani, Nanoscience: Nanotechnology and Nanophysics, 1st Edition, 2004, Springer.
2. K. J. Klabunde, Nanoscale Materials in Chemistry, 1st Edition, 2001, Wiley Interscience.
3. S. K. Kulkarni, Nanotechnology: Principles and Practices, 1st Edition, 2007, Capitol Publishing Company.
4. M. Wilson, K. Kannangara, G. Smith, M. Simmons, and B. Raguse, Nanotechnology: Basic Science and Emerging Technologies, 1st Edition, 2005, Overseas Press.
5. C. P. Poole Jr., and F. J. Ovens, Introduction to Nanotechnology, 2nd Edition, 2003, Wiley Interscience.
6. A. S. Edelstein, and R.C. Cammarata, Nanomaterials: Synthesis, Properties and Applications, 1st Edition, 1996, Institute of Physics Publishing.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-5	BH5203	ELECTIVE-I (ADVANCED CHEMICAL KINETICS)	3	0	0	3

Course Outcomes: The students will be able to

1. Utilize concepts of thermodynamics to explain phenomenological behavior of complex reactions.
2. Attain ideas of kinetics of biomolecules and its significance.
3. Develop essentials of sophisticated instruments for kinetics measurement.

Unit-I

Statistical theories of kinetics: Attractive and repulsive forces, potential energy surfaces. Lindemann's theory of unimolecular reactions- energy transfer, fall-off region and its limitations. Rice-Ramsperger and Kassel (RRK) model, and Marcus refinement of RRK model (RRKM) for the calculation of rate constants of simple unimolecular (isomerization) reactions.
Complex reactions: Chain reactions and oscillatory reactions, photochemical reactions, Homogeneous catalysis.

Unit-II

Enzyme kinetics*:* Michaelis-Menten mechanism - single and double intermediates. King-Altman method for working out the kinetics of complex enzyme reactions. Enzyme inhibition- reversibility and products inhibition. Computer simulation in chemical kinetics.

Unit-III

Reaction Dynamics: Molecular beams, principle of crossed-molecular beams. Molecular encounters and principal parameters, *e.g*. Impact parameter, Collision cross-section, Reaction cross-section and relation between reaction cross-section and reaction rate (single velocity). Dependence of collisional cross-section on translational energy. Probing the transition state, Dynamics of barrier less chemical kinetics in solution, dynamics of unimolecular reactions.

Suggested Readings:

1. M. J. Pilling, and P.W. Seakins, Reaction Kinetics, 1st Edition, 1997, Oxford University Press.
2. K. J. Laidler, Chemical Kinetics, 3rd Edition, 1997, Pearson Education.
3. P. L. Houston, Chemical Kinetics and Reaction Dynamics, 1st Edition, 2006, Dover Publication.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-6	BH5205	ELECTIVE-II (BIOPHYSICAL CHEMISTRY)	3	0	0	3

Course Outcomes: The students will be able to
1. Implement basics of thermodynamics to understand biological systems.
2. Gain available techniques and methodology for separation of different biomolecules.
3. Acquire knowledge on various tools for determination of macromolecules.

Unit-I

Physical basis of biological systems: Properties of water; Thermodynamic principles in biological systems; Properties and classification of amino acids; polypeptide chain geometries and internal rotational angles; Ramachandran plots; Structures of nucleic acids. Protein structure and function. Properties of nucleosides and nucleotides; composition of nucleic acids.

Unit-II

Separation techniques of Biomolecules: General principles, including Chromatography; Sedimentation, Moving Boundary Sedimentation, Zonal Sedimentation, Electrophoresis, Isoelectric focusing, Capillary electrophoresis, MALDI-TOF.

Unit-III

Structural Determination of Biomolecules:
Physical methods*:* Ultracentrifugation and other hydrodynamic techniques; Light scattering, fundamental concepts, scattering from a number of small particles: Rayleigh scattering, scattering from particles that are not small compared to the wavelength of radiation; Dynamic light scattering; Low angle X-Ray scattering; Neutron scattering; Raman scattering

Optical methods: Optical techniques in biological systems: Absorption spectroscopy, Fluorescence spectroscopy, Linear and Circular Dichroism, Single and multidimensional NMR spectroscopy. Single molecule spectroscopy of biomolecules.

Suggested Readings:

1. A. Cooper, Biophysical Chemistry, 2nd Edition, 2015, RSC.
2. D. L. Nelson, and M. M. Cox, Lehninger Principles of Bio-Chemistry, 7th Edition, 2017, W. H. Freeman & Co. Ltd.
3. J. M Berg, J. L. Tymoczko, and L. Stryer, Biochemistry, 9th Edition, 2019, W. H. Freeman & Co. Ltd.
4. D. Voet, J. G. Voet, and C.W. Pratt, Fundamentals of Biochemistry, 2nd Edition, 2011, John Wiley & Sons.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-5	BH5203	ELECTIVE-I (NATURAL PRODUCT CHEMISTRY)	3	0	0	3

Course Outcomes: Upon completion of this course students will be able

1. To acquire knowledge on classification and importance of various natural products.
2. To understand the isolation and structure elucidation of natural products
3. To gain a broad spectrum about total synthesis and characterization of various natural products

Unit-I

Terpenes and steroids: Classification and biosynthesis of mono- sesqui-, di- and tri-terpenoids and steroids. Acetyl CoA, Mevalonic acid, Acetoacetyl- CoA, squalene to lanosterol, lanosterol to Cholesterol, Cholesterol to estradiol and progesterone, diosgenin and its utility in hormone synthesis. General chemistry of the following compounds- Cholesterol, Artemisinin, Gibbereline A3, Azadirachtin.

Unit-II

Alkaloids*:* Isolation and structure elucidation of alkaloids, Biosynthesis of alkaloids using thiokinase, mixed function oxygenase, methyl transferase, amino acid decarboxylases. Total synthesis of morphine, reserpine and ergotamine.

Unit-III

Polyphenols: Biosynthesis of flavonoids and related polyphenols. Synthesis of apigenin, luteolin, quercetin, Daidzein, myrtucommulone A, prenylflavone, naringenin and bioflavanoids.

Suggested Readings:

1. I. L. Finar, Organic Chemistry Vol. 2: Stereochemistry and the Chemistry of Natural Products, 5th Edition, 2002, Pearson Education.
2. A. Puszati, Plant Lectins (Chemistry and Pharmacology of Natural Products), 1st Edition, 2008, Cambridge University Press.
3. N. R. Krisnaswamy, Chemistry of Natural Products: A Laboratory Handbook, 2nd Edition, 2012, Universities Press.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-6	BH5205	ELECTIVE-II (PHARMAEUTICAL CHEMISTRY)	3	0	0	3

Course/Learning Outcome: The students will acquire knowledge of
1. Drug designing and development, their SAR and QSAR.
2. Mode of action of different drugs.
3. Role of drugs to inhibit the particular enzymes and treatment of disease.
4. Drug delivery and pharmaceutical technologies development.

Unit-I

Drug Delivery: Importance of Targeted Drug Delivery, Efficacy, Safety and Toxicity Issues. Molecular basis of targeted drug delivery. Drug Release and Uptake Phenomenon.

Drug Encapsulation: Characterization, generation, efficacy, toxicity and release profile of nanomaterials (metal-based, metal oxide based and polymeric) in drug encapsulation and drug delivery. Factors affecting drug loading and drug release. Techniques to measure degree of loading and release efficiency. Metabolism and excretion of drug delivery carriers.

Unit-II

Drug Delivery Systems: Methods of preparations, characterization and applications of liposomes, ionosomers, erythrocytes, nanoparticulate systems, solid-liquid nanoparticles, dendrimers, organogels, multiple emulsions and nanoemulsions. Overview and application of aquasomes, pharmacosomes, liquid crystalline systems, protein and peptide-based drug delivery systems.

Unit-III

Polymers in drug encapsulation and drug delivery: Classification, synthesis and applications of biodegradable and natural polymers in formulation of controlled drug delivery systems.

Suggested Readings:

1. E. Mathiowitz, Encyclopaedia of Controlled Drug Delivery, 1st Edition, 1999, Wiley India Pvt. Ltd.
2. J. R. Robinson and Vincent H. L. Lee, Controlled Drug Delivery: Fundamentals and Applications, 2nd Edition, 1987, CRC Press.
3. W. M. Saltzman, Drug Delivery: Engineering Principles for Drug Therapy, 2nd Edition, 2022, Oxford University Press.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE Lab-2	**BH5503**	**BIOCHEMISTRY LABORATORY**	**0**	**0**	**3**	**2**

Course Outcomes: Upon completion of this course students will be able to

- Estimate proteins, DNA and RNA by spectroscopic techniques.
- Learn separation techniques for separating different biomolecules.
- Understand the enzyme activity and enzyme kinetics.

Syllabus

1. Spectroscopic/Colorimetric estimation of protein using Lowry's and Bradford methods.
2. Spectroscopic estimation of DNA using DPA method
3. Spectroscopic estimation of RNA using Orcinol method
4. Estimation of Iodine number and saponification value of fatty acids
5. Separation of amino acids by paper chromatography
6. Separation of sugars by thin layer chromatography
7. Separation of proteins by SDS-PAGE.
8. Assay of Enzyme activity: Protease from bacteria.
9. Assay of enzyme activity: Amylase from plant tissue & saliva.
10. Determination of Km and V_{max} of enzyme catalyzed reaction.

Essential Readings:

1. P. Mu, and D. T. Plummer, Introduction to Practical Biochemistry, 3rd Edition, 2008, Tata McGraw-Hill Education,

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE Lab-3	**BH5505**	**COMPUTATIONAL CHEMISTRY LABORATORY-II**	**0**	**0**	**3**	**2**

Course Outcomes:

- Develop expertise on drawing the structures uniformly using ChemDraw software.
- Project molecular properties based on different quantum mechanical theories using Gaussian9 software.
- Perform molecular modelling studies using Gaussian9 software.

Syllabus

1. Practicing ChemDraw software to draw the structures.
2. Use of Gaussian9 software to predict the energies, bond angle, bond length, spectral properties of some small molecules using different methods and basis sets.

Essential Readings:

1. F. Jensen, Introduction to Computational Chemistry, 2nd Edition, 2007, John Wiley & Sons Ltd.
2. C. J. Cramer, Essentials of Computational Chemistry, 2nd Edition, 2004, Wiley & Sons Ltd.
3. D. C. Young, Computational Chemistry, 1st Edition, 2001, Wiley-Interscience.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
SEMINAR	**BH5701**	**LITERATURE REVIEW AND SEMINAR**	**0**	**0**	**4**	**2**

Course Objectives:

a. To develop the attitude and to build confidence for presenting scientific facts and or theories etc.
b. To get the opportunities to explore own potentials on creative thinking through learning and writing skill.

Course Outcomes:

- Attain proper attitude and confidence for presenting scientific facts and or theories etc.
- Determine own potentials on creative thinking through learning and writing skill.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

10th SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-21	BH5102	INORGANIC CHEMISTRY-VI	4	0	0	4

Course Outcomes: After completion of this course, the students will be able to

1. Distinguish the structure of solids, their classification and the significance of lattice energy.
2. Basic idea about the bonding involved in different types of solids.
3. Define the electronic properties of solids and various types of defects in solids.
4. Characterize the structure of solids by different characterization techniques such as optical and electron microscopy and X-ray diffraction methods.

Unit-I

Chemical crystallography: Introduction, Space lattice, Crystal point groups, space group (working knowledge), packing in solids, Crystal structures of representative systems, Silicates and Zeolites, Spinels, Cements, Glasses, Quasicrystals, Nanostructures.

Bonding in solids and Crystal energetics: Crystal classifications, Madelung constant and Lattice energy.

Unit-II

Electronic properties and Band theory of solids: Metals, insulators and semiconductors, electronic structure of solids- Band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, *p-n* junctions, super conductors (Low temperature superconductor, BCS theory, High temperature superconductor).

Defects, Nonstoichiometry and Diffusion: Perfect and imperfect crystals, intrinsic and extrinsic defects–point defects-vacancies Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centers, non-stoichiometry defects, line defect- edge dislocation and Screw Dislocation and Plane defects- Grain boundaries, Tilt boundaries, Diffusion mechanisms, Fick's law, Kirkendall effect.

Unit-III

Characterization techniques:

Optical Microscopy: Optical microscope - Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarized light, Hot stage, Interference techniques), Stereomicroscopy, Photo microscopy, Colour metallography, Specimen preparation, Applications.

Electron Microscopy: Interaction of electrons with solids, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Transmission Electron Microscopy (STEM), Energy Dispersive Spectroscopy (EDS), Wavelength Dispersive Spectroscopy (WDS).

Unit-IV

X-ray Diffraction Methods: Generation of X-rays, Properties of X-rays: Continuous spectrum, characteristic spectrum, Filters, Bragg condition, Miller indices, Structure factor and its relation to intensity, identification of unit cells from systematic absences in diffraction pattern. Structure factor calculation for NaCl and KCl. Description of the procedure for an X-ray structure analysis, Laue method, Bragg method, Debye-Scherer's method of X-ray structural analysis of crystals, indexing of crystals.

Surface Analysis: Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), X-ray Photoelectron Spectroscopy (XPS).

Essential Readings:

1. S. Zhang, L. Li, and A. Kumar, Materials Characterization Techniques, 2nd Edition, 2009, CRC Press.
2. B.D. Cullity, and R.S. Stock, Elements of X-Ray Diffraction, 3rd Edition, 2001, Prentice-Hall.
3. A. R. West, Solid State Chemistry and Its Applications, 2nd Edition, 2014, John Wiley & Sons.
4. L. Smart, and E. Moore, Solid State Chemistry: An Introduction, 4th Edition, 2012, Chapman & Hall Co.
5. C. N. R. Rao, and J. Gopalkrishanan, New Directions in Solid State Chemistry, 2nd Edition, 2010, Cambridge University Press.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-22	BH5104	BIOINORGANIC AND SUPRAMOLECULAR CHEMISTRY	3	0	0	3

Course Outcomes: After completion of this course, the students will be able to

1. Understand the role of metal ions in living system and depict their storage and transport mechanisms.
2. Describe various types of metalloenzymes and their roles in biological systems.
3. Demonstrate pathways of biological systems like nitrogen fixation and photosynthesis and explain the mechanism of oxygen transport and its storage.
4. Illustrate supramolecular chemistry, molecular recognition and enumerate some selected building blocks referred in supramolecular chemistry.

Unit-I

Metal ions in biological systems and its storage transport and bio-mineralization: Essential and trace elements, siderophores.

Calcium in Biology: Transported regulation, Intracellular Ca^{2+} transport, Ca^{2+}-ATPase, Na^{+}/Ca^{2+} exchange, mitochondrial influx and efflux. Inositol triphosphate, Ca^{2+} regulated intracellular processes: Calmodulin, Troponin C.

Metalloenzymes: Zinc enzymes: Carboxypeptidase and carbonic anhydrase; Iron enzymes: catalase peroxidase and cytochromes, Cytochrome P450 (P450s or CYPs); Copper enzymes: Superoxide dismutase; Molybdenum oxotransferase enzymes: xanthine oxidase. Coenzyme vitamin B_{12}, Sulphur proteins.

Unit-II

Nitrogen fixation: Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenase model systems.

Photosynthesis: Chlorophylls, photo system I and photo system II in cleavage of water.

Transport and storage of dioxygen: Heme proteins and oxygen uptake, structure and function of hemocyanin and hemerythrin, model synthetic complexes of iron, cobalt and copper.

Unit-III

Supramolecular Chemistry: Introduction, meaning of supramolecular chemistry, phenomenon of molecular recognition and their quantification.

Building blocks of supramolecular chemistry: acyclic receptors for neutral and charged guests, macrocycles and crown ethers, macrobicycles and cryptands, macropolycycles, cucurbiturils and cyclodextrins.

Suggested Readings:

1. S.J. Lippard, and J. M. Berg, Principles of Bioinorganic Chemistry, 1st Edition, 1994, University Science Books.
2. I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valenting, Bioinorganic Chemistry, 2nd Edition, 2002, University Science Books.
3. A. K. Das, Bioinorganic Chemistry, 2nd Edition, 2007, Allied Books.
4. J. W. Steed, and J. L. Atwood, Supramolecular Chemistry, 2nd Edition, 2009, Willey India Pvt. Ltd.
5. P. S. Kalsi, and J. P. Kalsi, Bioinorganic and Supramolecular Chemistry, 2nd Edition, 2012, New Age International Publishers.
6. J.M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, 1st Edition, 1995, Wiley-VCH.
7. H. J. Schneider and A. Yatsimirsky, Principles and Methods in Supramolecular Chemistry, 2nd Edition, 2000, John Wiley& Sons Inc.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PC-23	BH5106	ORGANIC CHEMISTRY-VI	3	0	0	3

Course Outcomes: Upon completion of this course students will be able:

1. To understand the molecular origin of pericyclic reactions.
2. To comprehend the mechanism of photochemistry of various organic compounds.
3. To acquire knowledge on spatial arrangement of atom and basic factors influence selectivity in organic synthesis.
4. Synthetic strategies towards carbon-carbon bond forming reactions through enolates.

Unit-I

Pericyclic Reactions and Photochemistry: Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene and allyl system, classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams, FMO and PMO approach. Electrocyclic reactions: Conrotatory and disrotatory motion, 4n, 4n+2 and allyl systems.

Cycloadditions: Antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1, 3- dipolar cycloadditions and cheletropic reactions.

Unit-II

Sigmatropic rearrangements: Suprafacial and antarafacial shifts of H, Sigmatropic shifts involving carbon-carbon moieties, [3, 3] and [5, 5] Sigmatropic rearrangements, Claisen, Cope and Aza-Cope rearrangements, fluxional tautomerism, Ene reaction. Norrish Type-I and Type-II reactions. Paterno-Buchi reaction.

Unit-III

Synthetic Strategies: Umpolung reactivity – formyl and acyl anion equivalents. Selectivity in organic synthesis; chemo-, regio- and stereoselectivity. Concepts of asymmetric synthesis; resolution (including enzymatic), desymmetrization and use of chiral auxiliaries. Carbon-carbon bond forming reactions through enolates (including boron enolates), enamines and silyl enol ether, Michael addition reaction. Stereoselective addition to C=O groups (Cram and Felkin-Ahn models).

Suggested Readings:

1. F. A. Carey and R.J. Sundberg, Advanced Organic Chemistry: Part A & B, 5th Edition, 2007, Springer International.
2. R. O. C. Norman and J.M. Coxon, Principles of Organic Synthesis, 3rd Edition, 2002, CRC Press.
3. J. Clayden, N. Greeves, and S. Warren, Organic Chemistry, 2nd Edition, 2012, Oxford University Press.
4. J. Singh, Photochemistry and Pericyclic Reactions, 3rd Edition, 2012, New Age International, Publishers.
5. I. Fleming, Pericyclic Reactions, 1st Edition, 2002, Oxford Chemistry Primer, Oxford University Press.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-7	BH5202	ELECTIVE-III (NEWER SYNTHETIC REACTIONS AND REAGENTS)	3	0	0	3

Course Outcome: The students will acquire knowledge of
1. Application of modern synthetic reactions and reagents in organic synthesis
2. Nomenclature and reactivity and synthesis of different heterocyclic compounds.
3. Organic reactions involving green Chemistry.

Unit-I

Principles and applications of phase transfer catalysis, crown ethers and polymer- supported reagents in organic synthesis.
Enzymes in Synthesis: Classification of enzymes, advantages and disadvantages, Artificial enzymes, applications in organic synthesis; Principles of ultrasound and microwave assisted organic synthesis. Reactions in ionic liquids.

Unit-II

Five membered rings with two heteroatoms: Pyrazole, imidazole, oxazole, thiazole, isothiazole and benzofused analogs. Benzofused five membered heterocycles with one heteroatom, *e.g.* indole, benzofuran, benzothiophene.

Chemistry of bicyclic compounds containing one or more heteroatoms: benzopyrans, quinoline, isoquinoline, quinoxazalines, acridines, phenoxazines, phenothiazines, benzotriazines, pteridines.
Seven and large membered heterocycles: azepines, oxepines, thiepines. Chemistry of porphyrins and spiro heterocycles.

Unit-III

Green Chemistry: Principles, green solvents, concepts of atom economy, Domino and multi component reactions. Principle and applications to green synthesis of pharmaceuticals and industrial chemicals.
Green methods of synthesis: microwave, sonication, PTC, ball milling with principle, working and instrumentation
Suggested Readings:

1) F. A. Carey and R.J. Sundberg, Advanced Organic Chemistry: Part A & B, 5th Edition, 2007, Springer International.
2) W. Carruthers, Some Modern Methods of Organic Synthesis, 4th Edition, 2004, Cambridge University Press.
3) R. M. Acheson, Introduction to the Chemistry of Heterocyclic Compounds, 1st Edition, 1976, John Wiley & Sons.
4) P. Anastas, and J. C. Warner, Green Chemistry- Theory and Practical,1st Edition, 2005, Oxford University Press.
5) R. A. Sheldon, I. Arends, and U. Hanefeld, Green Chemistry and Catalysis,1st Edition, 2007, Wiley-VCH.

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Syllabus Structure (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-7	BH5202	ELECTIVE-III (NUCLEAR AND RADIOCHEMISTRY)	3	0	0	3

Course Outcomes: Upon completion of this course, the students will be able to

1. Encompass various types of radioactive decay and detectors.
2. Illustrate the fundamental theories of nucleus and different types of nuclear reactions.
3. Explain the principles of functioning of nuclear reactors and processes followed for nuclear waste management.
4. Understand radiation chemistry and describe the wide-spread applications of radioisotopes.

Unit-I

General Aspects of Nuclear Chemistry: Discovery, Types of decay, Decay kinetics; Decay constant, half-life period, mean life, Parent daughter decay, growth relationships, Secular and transient equilibrium, Units of radioactivity, Alpha, beta and gamma decay, Theory of decay, energies and properties; Artificial radioactivity- Detectors, Ionization chamber, electron pulse counters, scintillation detectors, semiconductor, detectors, thermo luminescence detectors and neutron detectors. Bethe notation, Types of nuclear reactions; The compound nucleus theory, Reaction cross section, Transmutation reactions, elastic and inelastic scattering, spallation, fragmentation, stripping and pick-up, fission, fusion, photonuclear reactions, Thermonuclear reactions.

Unit-II

Nuclear Disintegration and Reactors: The fission energy, Reproduction factor, Classification of reactors- Based on Moderators, Coolant, Phase of Fuel and Generation, Principle of Thermal nuclear Reactors: The four factor formula, Reactor power, Critical size of a thermal reactor, Excess reactivity and control, Breeder reactor, Reprocessing of spent fuels, Nuclear waste management, Safety culture; Active and passive safety, containment building, nuclear criticality safety, ionizing radiation protection, enforcement agencies.

Unit-III

Radiation Chemistry: Passage of radiation through matter, Units for measuring radiation absorption, Radiation dosimetry, Radiolysis of water, Free radicals in Water Radiolysis, Chemical dosimetry, Radiolysis of Fricke Dosimeter Solution.

Application of radioisotopes: probing by isotopes, reactions involved in the preparation of radioisotopes, The Szilard-Chalmers Reaction, Radiochemical principles in the use of Tracers, Applications of radioisotopes as tracers, Chemical investigations, analytical applications, agricultural and industrial applications, Neutron Activation Analysis Carbon and Rock Dating, Use of nuclear reactions, Radioisotopes as source of electricity, Nuclear medicines.

Essential Readings:

1. H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition, 1995, New Age International Publishers Ltd.
2. K. H. Lieser, Nuclear and Radiochemistry, 2nd Edition, 2001, Wiley-VCH.
3. G. Choppin, J. O Liljenzin and J. Rydberg, Radiochemistry and Nuclear Chemistry, 3rd Edition, 2002, Butterworth-Heinemann,.
4. W. D. Loveland, and D. J. Morrissey, Modern Nuclear Chemistry,2nd Edition, 2006, Wiley India Pvt. Ltd.

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PE-7	BH5202	ELECTIVE-III ADVANCED ELECTRO CHEMISTRY)	3	0	0	3

Course Outcomes: The students will be able to

1. Attain working fundamentals on of electrode kinetics such as constant potential Chronoamperometry, constant current Chronoamperometry impedance methods *etc*.
2. Implement concepts of electrochemical principles in various applications *i.e.*, energy storage/conversion, electrocatalysis, corrosion, electrodeposition and bioelectrochemistry
3. Conversant with the phenomenon of Bioelectrochemistry.

Unit-I

Experimental Electrochemical Techniques:

Constant Potential Chronoamperometry: Reversible and quasi-reversible charge transfer, Cottrell equation, Influence of uncompensated solution resistance, Application of cyclic voltammetry for characterization of various electrochemical processes.

Constant Current Chronopotentiometry: Reversible and quasi-reversible charge transfer, Sand equation.

Impedance Methods: Reversible and quasi-reversible charge transfer, Warburg equation, Influence of uncompensated solution resistance, Equivalent circuit's models.

Unit-II

Conversion and storage of electrochemical energy: Fuel cells, Supercapacitors and Li- ion batteries.

Electrocatalysis: Influence of various parameters on water splitting, HER and OER.

Corrosion: Introduction to corrosion, forms of corrosion, Corrosion monitoring and prevention methods.

Semiconductor interfaces: Structure of double layer at the semiconductor-solution interface, Effect of light at semiconductor-solution interface. Dye sensitized solar cells.

Electro crystallization: Electro-growth of metals on electrode- Nucleation, Growth, Surface Diffusion, Underpotential deposition, Variety of shapes formed in electrodeposition.

Unit-III

Bioelectrochemistry: Nerve impulses, Membrane potentials, Nernst-Planck equation, Hodgkin-Huxley equations, Core conductor model.

Electrochemical instrumentations and scanning probe techniques.

Suggested Readings:

1. A.J. Bard, and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition, 2002, John Wiley & Sons.
2. K. B. Oldham, J. C. Myland, and A. M. Bond, Electrochemical Science and Technology: Fundamentals, 1st Edition, 2011, Wiley Interscience.
4. J.O.M. Bockris, and A. K. N. Reddy, Modern Electrochemistry Vol. I and II, 3rd Edition, 1997, Plenum Press.

School/ Department: School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Chemistry, Duration: 5 years (Ten Semesters)

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit
			L	T	P	
PROJECT	**BH5602**	**PROJECT**	**3**	**0**	**0**	**3**

Course Outcomes:

- Create interest on R&D activities.
- Get experience in handling of instruments for their practical applications.
- Garner knowledge on scientific advances in a particular field of research.
- Improve upon the technical writing skills on presenting the research outcomes

A student has to carry out an original and innovative research work according to his/her area of interest in applied chemistry under the guidance of faculty member of OUTR and or in collaboration with expert(s) from other institutes. He/she has to submit a report of the findings and present the outcome of the research work.