DEPARTMENT OF CHEMISTRY

Unique Features of the Syllabi

B.Sc. Chemistry

Introduced the Computer Programming Course to improve the chemistry graduates to acquire programming skills so as to combat with information world requirement of recruiters.

M.Sc. Chemistry

The new elective course on Computational Chemistry Course was included in the current curriculum, which will help the post graduate students of Chemistry in utilizing the advantage of Computational Chemistry in the research field.

Certificate Courses

Our contribution for the national human resource development as higher educational institute, a new skill development certificate programme of six months duration on "Aromatherapy and Cosmetics" will be offered from the next academic year 2022-2023. The aim of this programme is to empower the economically and socially challenged women of our region. This also helps the students to understand the basic concepts of aromatherapy and cosmetics. Aromatic art of blending essential oil and their chemistry helps to solve both physical and psychological issues and to become a successful entrepreneur. This programme comprises of learning theoretical background of aromatherapy and to acquire practical skills developed during preparative lab for training the students on how to prepare cosmetic products. This helps students to become successful entrepreneur on cosmetic and aromatherapy products.

DEPARTMENT OF CHEMISTRY

Vision

Imbibing the service attitude and to transform the graduates through learning experience for achieving excellence in research and to create the transformative impact on women through sustained global innovation and entrepreneurship.

Mission

- Offering innovative research projects for budding chemists
- To produce quality entrepreneurs to meet the global challenges

Programme Educational Objectives (PEO)

PEO1: To create and strengthen women leaders through disciplinary knowledge, professional skills and ethical sensitivity

PEO2: To transform students as successful entrepreneurs to face the modern challenges

PEO3: To nurture the students to invent, innovate and create solutions for current moral, ecological and economic issues

Programme Outcome (PO)

M.Sc.

PO1: **Disciplinary Knowledge:** Acquiring knowledge of different dimensions in the related areas of study and identifying the assumptions that frame thinking and actions

PO2: **Effective Communication:** Ability to share thoughts, ideas, and applied skills of communication in its various perspectives

PO3: **Research Skill and Critical Thinking:** Ability to plan, execute and report the results of an experiment and to draw conclusions from the evidence and the capability to apply analytical thought by following a scientific approach to knowledge development

PO4: **Moral Ethical Awareness/Reasoning:** Ability to embrace moral/ethical values in conducting one's life, about an ethical issue from multiple perspectives, and use ethical practices in all works and appreciating environmental and sustainability issues and adopting unbiased and truthful actions in all aspects of work

PO5: **Information/Digital Literacy:** Capability to use ICT in case of need and the ability to access, evaluate and use the relevant information

PO6: **Problem solving**: Ability to apply their competence to solve non-familiar everyday problems in real-life situations

PO7: **Self–directed and Lifelong Learning:** Acquire the ability to engage in independent and lifelong learning through self-paced and self-directed learning to meet out the change in life

CHEMISTRY

(Two years Regular Programme)

(For Students Admitted from 2022-23)

Programme Specific Objectives:

PSO1: The student will acquire knowledge on Physical, Inorganic, Organic, Analytical, Computational and Industrial Chemistry

PSO2: Apply appropriate techniques for the qualitative and quantitative analysis of chemicals in laboratories

PSO3: Relate the knowledge acquired about chemical reactions and their mechanisms to design novel eco-friendly and sustainable synthetic pathways

PSO4: Deduce the chemical structures using data set obtained with the help of spectroscopic techniques

PSO5: Students will gain knowledge and practical skills to work in research projects at different industries and research/academic institutions

PSO6: Consolidate and deliver chemistry related knowledge through effective written, graphical/virtual communications and interact effectively with people from various backgrounds

PSO7: Students will achieve in noble profession of teaching and helping in nation building through innovative research and entrepreneurship

PREAMBLE

Introduced a new elective course on Computational Chemistry in the 1st Semester.

Programme Structure
Program Code : PCH

Sem.	Subject Code	Course	Subject Title	Hrs. / wk.	Credit	CIA	ESE	Total
I	HMCHC11	Core-I	Organic Chemistry-I	6	5	40	60	100
	HMCHC12	Core-II	Inorganic Chemistry-I	6	5	40	60	100
	HMCHC13	Core-III	Physical Chemistry-I	6	5	40	60	100
	HMCHC14P	Core -IV	Organic Chemistry practicals	6	5	40	60	100
	HMCHE1A/ HMCHE1B/ HMCHE1C	DSE -I	a. Instrumental Methods of Analysis -# internship (or) b. Green and Environmental Chemistry (or) c. Computational Chemistry	6	5	40	60	100
	HMCHX1/ HMCHX1O	Extra Credit-I	Forensic Chemistry / online Course*	-	2	-	100	100
			Total	**30**	**25+2**	**200**	**300 + 100**	**500 + 100**
II	HMCHC21	Core-V	Organic Chemistry-II	6	5	40	60	100
	HMCHC22	Core-VI	Inorganic Chemistry-II • Integrated with online course	6	5	40	60	100
	HMCHC23	Core-VII	Physical Chemistry-II	6	5	40	60	100
	HMCHC24P	Core-VIII	Inorganic Chemistry practicals	6	5	40	60	100
	HMCHE2A/ HMCHE2B	DSE-II	a. Applied Electrochemistry (or) b. Polymer Chemistry	6	5	40	60	100
	HMCHX2/ HMCHX2O	Extra Credit-II	Applied Chemistry/ online Course*	-	2	-	100	100
			Total	**30**	**25+2**	**200**	**300 + 100**	**500 + 100**
III	HMCHC31	Core -XI	Organic Chemistry-III	6	5	40	60	100
	HMCHC32	Core -XII	Inorganic Chemistry-III • Integrated with online course	6	5	40	60	100
	HMCHC33	Core -XIII	Physical Chemistry-III	6	5	40	60	100
	HMCHC34P	Core –XIV	Physical Chemistry practical	6	5	40	60	100
	HMCHE3A/ HMCHE3B	DSE -III	a. Nanoscience and Nanotechnology (or)	6	5	40	60	100

			b. Material Chemistry - # internship					
	HMCHX3/ HMCHX3O	Extra Credit-III	Employability Skills/online Course*	-	2	100	-	100
			Total	**30**	**25+2**	**200 + 100**	**300**	**500 + 100**
IV	HMCHC41PW	Core -XIII	Project	30	15	100	100	200
	HMCHX4/ HMCHX4O	Extra credit-IV	Agricultural Chemistry/ online Course*	-	2	-	100	100
			Total	**30**	**15+2**	**100**	**100 + 100**	**200 + 100**
			Grand Total	**120**	**90 + 8**	**700**	**1000 + 400**	**1700 + 400**

DSE - Discipline Specific Elective; *For online certification credit alone will be assigned on submission of certificate obtained through appearing for online examination from Spoken Tutorial, EDX, SWAYAM, NPTEL or Coursera. #- CIA internship program will be arranged for the student with Aquagri/CECRI/MKU/NITT

Core I – Organic Chemistry-I

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 6**
Subject Code: HMCHC11 **Credit: 5**

Course Objectives:

1. To enable the students to learn the principles of reaction mechanism and modern reagents used in various reactions
2. To acquire basic knowledge on bonding in the aliphatic / aromatic compounds and various classes of organic reactions

Unit I **(18 hours)**

Nature of Bonding in Organic Molecules: Delocalized chemical bonding-Conjugation, Cross conjugation, Resonance, Hyper Conjugation, Tautomerism, Aromaticity, Alternant and non-alternant hydrocarbons, Huckel's rule, Craig's rule, Energy level of π-molecular orbitals, Annulenes, Anti-aromaticity, Homo-aromaticity, Bonds weaker than covalent, addition compounds, non-covalent bonding and inclusion complexes.

Unit II **(18 hours)**

Aliphatic and Aromatic Nucleophilic Substitution Reactions: Bonding-Structure and reactivity of acids and bases (hard and soft acid base theory), methods of determination and the study of reaction mechanisms, S_N1, S_N2, S_Ni and neighbouring group participation, hydrolysis of esters-Wurtz reaction, Claisen and Dieckmann condensation, Williamson reactions, different mechanisms of aromatic nucleophilic substitution-Chichibabin reaction, Cine substitution, Diazonium group as leaving group-Benzyne mechanism.

Unit III **(18 hours)**

Aliphatic and Aromatic Electrophilic Substitution Reactions: S_E1 and S_E2 reactions-mechanisms and reactivity, typical reactions involving migration of double bond-Keto-enol tautomerism, Halogenation of carbonyl compounds, Stork enamine reactions, aromatic electrophilic substitution (Ortho and Para ratio)-reactivity, orientation and mechanisms-Nitration, Halogenation and Sulphonation, Friedel Crafts alkylation and arylation (Scholl reaction) Formylation with (i) Disubstituted formamides (Vilsmeyer- Haack reaction) (ii) Gatterman reaction (iii) Chloroform (Reimer - Tiemann reaction).

Unit IV **(18 hours)**

Addition and Elimination Reactions: Addition to C-C and C-O multiple bonds-Electrophilic, Nucleophilic and Free-radical additions, additions to conjugated systems Orientation, Birch reduction, Michael addition, 1,3 dipolar additions, carbene addition to double bonds-Mannich reaction, Meerwein-Pondorf reduction, Grignard reactions, Aldol, Stobbe, Wittig, Cannizarro reaction.

Elimination reactions-E1 and E2 Mechanisms, Orientations, Hofmann and Saytzeff's rules, elimination versus substitution-Chaugav reaction, Bredt's rule, dehydration of alcohols, dehydrohalogenation-mechanisms and orientation in pyrolytic elimination.

Unit V **(18 hours)**

Oxidation and Reduction: Formation of C=C, C-C bonds by dehydrogenation, allylic oxidation, oxidation of alcohols, glycols, halides and amines to aldehydes and ketones, ozonolysis, oxidation of olefinic double bonds and unsaturated carbonyl compounds, Sommelet reaction and selectivity in reduction, metal hydride

reduction, metal alkoxide reduction, reduction by dissolving metals, reduction of nitro compounds and carbenes and nitrenes - structure and generation, addition reaction with alkenes and insertion reactions.

Course Outcomes:

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

CO1: Relate the electronic structure of organic compounds to infer on chemical reactivity

CO2: Choose the reaction pathways for S_N1, S_N2 and S_Ni

CO3: Categorize organic reagents based on type of reaction

CO4: Evaluate the products based on competing reactions

CO5: Design the novel organic compounds using oxidation and reduction reactions

Text Book:

1. J. March and M. B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, Wiley, New York, 8th Edition, 2020.

Reference Books:

1. J. Clayden, N. Greeves, *Organic Chemistry*, Oxford University Press, UK, 2nd Edition, 2014.
2. Raj K Bansal, *Organic Reaction Mechanisms*, New age International Private Ltd-Publishers, 4th Edition, 2012.

Journals:

1. Royal Society of Chemistry
2. ACS Organic and Inorganic Journal
3. The Journal of Organic Chemistry

E- Resources:

1. http://maharajacollege.ac.in/material/nature_of_bonding_in_organic_molecules_converted.pdf
2. https://www.scribd.com/doc/25382780/Aliphatic-Nucleophilic-Substitution-Reactions
3. https://www.organic-chemistry.org/namedreactions/
4. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%209.pdf
5. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%207.pdf

Course Outcomes	**Programme Outcomes**							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	3	3	3	3	**27**
CO2	9	3	9	3	9	3	3	**39**
CO3	9	9	3	3	9	3	3	**39**
CO4	9	3	9	1	9	9	9	**49**
CO5	9	3	9	1	9	9	9	**49**
Total	**45**	**21**	**33**	**12**	**39**	**27**	**27**	**203**

Low-1 **Medium-3** **High-9**

Core II – Inorganic Chemistry-I

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 6**
Subject Code: HMCHC12 **Credit: 5**

Course Objectives:

1. To acquire basic knowledge about the radiations, solid state materials, acid- base systems and non-aqueous solvents
2. To get an insight on the use of several inorganic rings, cages and clusters

Unit I **(18 hours)**

Acid-Base Systems and Non-aqueous Solvents: Concepts of acids and bases-Bronsted-Lowry, Lewis, Lux-Flood concepts, steric effects and solvation effects, measures of acid-base strength, factors affecting the strength of acids and bases, common ion effect and Henderson's equation, hard and soft acids and bases-symbiosis, theoretical basis of hardness and softness.

Classification of solvents: Properties of ionizing solvents, typical reactions in non-aqueous solvents-liquid HF, hydrogen cyanide, sulphuric acid and acetic acid.

Unit II **(18 hours)**

Nuclear Chemistry: Different types of nuclear reaction, nuclear fission and fusion, theories of fission-fissile and fertile isotopes characteristics of nuclear fission and fusion, chemical effects of nuclear transformations, positron annihilation and autoradiography, synthesis of transuranic elements such as neptunium, plutonium, curium, berkelium, einsteinium, mendelevium, nobelium, lawrencium.

Nuclear forces: Liquid drop model and shell model, nuclear reactors-classification of nuclear reactors, breeder reactor, applications of radioactive isotopes in chemical investigations, age determination, medicinal and agricultural field.

Unit III **(18 hours)**

Radiation Chemistry : Interaction of radiation with matter-range of alpha, beta and gamma radiations, neutron through matter, analytical applications of radioisotopes-Radiometric titrations, kinetics of exchange reactions, measurement of physical constants including diffusion constants, Radioanalysis-neutron activation analysis, prompt gama neutron activation analysis and Neutron absorptiometry, applications of radioisotopes-industry, medicine, autoradiography, radiopharmacology, radiation safety precaution, nuclear waste disposal, radiation chemistry of water and aqueous solutions.

Unit IV **(18 hours)**

Inorganic Rings, Cages and Metal Clusters: Inorganic Rings-P-N compounds, cyclophosphazanes and cyclophosphazenes, S-N compounds-S_2N_2, S_4N_4, $(SN)_x$, polythiazyl S_xN_4 compounds, S-P compounds-molecular sulphides such as P_4S_3, P_4S_7, P_4S_9 and P_4S_{10}.

Cages-Borane and carboranes-nomenclature, synthesis, properties, structure and bonding in diborane and tetraborane, Wades rule, Styx numbers, synthesis, properties and structure of ferrocene. Metal clusters - Polyacids - classification of polyacids, synthesis, structure and bonding in polyanions and isopolyanions of phosphorous, molybdenum and tungsten.

Unit V **(18 hours)**

Solid State Chemistry: Defects in solids-point, line and plane defects, stoichiometry and non- stoichiometry defects and effects of defects on physical properties, band theory and free electron theory, metals and

insulators, semiconductors-types of semi-conductors, semiconductors in solar energy conversion, hoping semiconductors rectifiers and transistors, bonding in metals, electronic specific heat, hall effect, electrical and thermal conductivity of metals, superconductors, Illustrative examples of ionic, covalent and hydrogen bonded solids-Perovskite, Iilmenite and Rutile, Spinel and Inverse Spinel.

Course Outcomes:

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

CO1: Define the basic concepts of nuclear chemistry and classify the nuclear reactions
CO2: Apply the basics of metallic clusters, inorganic rings and cages
CO3: Assume the principles of radioactivity and relate to chemistry
CO4: Compare the acid-base concepts and classify the solvents
CO5: Construct the basic concepts of solid-state chemist

Text Book:

1. Weller, Overton, Rourke, Armstrong, *Inorganic Chemistry*, Oxford University Press 6th Edition, 2015.

Reference Books:

1. C. V. Shekar, *A Text Book of Nuclear Chemistry*. New Delhi Dominant publishers and Distributors (P) Ltd., 1st Edition 2014.
2. S. Glasstone *Sourcebook on Atomic Energy.* New Delhi: East West Press. 3rd Edition. 2014.
3. J. E. Huheey, E. A. Keitler, & R. L. Keitler, *Inorganic Chemistry- Principles of Structure and Reactivity* Singapore: Pearson Education. 4th Edition, 2011.

Journals:

1. European Journal of Inorganic Chemistry
2. International Journal of Inorganic Chemistry
3. Journal of Inorganic Chemistry

E- Resources:

1. http://elibrary.vssdcollege.ac.in/web/data/books-com-sc/bsc-2/CHEMISTRY/inorganic%20chemistry/Acids,%20Bases%20and%20Non-Aqueous%20Solvents.pdf
2. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/21%3A_Nuclear_Chemistry
3. https://www.slideshare.net/AntoArockiaRajA/inorganic-chains-rings-cages-and-clusters
4. https://www.uobabylon.edu.iq/eprints/publication_10_10256_250.pdf
5. https://ncert.nic.in/ncerts/l/lech101.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	3	3	9	3	3	**39**
CO2	9	9	3	9	9	9	9	**57**
CO3	9	9	9	3	9	3	9	**51**
CO4	9	9	3	3	9	9	3	**45**
CO5	9	3	3	3	9	3	3	**33**
Total	**45**	**42**	**21**	**21**	**45**	**27**	**27**	**225**

Low-1 Medium-3 High-9

Core III – Physical Chemistry-I

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 6**
Subject Code: HMCHC13 **Credit: 5**

Course Objectives:

1. To enable the learners to understand the significance of classical thermodynamics
2. To acquire the knowledge of chromatography and their applications

Unit I **(18 hours)**

Classical Thermodynamics: Concepts involved in first, second and third law of thermodynamic, thermodynamic equation of state, Maxwell relations, free energy and entropy of mixing, partial molar quantities, Gibbs-Duhem equation, equilibrium constant, temperature-dependence of equilibrium constant, Phase rule for one and two component system, thermodynamic description of phase transitions, experimental determinations of fugacity of real gases, activity, activity co-efficient and its determination.

Unit II **(18 hours)**

Statistical Thermodynamics: Combinatory rule, probability theorem, permutations and combinations, concept of ensembles energy states and energy levels, macro-states and micro-states, Maxwell-Boltzmann statistics, thermodynamic probability, Sterling's approximation, Legrange's undetermined multiplier, distribution functions.

Partition function and thermodynamic functions - molar partition function, separation of partition function, translational, rotational, vibrational and electronic partition functions, combined partition function, equilibrium constant and partition function.

Quantum statistics -Fermi-Dirac and Bose-Einstein statistics, population inversion.

Unit III **(18 hours)**

Surface Chemistry: Different types of surfaces, thermodynamics of surfaces, Gibbs adsorption equation and its verification, surfactants and micelles, surface films.

Adsorption - Introduction, adsorption of gases on solids, physisorption and chemisorption, adsorption isotherms - Freundlich, Langmuir, BET, Temkin adsorption isotherms, adsorption on liquid surface, surface tension, surface area determination by electro-osmosis and electrophoresis.

Colloids - Zeta potential, sedimentation potential and streaming potential, Donnan membrane equilibrium.

Unit IV **(18 hours)**

Chemical Kinetics: Parallel, consecutive and reversible reactions, determination of order of reaction, Arrhenius equation, energy of activation and its experimental determination, simple collision theory– mechanism of bimolecular reaction, Lindemann's theory, activated complex theory of reaction rate, Kinetics of reactions in solution-salt effects, effect of dielectric constant (single sphere and double sphere model), homogeneous catalysis-acid-base catalysis, enzyme catalysis-derivations of Michaelis & Menton's equation, kinetics of heterogeneous reactions-unimolecular and bimolecular surface reactions, Advanced unimolecular theory-Marcus theory or Rice, Ramspergcr, Kassel and Marcus (RRKM) theory.

Unit V **(18 hours)**

Chromatography: Partition chromatography-Paper chromatography, Thin layer chromatography, R_f value, chromatogram, ascending and descending chromatography, applications of partition chromatography.

Adsorption chromatography-principle, classification of column chromatography, column efficiency, preparation of column.

Exclusion or Gel chromatography-technique in gel chromatography, gel preparation, packing of column, theory and application of gel chromatography.

HPLC-Principle, instrumentation, advantages of HPLC, Effect of temperature in HPLC and HPTLC. Gas Chromatography-principle, GC columns, instrumentation, methodology, GC-MS, applications of GC.

Course Outcomes:

After successful completion of his course, student will be able to

CO1: Define the principles of adsorption and understand the knowledge of thermodynamics

CO2: Construct the significance of laws of thermodynamics

CO3: Explain the details of quantum statistics

CO4: Determine the theories of reaction rates, how reaction rates are measured and represented in rate laws

CO5: Develop the practical knowledge of separation techniques by using chromatography

Text Book:

1. Peter Atkins, Atkins' *Physical Chemistry*, Oxford University Press, New York, 11th Edition, 2018.

Reference Books:

1. I.N.Levine, *Quantum Chemistry* New Delhi: Pearson Education Pvt. Ltd.8th Edition, 2016.
2. J. Rajaram and J. C. Kuriacose, *Thermodynamics for Students of Chemistry - Classical, Statistical and Irreversible*, Pearson Education, New Delhi, 2013.
3. P. Atkins, & J. De Paula, *Atkins Physical Chemistry* (X Edition). Oxford: Oxford University Press.10th Edition, 2014.

Journals:

1. The Journal of Physical Chemistry
2. Journal of Physics and Chemistry Solids
3. Journal of Physical Chemistry

E- Resources:

1. https://www3.nd.edu/~powers/ame.20231/notes.pdf
2. https://soaneemrana.org/onewebmedia/THE%20PRINCIPLES%20OF%20THERMO DYNAMICS%20BY%20N.D%20HARI%20DASS.pdf
3. http://www0.unsl.edu.ar/~cornette/ME/An-Introduction-to-Statistical-Mechanics-and-Thermodynamics.pdf
4. https://uh.edu/engines/StatisticalThermodynamics.pdf
5. https://www.saurashtrauniversity.edu/docs/eBooks/Chemical-Kinetics.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	9	9	9	9	9	**63**
CO2	9	9	9	3	9	9	9	**60**
CO3	9	3	9	3	9	3	3	**42**
CO4	9	9	3	3	9	3	3	**39**
CO5	9	9	3	9	9	3	3	**45**
Total	**45**	**42**	**33**	**27**	**45**	**27**	**27**	**249**

Low-1 Medium-3 High-9

Core IV – Organic Chemistry Practicals

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 6**
Subject Code: HMCHC14P **Credit: 5**

Course Objectives:

1: To understand the basic principles of lab techniques adopted in organic laboratories
2: To learn about the quantitative and qualitative analysis

1. **Qualitative analysis:** **(30 hours)**

i. Separation, purification of organic compounds - Phenols, Carbonyl compounds (Aldehydes & Ketones), Acids, Nitro compounds, Amines, Amides and Carbohydrates.
ii. Identification of organic compounds in binary mixtures by chemical tests and preparation of their solid derivatives

2. **Quantitative analysis:** **(30 hours)**

i. Estimation of phenol, aniline, ketone and reducing sugars.
ii. Estimation of functional groups like hydroxyl, methoxyl, carbonyl and nitro groups.

3**. Preparation of organic compounds (Double stage)** **(30 hours)**

i. benzillic acid from benzoin (rearrangement)
ii. p-amino benzoic acid from p-nitro toluene (oxidation and reduction)
iii. p-bromoaniline from acetanilide (bromination and hydrolysis)
iv. 1, 2, 4-triacetoxy benzene from hydroquinone (oxidation and acylation)
v. p-bromo acetanilide from aniline (acetylation and bromination)

Evaluation Scheme: One experiment or a part of it has to be carried out and the product has to be purified by recrystallization. The yield of the crude product and the melting point of the recrystallized product are to be noted. Both crude and recrystallized products are to be submitted.

Course Outcomes:

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

CO1: Recall the standard procedure for purification and separation of organic analysis and describe about the qualitative and quantitative analysis
CO2: Apply the knowledge of qualitative analysis for the determination of organic mixtures
CO3: Classify the systematic separation of qualitative analysis
CO4: Explain the preparation of organic compound by double stage
CO5: Discuss the preparation of organic compound

Reference Books:

1. A. O. Thomas, *Practical Chemistry*. Cannanore, Scientific Book Center. 2013.
2. Arun Sethi, *Systematic Lab Experiments in Organic Chemistry*. New Delhi: New Age Publisher, 2010.

Journals:

1. Beilstein Journal of Organic Chemistry
2. Bulletin of the chemical Society of Japan
3. The Journal of Organic Chemistry

E-Resources:

1. https://people.chem.umass.edu.PDF Web results 70 Qualitative Organic Analysis.
2. http://rushim.ru Manned practical organic chemistry
3. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_General_Chemistry_(Petrucci_et_al.)/27%3A_Reactions_of_Organic_Compounds/27.09%3A_Synthesis_of_Organic_Compounds
4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Book%3A_Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/09%3A_Separation_Purification_and_Identification_of_Organic_Compounds
5. https://www.researchgate.net/publication/332029217_Qualitative_analysis_of_organic_mixture_Binary_and_Ternary_chart_for_MSc_organic_students

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	3	1	9	3	9	9	3	**34**
CO2	9	3	9	3	9	9	1	**43**
CO3	9	3	9	1	9	3	9	**43**
CO4	3	3	9	3	9	9	3	**39**
CO5	9	3	1	3	9	1	3	**29**
Total	**33**	**13**	**37**	**13**	**45**	**31**	**19**	**188**

Low-1 Medium-3 High-9

Disciple Specific Elective I (A) - Instrumental Methods of Analysis

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 6**
Subject Code: HMCHE1A **Credit: 5**

Course Objectives:

1. To learn about the various methods involved in analytical techniques
2. To learn about the various methods involved in thermoanalytical techniques

Unit I **(18 hours)**

Error Analysis: Classification of errors, accuracy and precision, minimization of errors, significant figures, significant figures in computation, statistical treatment of data-mean, median, standard deviations, variance, relative standard deviation-spread, errors-standard deviation of computed results, student's t-test, F-test, comparison of the means of two samples, correlation and regression– linear regression (least square analysis).

Unit II **(18 hours)**

Precipitation Techniques: Introduction, properties of precipitates and precipitating reagents, colloidal precipitates, co-precipitation, post precipitation, precipitates from homogeneous solution, surface adsorption, drying and ignition of precipitates, application of gravimetric methods.

Unit III **(18 hours)**

Electroanalytical Techniques: Electrogravimetry, theory of electrogravimetric analysis, electrolytic separation and determination of metal ions, Coulometry-electrolytic cell, working electrodes, auxiliary electrode and reference electrode, coulometric titrations, Voltammetry-stripping voltammetry, Chronopoteniometry, Amperometry-Amperometric titrations.

Unit IV **(18 hours)**

Thermoanalytical Methods: Thermal analysis, theory and principles of DTA and TGA, factors affecting the position of DT and TG traces, application of DTA and TGA to the thermal behavior of the following compounds, crystalline copper sulphate, calcium oxalate monohydrate, calcium acetate monohydrate, zinc hexafluorosilicate, complementary nature of DTA and TGA , principle and application of DSC, determination of degree of conversion of high alumina cement, purity determination phase transition study in forensic laboratory.

Unit V **(18 hours)**

Spectroanalytical Methods: Colorimetry-Beer and Lambert's law, terminology-condition for a satisfactory colorimetric analysis, method of colour measurement or comparison, principles of colorimetric determinations of NH_3, Cr, Cu, Fe, Mn, simultaneous spectrophotometer determination of Cr and Mn.

Nephelometry and Turbidimetry-principle, determination of sulphate and phosphate, Fluorimetry- principle, application of Fluorimetry in the determination of Cd, Ca and Zn and determination of codeine and morphine in a mixture, Flame spectrometry-theory, interferences, AAS-applications in the determination of Mg^{+2} and Ca^{+2} in tap water, V in lubricating oil, trace lead in a ferrous alloy and trace elements in contaminated soil.

Course Outcomes:

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

CO1: Find the statistical treatment of data and demonstrate error analysis
CO2: Apply the suitable methods involved in electroanalytical techniques
CO3: Analyse the forms of precipitation
CO4: Determine the various methods involved in spectroanalytical techniques
CO5: Discuss the various methods involved in thermoanalytical techniques

Text Book:

1. A. Douglass koog, F. James holler, S.R. Crouch, *Instrumental Analysis*, Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, 7th Edition 2020.

Reference Books:

1. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas and B. Sivasankar, *Vogel's Textbook of Quantitative Chemical Analysis*, Pearson Education, New Delhi, India, 6th Edition, 2012.
2. D.A. Skoog, E.J. Holler and T.A. Nieman, *Principles of Instrumental Analysis*, Thomson Asia Pvt. Ltd., Singapore, 5th Edition, 2004.

Journals:

1. Journal of Analytical Chemistry

2. International Journal of Analytical Chemistry
3. Journal of Analytical Chemistry

E- Resources:

1. http://www.uoxray.uoregon.edu/phys290/ErrorNotes.pdf
2. https://lcn.people.uic.edu/classes/che205s17/docs/che205s17_reading_12b.pdf
3. https://pg.gda.pl/info/polimery/files/2013/10/im-swp-l-002f.pdf
4. http://web.iyte.edu.tr/~serifeyalcin/lectures/chem305/cn_1.pdf
5. https://www.britannica.com/science/nephelometry

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	3	1	9	3	9	9	3	**34**
CO2	9	3	9	3	9	9	1	**43**
CO3	9	3	9	1	9	3	9	**43**
CO4	3	3	9	3	9	9	3	**39**
CO5	9	3	1	3	9	1	3	**29**
Total	**33**	**13**	**37**	**13**	**45**	**31**	**19**	**188**

Low-1 Medium-3 High-9

Disciple Specific Elective I (B) – Green and Environmental Chemistry

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 6**
Subject Code: HMCHE1B **Credit: 5**

Course Objectives:

1. To teach the importance of various types of green synthesis and their applications
2. To impart the knowledge on the chemistry of atmosphere and their crucial applications

Unit I **(18 hours)**

Introduction of Green Chemistry: Principles of green chemistry, need for green chemistry-sustainability and cleaner production, eco efficiency, environmental protection laws, challenges ahead for a chemist-education on green chemistry, dreaming green chemistry-Innovations for a cleaner world, pollution - a price tag of modern society, Pollution control to pollution prevention, Green chemistry-need of the day, green methods, green products, recycling of waste.

Unit II **(18 hours)**

Designing Green Synthesis: Green synthesis-designing, choice of starting materials, choice of reagents, choice of solvents and choice of catalyst organic synthesis in water-reactions in water-Claisen rearrangement, Knoevenagel reaction, Pinacol coupling, Benzoin condensation and strecker synthesis.

Ionic liquids-types of ionic liquids, synthesis of ionic liquids, reaction in ionic liquids-Suzuki coupling, Claisen - Schimidt condensation and Waker-type oxidation reactions.

Super critical fluids-Introduction, supercritical CO_2-super critical polymerization, Kolbe-Schmitt synthesis and Friedel - Craft reaction.

Unit III **(18 hours)**

Solvent-Free Organic Synthesis: Microwave assisted synthesis–microwave activation, microwave heating, advantages of microwave exposure and specific effects of microwaves.

Microwave assisted synthesis in water-Hoffmann elimination, hydrolysis of benzamide and Oxidation of toluene.

Ultrasound assisted organic synthesis-introduction, types of sonochemical reactions, homogeneous sonochemical reactions-Curtius rearrangement, heterogeneous liquid-liquid reactions - esterification, heterogeneous solid-liquid reactions - Hydroboration.

Phase Transfer Catalysts- advantage, types and application in conversion of nitriles from alkyl and aryl halides.

Biocatalyst-Microbial oxidation and enzymatic hydrolysis, polymer supported catalysts.

Unit IV **(18 hours)**

Air Pollution, Water Pollution and Soil Pollution: Air pollution- pollution by C, CO, NO_X, SO_X, HC, acid rain, smog, particulates, greenhouse effect/global warming, ozone layer depletion, effects & control of air pollutants.

Water pollution- source and classification - organic, inorganic and radioactive pollutants.

Soil pollution- chemical composition, micro and macro nutrients in soil, pollution by fertilizers, pesticides, plastics and heavy metal compounds, plant as indication of soil pollution.

Unit V **(18 hours)**

Industrial Pollution, Radiation pollution & Environmental Toxicology: Introduction, causes of industrial pollution, thermal power plants, nuclear power reactors, fertilizers and chemical industry-pulp and paper industries, agro based industries, cement industry.

Classification & effects of radiation, effects of ionizing radiation on man, effects of non-ionizing radiation on life, radioactivity and nuclear fallout, protection and control from radiation.

Toxic chemicals in the environment-biochemical effects of arsenic, cadmium, lead, mercury and cyanide, bio-ware agents, chemical solutions to environmental problems biodegradability, principles of decomposition better industrial processes, Bhopal gas tragedy, Chernobyl, Three-mile island, Sewozo and Minamata disasters.

Course Outcomes (CO):

After successful completion of this course, students will be able to

CO1: Recall the various greener synthetic pathways and understand it in the production of pharmacological compounds

CO2: Identify the techniques of green synthesis in organic reactions

CO3: Examine the chemical products and processes

CO4: Evaluate the various alternative resources for green technology in organic synthesis

CO5: Create an awareness for reducing waste, minimizing energy consumption in organic synthesis

Text Book:

1. Shweta Sharma and Pooja Sharma, *Environmental Chemistry*, Narosa Publishing House Pvt. Ltd., New Delhi, 2014.

Reference Books:

1. V. K. Ahluwalia, & M. Kidwai, *New Trends in Green Chemistry* Germany: Kluwer Academic Publisher, 7th Edition, 2012.
2. Rashmi Sanghi & M. M. Shrivastav, *Green Chemistry, Environment Friendly Alternatives*, Narosa Publishing House Pvt. Ltd., New Delhi, 2012.

Journals:

1. Current Research in Green and Sustainable Chemistry
2. The Journal of Green Chemistry
3. ACS Sustainable Chemical Engineering

E- Resources:

1. https://www.asdlib.org Gree...PDF green chemistry
2. http://www.upv.es files tra...PDF Green Chemistry A Synthetic Chemist's Perspective – UPV
3. http://alpha.chem.umb.edu ...PDF Advanced Organic Chemistry/ Organic Synthesis – CH 621
4. https://www.researchgate.net 3155... (PDF) The Minimization and Prevention of Pollution; Green
5. http://pustaka.unp.ac.id file. PDF Web results Environmental Toxicology, Third Edition

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	9	3	3	3	**33**
CO2	3	1	9	1	9	9	1	**33**
CO3	3	1	9	1	9	1	9	**33**
CO4	9	3	9	1	9	9	3	**43**
CO5	9	9	3	9	9	3	1	**43**
Total	**33**	**17**	**33**	**21**	**39**	**25**	**17**	**185**

Low-1 Medium-3 High-9

Discipline Specific Elective - I (C) Computational Chemistry

(For Students Admitted from 2022-23)

Semester I **Hours/Week: 6**
Subject Code: HMCHE1C **Credit: 5**

Course Objectives:

1: To compare the computational methods with insight gained from quantum chemistry
2: To develop analytical skills for interpretation of experimental results with insight from computational data

Unit I **(18 hours)**

Hartree-Fock Theory: Molecular Hamiltonian - Bonn-Oppenheimer approximation - Mean field theory - Fock operator - trial wave functions - LCAO approximation - Roothan's equations - Fock matrix - Self-Consistent Field theory – MO, Total Energies - Koopman's Theorem - open shell systems - UHF vs ROHF - broken symmetry solutions - spin polarization - spin contamination.

Unit II **(18 hours)**

Post-Hartree Fock Methods: Static vs dynamic correlation - Configuration Interaction (CI) – CI matrix - Brillion's Theorem - Slater-Condan's rules - configuration state functions - Multiconfiguration SCF - choice of active spaces - Many body perturbation theory - Moller-Plesset (MP_n) method - Coupled cluster methods - size consistency and extensivity - time, space complexities.

Unit III **(18 hours)**

Basis of Sets: Single center (vs) Multi center expansions - Slater type Orbitals-minimal vs extended basis sets-split-valence basis sets-Gaussian Type orbitals-Primitive and Contracted Gaussians-polarization functions-diffuse functions - Effective Core Potential (ECP)-Pople's Notation-Basis set Limit - Basis set superposition Error (BSSE)-Counterpoise Correction.

Unit IV **(18 hours)**

Density Functional Theory: Electron Density vs Wave functions - Hole functions-Thomas-Fermi model-Slater's approximation-Hohenberg-Kohn theorems-Kohn-Sham theory-exchange and Correlation holes-Local Density Approximation (LDA), Gradient-corrected Methods-Kohn-Sham orbitals-hybrid functionals-performance of DFT models.

Unit V **(18 hours)**

Molecular Properties: Geometry optimization-Symmetry-Hellmann Feynman Theorem - properties (time dependent and independent)-normal modes-vibrational analysis and characterization of stationary points IR /Raman spectra-anharmonic corrections-electrical, magnetic and thermodynamic properties-characterizing transition states-solvent models.

Course Outcomes:

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

CO1: Recall and understand the basic theories of quantum chemistry

CO2: Compare the computational methods with insight gain from quantum chemistry

CO3: Correlate approximation applied in basis sets to better accuracy

CO4:Evaluate the vibrational and rotational spectra for arriving various properties of materials

CO5: Develop an analytical skills for interpretation of experimental results with insight from computational data

Text Book:

1. David C. Young, *Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems*, John Wiley & Sons, Inc. 2018.

Reference Books:

1. Ram Yatan Prasad, *Computational Quantum Chemistry*, 2nd Edition, 2021.
2. David Young, *Computational Chemistry*, Wiley, 1st Edition, 2018.

Journals:

1. The Journal of Computational Chemistry
2. Journal of Chemical Theory and Computations
3. Journal of Computer Aided Chemistry

E- Resources:

1. https://encyclopedia.pub/7607
2. https://nptel.ac.in/courses/104/101/104101095/
3. http://vergil.chemistry.gatech.edu/courses/chem4681/background/node1.html
4. https://www.cs.mcgill.ca/~rwest/wikispeedia/wpcd/wp/c/Computational_chemistry.html
5. https://www.pdfdrive.com/computational-chemistry-books.html

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	3	9	3	3	3	**42**
CO2	9	9	9	1	9	3	9	**49**
CO3	9	3	9	3	9	9	9	**51**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	9	9	3	9	9	9	**57**
Total	**45**	**33**	**39**	**19**	**39**	**33**	**39**	**250**

Low-1 Medium-3 High-9

Extra Credit I – Forensic Chemistry

(For Students Admitted from 2022-23)

Semester: I **Credit: 2**
Subject Code: HMCHX1

Course Objectives:

1. To give an insight on the medicinal, legal and analytical aspects of forensic chemistry
2. To find out a suitable method to detect the crime

Unit I

Introduction of Forensic Chemistry: Basic principles and its significance, History & development of forensic science, nature and scope of forensic science, organizational structure of forensic science laboratories at central & State level, ethics in forensic science, method of analysis in forensic science -spectrometry and microscopy.

Unit II

Scene of Crime: Types, protection of scene of crime, preservation (recording) of scene of crime- photography and sketching methods.

Physical evidence: Meaning, types, search methods, collection and preservation, forwarding, chain of custody, collection, preservation, packing and forwarding of blood, semen and other biological stains, firearm exhibits, documents, fingerprint, viscera, hair & fiber, glass, soil and dust, petroleum products, drugs and poisons, etc.

Unit III

Crime: Definition, theories of causation of crime - pre-classical and neo-classical, constitutional, geographical, economic, psychological, sociological, multiple causation approach.

Unit IV

Indian Penal Code: Introduction, General exceptions, Offences against person, Offences against property, Attempt to suicide, Sexual offences.

Criminal Procedure Code: Introduction and general idea of sections - 291-93, 154, 155, 156, 157, 158, 159, 160, 161, 162, 172, 173, 174, 175, and 176.

Indian Evidence Act: Introduction and general idea of sections - 32, 45, 46, 47, 57, 58, 60, 73, 135, 136, 137, and 159.

Unit V

Forensic Medicine: Definition of Forensic Medicine and medical jurisprudence, Dying declaration, Death – definition, types, somatic, sudden natural and unnatural deaths, medical aspects aids – misuse of scheduled drugs, burns and their treatment by plastic surgery.

Forgery: Detecting forgery in bank cheques / drafts and educational records (mark lists, certificates), using UV-light, hand writing comparison - genuine and forged writing, collection of samples, detection.

Transportation: Drunken driving – breath analyzer for ethanol, Incendiary and timed bombs in road and railway tracks, defusing live bombs, Accidental explosions during manufacture of matches and fire-works (as in Sivakasi).

Course Outcomes:

After successful completion of this course, students will be able to

CO1: Define the importance of forensic chemistry and relate the methods to detect the crime
CO2: Build the scene of crime
CO3: Catagorize the crimes against person
CO4: Evaluate the suitable method to detect the crime
CO5: Construct the theories of causation of crime

Text Book:

1. Saferstein, Richard and Criminalistics, *An Introduction to Forensic Science*, Prentice Hall, Fifth edition, 2018.

Reference Books:

1. B.R. Sharma, Forensic Science Griminal *Investigation & Trials*, Universal Publishing, 6th Edition, 2020.
2. Dr.C.F. Mulimani, *Fundamentals of Forensic Science*, Manjugounda R. Patil Publishing, 1st Edition, 2020.

Journals:

1. Journal of Forensic chemistry
2. Forensic science International
3. Royal Society of Chemistry Advance

E-Resources:

1. http://www.remondini.net n...PDF FORENSIC CHEMISTRY – Remondini
2. https://www.cbsd.org DomainPDF Crime Scene Investigation
3. https://www.slideshare.net shakib07 Web results Theories of Crime (Criminology) – Slideshare
4. https://legislative.gov.in files PDF Web results Indian Penal Code - Legislative Department
5. https://www.pdfdrive.com/search?q=Scene+of+Crime&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	9	9	9	9	9	**63**
CO2	3	3	3	1	3	1	1	**15**
CO3	9	3	3	1	3	3	3	**25**
CO4	3	3	9	3	9	9	9	**45**
CO5	9	3	1	1	1	1	1	**17**
Total	**33**	**21**	**25**	**15**	**25**	**23**	**23**	**165**

Low-1 Medium-3 High-9

Core V – Organic Chemistry-II

(For Students Admitted from 2022-23**)**

Semester: II **Hours/Week: 6**
Subject Code: HMCHC21 **Credit: 5**

Course Objectives:

1. To enable the students to learn the synthesis and the isolation of amino acids proteins, enzymes and nucleic acids
2. To impart the knowledge on photochemistry reactions

Unit I **(18 hours)**

Molecular Rearrangements and Reactions: Types of organic rearrangements-anionic, free radical, Carbene, Nitrene and long-range rearrangements, mechanism of Wagner-Meerwein, Hofmann, Curtius, Schmidt, Lossen, Beckmann, Wolf, Fries, Hofmann-Martius, Orton, Smiles, Favorskii, Stevens, Wittig, Sommelet, Hauser, Bayer-Villiger, Neber, Zimmermann, Chapman, Hydroperoxide and borane rearrangements.

Unit II **(18 hours)**

Stereochemistry and Conformation Analysis: Stereochemistry-Elements of symmetry, Chirality, R-S nomenclature, Diastereoisomerism in acyclic and cyclic systems, E-Z isomerisms, interconversion of Fischer, Newman and Sawhorse projections, molecules with more than one chiral center, Threo and Erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, asymmetric synthesis-Cram's rule, Prelog's rule. Conformational analysis-acyclic compounds-conformation of monosubstituted and disubstituted cyclohexanes.

Unit III **(18 hours)**

Pericyclic Reactions: Molecular orbital symmetry, frontier orbitals of ethylene, 1,3- butadiene, 1,3,5-hexatriene and allyl systems, classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams, FMO and PMO approach. Electrocyclic reactions-conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems cycloaddditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 1,3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements-suprafacial and antarafacial shifts of H, 3,3- and 5,5-sigmatropic rearrangements, Claisen, Cope and Aza-Cope rearrangements, fluxional tautomerism, Ene reaction (with selected examples).

Unit IV **(18 hours)**

Organic Photochemistry: Introduction, photochemistry of alkenes-intramolecular reactions of the olefinic bond, geometrical isomerism, photochemistry of carbonyl compounds-intramolecular reactions of carbonyl compounds, saturated, cyclic and acyclic (Norrish type I) and Norrish type-II reactions, photochemistry of aromatic compounds-isomerisations, additions and substitutions, Photo-Fries rearrangement. Barton reaction, singlet molecular oxygen reactions– Paterno - Buchi reaction.

Unit V **(18 hours)**

Bioorganic Chemistry: Amino acids-Structure, classification, synthesis and properties of amino acids.Proteins-classification and properties (denaturation, isoelectric point and electrophoresis), primary, secondary, tertiary and quaternary structures of proteins, Enzymes-Typical enzyme mechanisms (Chymotrypsin).Nucleic Acids-Nucleotides and Nucleosides, DNA-Primary and secondary structure, replication of DNA, RNA and Protein synthesis-Messenger RNA synthesis, transcription ribosomes-rRNA, Transfer RNA.

Course Outcomes:

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

CO1: Find the synthesis and isolation of bioorganic compounds and illustrate the principle of conformational analysis and stereochemistry

CO2: Apply the versatile knowledge of rearrangements

CO3: Classify the basic ideas of pericyclic reactions

CO4: Evaluate the type of photochemical reactions

CO5: Estimate the concerted and free radical reaction pathways

Text Books:

1. J. Clayden, N. Greeves, S. Warren, and P. Wothers, *Organic Chemistry*, Oxford University Press, UK, 2nd Edition, 2012.
2. J. March and M. B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, Wiley, New York, 8th Edition, 2020.

Reference Books:

1. Mukhergji and S. P. Singh, *Reactions Mechanisms in Organic chemistry*, Mc Millan 2015.
2. P.S. Kalsi, *Stereochemistry – Conformation and Mechanism*, New Age International Publishers, New Delhi, India, 10th Edition, 2019

Journals:

1. Royal Society of Chemistry
2. ACS Organic and Inorganic Journal
3. The Journal of Organic Chemistry

E-Resources:

1. https://application.wiley-vch.de/books/sample/3527347852_c01.pdf
2. http://www.gbv.de/dms/ilmenau/toc/025899171.PDF
3. http://courses.washington.edu/medch562/pdf/MEDCH400_Stereochem.pdf
4. https://www.asu.edu/courses/chm332/PericyclicReactions.pdf
5. http://www-oc.chemie.uni-regensburg.de/OCP/ch/chb/oc5/Photochemie-08.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	3	9	9	9	9	**60**
CO2	9	3	9	3	9	9	9	**57**
CO3	9	3	3	3	3	3	1	**25**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	1	9	1	9	3	9	**41**
Total	**45**	**19**	**33**	**19**	**39**	**33**	**47**	**234**

Low-1 Medium-3 High-9

Core VI– Inorganic Chemistry-II

(For Students Admitted from 2022-23**)**

Semester: II **Hours/Week: 6**
Subject Code: HMCHC22 **Credit: 5**

Course Objectives:

1. To enable the student to understand about coordination chemistry
2. To know the details of bioinorganic chemistry and inorganic photochemistry

Unit I **(18 hours)**

Theory of Coordination Chemistry: Nomenclature of coordination complexes, labile and inert complexes, stability constants of complexes, stepwise and overall stability constant, their determination-Jobs continuous variation method and spectrophotometric method, factors affecting the stability constants, Valence Bond Theory-explanation with examples, drawbacks of VBT. Metal-ligand bonding-Overview of crystal field and ligand field theories of 4-, 5- and 6- coordinated complexes, d-orbitals splitting in linear, trigonal, octahedral, square planar, tetrahedral, trigonal-bipyramidal and cubic complexes, Measurement of CFSE (d^1 to d^{10}) in weak and strong ligand fields, Jahn-Teller distortion, Nephelauxetic series, variation of lattice energy, ionic radii and heat of hydration across 1^{st} row transition metal ions.

Unit II **(18 hours)**

Reaction Mechanism of Coordination Chemistry: Substitution reactions - square planar substitution reactions - Factors affecting reactivity of square planar complexes, Trans effect - theories of Trans effect, substitution reactions in octahedral complexes, (S_N1, S_N2, S_NiCB) - reactions of coordinated ligands, acid hydrolysis -anation reactions and base hydrolysis.

Mechanism of electron transfer reactions - outer sphere, inner sphere electron transfer reactions, synthesis of coordination compounds using electron transfer and substitution reaction, applications of coordination compounds.

Magnetic properties in coordination compounds - diamagnetic, paramagnetic, ferromagnetic antiferromagnetic and ferromagnetic behaviour of transition metal complex compounds.

Unit III **(18 hours)**

Lanthanides and Actinides: Lanthanides - Occurrence, separation techniques (precipitation, ion-exchange, solvent-extraction and selective reduction and oxidation), electronic configuration and oxidation states,

lanthanide contraction, spectral and magnetic properties, uses of lanthanides and their compounds, position in the periodic table.
Actinides - Extraction of Th, U and Pu from fission products, electronic configuration and oxidation states, spectral and magnetic properties, position in the periodic table.

Unit IV **(18 hours)**

Inorganic Photochemistry: Electronic transitions in metal complexes, metal-centred and charge-transfer transitions, various photophysical and photochemical processes of coordination compounds, unimolecular charge-transfer photochemistry of cobalt (III) complexes, ligand-field photochemistry of chromium(III) complexes, adamson's rules, photoactive excited states, V-C model, photophysics and photochemistry Of ruthenium, polypyridine complexes, photochemistry of organometallic compounds, metal carbonyl compounds.

Unit V **(18 hours)**

Bioinorganic Chemistry: Reversible oxygenation in life process O_2-uptake proteins-myoglobin, haemoglobin, hemerythrin, hemocyanin and model systems, electron transport proteins-Fe-S proteins, ferredoxin, rubredoxin and model systems, respiratory electron transport chains- cytochromes, photosynthetic electron transport chain (PS-I and PS-II) chlorophyll, biological nitrogen fixation (nitrogenase) and abiological nitrogen fixation, metal dependent diseases Wilsons, Alzheimer, Vitamin B_{12} -enzyme, metal complexes in therapeutic use of chelated and non-chelated compounds, chelation therapy.

Course Outcomes:

After successful completion of this course, student will be able to
CO1: Relate the theories of coordination compounds and describe reaction mechanism
CO2: Apply the structural feature of bioinorganic compound and correlate with the function
CO3: Identify the photochemistry of metal complexes
CO4: Classify the inner transition metals based on periodic property.
CO5: Propose the geometries of simple molecules

Text Books:

1. F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, and Manfred Bochmann, *Advance Inorganic Chemistry*, John Wiley and Sons, INC, New York, 6th Edition, 2014.
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter and Okhil K. Medhi, *Inorganic Chemistry – Principles of Structure and Reactivity*, Indian Edition, New Delhi, India, 4th Edition, 2013.

Reference Books:

1. W. Kaim and B. Schewederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, John Wiley and Sons, New York, USA, 2nd Edition, 2013.
2. Weller, Overton, Rourke, Armstrong, *Inorganic Chemistry*, Oxford University Press 6th Edition, 2015.
3. E. H. Catherine, & G. S. Alan, *Inorganic Chemistry* England: Pearson Education Limited, Harlow. 4th Edition, 2012.

Journals:

1. European Journal of Inorganic Chemistry
2. International Journal of Inorganic Chemistry

3. Journal of Inorganic Chemistry

E-Resources:

1. https://www.ch.ntu.edu.tw/~jtchen/course/inorganic/note/Coordination%20Chemistry.doc.
2. https://chem.yonsei.ac.kr/chem/upload/CHE3103-01/122447755644547.pdf
3. http://www.nou.ac.in/econtent/Msc%20chemistry%20paper%202/MSc%20Chemistry%20Paper-II%20Unit-3.pdf
4. https://old.amu.ac.in/emp/studym/99997377.Sc._IV.pdf
5. https://www.chemie-biologie.unisiegen.de/ac/hjd/lehre/master/bioinorganic_handout.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	1	3	9	1	3	**34**
CO2	9	3	9	1	9	9	1	**41**
CO3	9	3	9	3	9	9	3	**45**
CO4	9	3	3	1	3	3	3	**25**
CO5	9	3	9	9	9	3	9	**51**
Total	**45**	**21**	**33**	**17**	**39**	**25**	**19**	**196**

Low-1 Medium-3 High-9

Core VII – Physical Chemistry-II

(For Students Admitted from 2022-23**)**

Semester: II **Hours/Week: 6**
Subject Code: HMCHC23 **Credit: 5**

Course Objectives:

1. To teach the students to understand the basic principles group theory and molecular spectroscopy
2. To gain versatile knowledge about the photochemistry, nuclear quadruple resonance and electrons spin resonance spectroscopy

Unit I **(18 hours)**

Photochemistry: Fundamentals of photochemistry, unimolecular photochemical processes, Jablonski diagram, quantum yield, chemical actinometry, excimers, exciplexes, E-type and P-type fluorescence, short range and long range energy transfer, quenching and sensitization, kinetics of photochemical processes, Stern-volmer equation, photochemical techniques– flash photolysis, radiation chemistry - pulse radiolysis, solar energy conversion and storage, solar cell and its working, photochemistry of environment – ozone layer in the stratosphere, greenhouse effect and photochromism.

Unit II **(18 hours)**

Electrochemistry-I: Mean ion activity and activity coefficient of electrolytes in solution, ion association, ionic strength, Debye-Huckel theory and Debye-Huckel limiting law – its validity and limitations, strong and weak electrolytes, Debye theory of electrolytic conductance, Debye-Huckel-Onsager equation - verification and limitations, electrochemical cells and applications of standard redox potentials.

Unit III **(18 hours)**

Electrochemistry-II: The electrical double layer, polarizable and non-polarizable interfaces, structure of electrical double layer, Double layer models-Helmholtz, Guoy-Chapman and Stern models, kinetics of electrode processes, current-potential curve, Butler-Volmer relation and its approximations, symmetry factor and transfer coefficient, Tafel equation, charge transfer resistance, Nernst equation from Butler-Volmer equation, primary and secondary batteries, fuel cells.

Unit IV **(18 hours)**

Nuclear Magnetic Resonance: 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 including coupling constant 'J', classification (ABX, AMX, ABC, A_2B_2, etc), spin decoupling, basic ideas about instruments, FT- NMR, advantages of FT-NMR, use of NMR in medical diagnostics, Carbon-13 NMR spectroscopy, two dimension NMR Spectroscopy– COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techiniques.

Unit V **(18 hours)**

Nuclear Quadruple Resonance and Electron Spin Resonance: Nuclear quadruple resonance spectroscopy - quadruple nuclei, quadruple moments, electric field gradient, coupling constant, splitting, applications.
Electron spin resonance spectroscopy - basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value, isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, applications.

Course Outcomes:

After successful completion of this course, students will be able to

CO1: Explain the fundamentals of photochemistry and understand the atmospheric chemistry
CO2: Apply the theories to verify the dilution effect of electrolyte
CO3: Analyse the various principle involved in NMR spectroscopy
CO4: Assess the models and kinetics in electrical double layer of electrode processes
CO5: Discuss principle behind ESR to find the free radical species

Text Book:

1. R.K. Prasad, *Quantum Chemistry*, New Age International Publishers, New Delhi, 4th Edition, 2020.

Reference Books:

1. I. N. Levine, *Quantum Chemistry*, New Delhi: Pearson Education Pvt. Ltd. 7th Edition 2016.
2. J. Rajaram and J. C. Kuriacose, *Thermodynamics for Students of Chemistry - Classical, Statistical and Irreversible*, Pearson Education, New Delhi, 2013.
3. Atkins, P., & De Paula, J. *Atkins Physical Chemistry* Oxford University Press. 10th Edition, 2014.

Journals

1. The Journal of Physical Chemistry
2. Journal of Physics and Chemistry Solids
3. Journal of Physical Chemistry C

E- Resources:

1. https://www3.nd.edu/~powers/ame.20231/notes.pdf
2. https://soaneemrana.org/onewebmedia/THE%20PRINCIPLES%20OF%20THERMODYNAMICS%20BY%20N.D%20HARI%20DASS.pdf
3. http://www0.unsl.edu.ar/~cornette/ME/An-Introduction-to-Statistical-Mechanics-and-Thermodynamics.pdf
4. https://uh.edu/engines/StatisticalThermodynamics.pdf
5. https://www.saurashtrauniversity.edu/docs/eBooks/Chemical-Kinetics.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	1	3	3	1	3	**29**
CO2	9	3	3	3	9	3	3	**33**
CO3	9	3	9	3	9	9	9	**51**
CO4	9	3	9	1	9	3	9	**43**
CO5	9	3	1	3	3	1	3	**23**
Total	**45**	**21**	**23**	**13**	**33**	**17**	**27**	**179**

Low-1 Medium-3 High-9

Core VIII – Inorganic Chemistry Practicals

(For Students Admitted from 2022-23**)**

Semester: II **Hours/Week: 6**
Subject Code: HMCHC24P **Credit: 5**

Course Objectives:

1. To understand the basic principles of lab techniques adopted in inorganic laboratories
2. To apply the principle in the semi-micro analysis of an inorganic salt mixture

List of Experiments: **(90 hours)**

1. **Qualitative analysis:** Semi - micro qualitative analysis - Analysis of mixtures containing one familiar and one less familiar cations from the following W, Pb, Se, Te, Mo, Cu, Cd, As, Sb, Ce, Th, Zr, Ti, V, Cr, Mn, U, Ni, Co, Zn, Ca, Ba, Sr, Li, Mg.
2. **Quantitative analysis** involving volumetric and gravimetric estimations of at least four mixtures of cations.
3. **Titrimetry:** Complex metric titrations involving estimations of calcium, magnesium, nickel, zinc and hardness of water.
4. **Preparation of inorganic complexes:** About five preparations involving different techniques selected from the following.
   (i) Potassium tris (oxalato)aluminate
   (ii) Nickel ammonium sulphate

(iii)Tris(thiourea) copper(I) chloride
(iv)Potassium tris(oxalato)ferrate
(v) Hexammine cobalt (III) chloride
(vi)Ammonium hexachloro stannate (IV)
(vii)Tetrammine copper(II) sulphate
(viii)Cis and trans bis(glycinate) copper

Note: Any two experiments asked in examination with concern from external examiners.

Course Outcomes:

After successful completion of this course, students will be able to

CO1: Recall the qualitative and quantitative analysis of inorganic compounds and understand different types of reactions and their workup procedure

CO2: Apply the knowledge of qualitative analysis for the determination of inorganic mixtures

CO3: Analysis the safety measurements in the chemistry laboratory

CO4: Assume the exact solutions for quantitative analysis

CO5: Synthesize Inorganic complexes and find their purity

Reference Book:

1. J. Mendham, R.C. Denney, J.D. Barnes, and M. J.K. Thomas, *Vogel's Textbook of Quantitative Analysis*, Pearson Education, 7th Edition, 2013.

Journals:

1. European Journal of Inorganic Chemistry
2. International Journal of Inorganic Chemistry
3. Journal of Inorganic Chemistry

E- Resources:

1. http://www.iscnagpur.ac.in ...PDF semi micro qualitative analysis of inorganic
2. https://www.academia.edu semi_... (PDF) semi – micro qualitative analysis of simple
3. https://www.pdfdrive.com/search?q=2.%09Quantitative+analysis+involving+volumetric&pagecount=&pubyear=&searchin=&em=&more=true
4. https://www.pdfdrive.com/search?q=5.%09Preparation+of+inorganic+complexes&pagecount=&pubyear=&searchin=&em=&more=true
5. https://www.pdfdrive.com/search?q=Semi+-+micro+qualitative+analysis+&pagecount=&pubyear=&searchin=&em=&more=true

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	3	**39**
CO2	9	1	9	1	9	9	1	**39**
CO3	9	3	9	3	9	9	3	**45**
CO4	9	1	9	3	3	9	3	**37**
CO5	9	3	9	3	3	9	3	**39**
Total	**45**	**11**	**45**	**13**	**27**	**45**	**13**	**199**

Low-1 Medium-3 High-9

Disciple Specific Elective II (A) – Applied Electrochemistry

(For students admitted from 2022-23**)**

Semester: II **Hours/Week: 6**
Subject Code: HMCHE2A **Credit: 5**

Course Objectives:

1. To teach the importance of various types of battery and their applications
2. To create awareness on conversion and storage of electrochemical energy

Unit I **(18 hours)**

Conversion and Storage of Electrochemical Energy: History of fuel cells, direct energy conversion by electrochemical means, electrochemical generators (fuel cells) -Hydrogen Oxygen cells, Hydrocarbon air cell, Alkaline fuel cell and Phosphoric fuel cell, Applications of fuel cells.

Unit II **(18 hours)**

Electrochemical Energy Storage: Properties of electrochemical energy stores-measure of battery performance, charging and discharging of a battery, storage density, energy density, classical batteries -(i) Lead acid (ii) Nickel-cadmium, (iii) Zinc manganese dioxide, Modern batteries-(i) Zinc-air (iii) Lithium battery.

Unit III **(18 hours)**

Corrosion and Stability of Metals: Civilization and surface mechanism of the corrosion of the metals– thermodynamics and the stability of metals, potential - pH (or Pourbaix) diaphragms, uses and abuses, corrosion current and corrosion potential -Evans diagrams, measurement of corrosion rate-(i) weight loss method, (ii) Electrochemical method, inhibiting corrosion-cathodic and anodic protection, organic inhibitors, passivation-structure of passivation films, mechanism of passivation.

Unit IV **(18 hours)**

Kinetic of Electrode Process: Methods of determining kinetic parameters for quasi-reversible and irreversible waves-Koutecky's methods, Meits Israel method, Gellings method, Electrocatalysis-chemical catalysts and electrochemical catalysts with special reference to porphyrin oxides of rare earths, electrocatalysis in simple redox reactions, in reaction involving adsorbed species, Influence of various parameters.

Unit V **(18 hours)**

Potential Sweep Methods: Cyclic Voltammetry-theory and applications, diagnostic criteria of Cyclic voltammetry, Chronopotentiometry-theory and applications, Bulk electrolysis methods-Controlled potential coulometry, Controlled coulometry, Stripping analysis-anodic and cathodic modes, Bioelectrochemistry-bioelectrodics, membrane Potentials, simplistic theory and modern theory.

Course Outcomes:

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

CO1: Define the energy efficiency and understand the knowledge of columbic efficiency for a battery charge/discharge cycle
CO2: Identify the corrosion and stability of metals
CO3: Differentiate the various methods involved in the Potential Sweep Methods.
CO4: Compare the operation of batteries to hydrogen fuel cells and other types of fuel cells

CO5: Discuss the importance of kinetic electrode process

Text Books:

1. J. Bockris, *Modern Electrochemistry*, Plenum Publication, New York, 2018.
2. Samuel Glasstone, *An Introduction to Electrochemistry*, Litton Educational Publishing, Inc., New York, 2008.

Reference Books:

1. H. Vessor Basil & W. Galen, *Electroanalytical Chemistry*, Wiley Interscience. 2012
2. S.K. Rangrajan, *Topics in pure and Applied Chemistry*, SAEST Publication, Karaikudi (India). 2014

Journals:

1. Journal of Applied Electrochemistry
2. Journal of electroanalytical chemistry
3. International journal of Electrochemistry

E- Resources:

1. https://nptel.ac.in/content/storage2/courses/121106014/Week11/lecture34.pdf
2. https://opentextbc.ca/chemistry/chapter/17-5-batteries-and-fuel-cells/
3. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Exemplars/Membrane_Potentials
4. https://en.m.wikipedia.org/wiki/Membrane_potential
5. https://www.pdfdrive.com/search?q=Corrosion+and+Stability+of+Metals&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	1	3	1	1	3	**21**
CO2	9	3	9	3	9	3	3	**39**
CO3	9	3	3	3	3	3	1	**25**
CO4	9	3	9	3	9	3	3	**39**
CO5	9	9	3	9	9	3	3	**45**
Total	**45**	**21**	**25**	**21**	**31**	**13**	**13**	**169**

Low-1 Medium-3 High-9

Disciple Specific Elective II (B) – Polymer Chemistry

(For Students Admitted from 2022-23**)**

Semester: II **Hours/Week: 6**
Subject Code: HMCHE2B **Credit: 5**

Course Objectives:

1. To create awareness on polymer processing
2. To impart the knowledge on the chemistry of polymers and their crucial applications

Unit I **(18 hours)**

Introduction to Polymers: Concept of macromolecules, monomer structure and polymerizability nomenclature of polymers, different ways in classification of polymers depending on - a) the origin (natural, semisynthetic, synthetic etc.) b) The structure (linear, branched, network, hyper branched, dendrimer) c) The type of atom in the main chain (homochain, heterochain) d) The formation (condensation, addition).

Unit II **(18 hours)**

Kinetics and Mechanism of Chain Polymerization Processes: Chain reaction (addition) polymerization, free radical addition polymerization mechanism of vinyl polymerization, generation of free radicals, initiation, propagation, termination, chain transfer inhibition of retardation, configuration of monomer units in vinyl polymer chains, kinetics of free radical addition polymerization, Ionic and coordination chain (addition) polymerization-common features of two types of ionic polymerization, mechanism of cationic and anionic polymerization.

Unit III **(18 hours)**

Condensation Polymerization: Step reaction (condensation) polymerization - Mechanism of step reaction polymerization, kinetics of step reaction polymerization, reactivity and molecular size, kinetic expressions for polymerization in absence and in presence of a catalyst, hyper-branched polymers, dandled with highlighting their methods of synthesis and properties, preparation, properties and application of the following - polyamides , Nylon-6, Nylon - 6,6, Nylon - 6,10 etc., polyesters.

Unit IV **(18 hours)**

Analytical Chemistry of polymers: Instruments and specimen, elucidation of structure – Proton NMR and C^{13} NMR phenomenon, broad line spectra, analysis of molecular structure of simple polymers, Thermogravimetric analysis, differential thermal analysis and DSC - introduction, instrumentation and application, determination of kinetic parameters, thermal degradation behaviour of some polymer by TGA methods.

Unit V **(18 hours)**

Polymer Processing: Compounding of plastics, rubber and fibres (plasticizers, colorants, flame retardants), polymer processing - compression, blow and injection mouldings, film extrusion and calendaring, die casting and rotational casting, thermo foaming, reinforcing, biopolymers, biomedical polymers - contact lens, dental polymers, artificial heart, kidney, skin and blood cells.

Course Outcomes:

After successful completion of this course, students will be able to

CO1: Recall the essential role of polymer in industries and outline the mechanism of polymer
CO2: Illustrate the awareness on polymer processing
CO3: Distinguish the mechanisms of polymerization
CO4: Compare the importance of various types of polymers
CO5: Propose the polymer sample to obtain using different techniques

Text Book:

1. Fred W. Billmayer, *Textbook of Polymer Science*, John Wiley & Sons Pvt. Ltd., Singapore, Indian Edition, 9th Edition, 2017.

Reference Books:

1. Alka L Gupta, *Polymer Chemistry*, Anu Books Publishing, 2019.
2. P.V. Anil Kumar, *Polymer Chemistry*, Vishal Publishing, 1st Edition, 2021.

Journals:

1. Polymer Chemistry
2. European Polymer Journal
3. Reactive & Functional Polymers

E- Resources:

1. https://www.slideshare.net/guest32ca93/polymer-course
2. https://chemistryklipz.files.wordpress.com/2016/12/condensation-polymers.pdf
3. http://pioneer.netserv.chula.ac.th/~sanongn1/processing.pdf
4. https://www.pdfdrive.com/search?q=Condensation+Polymerization&pagecount=&pubyear=&searchin=&em=
5. https://www.pdfdrive.com/search?q=Analytical+Chemistry+of+polymers&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	3	3	9	3	3	**39**
CO2	9	9	3	3	9	3	3	**39**
CO3	9	3	3	9	9	1	3	**37**
CO4	9	9	9	3	9	3	1	**43**
CO5	9	3	9	3	9	9	3	**45**
Total	**45**	**33**	**27**	**21**	**45**	**19**	**13**	**203**

Low-1 Medium-3 High-9

Extra Credit II – Applied Chemistry

(For Students Admitted from 2022-23**)**

Semester: II

Subject Code: HMCHX2 **Credit:2**

Course Objectives:

1**.** To understand the basic concept of lubricants and protective coatings
2. To enable the learners to understand the water

Unit I

Water: Methods of treatment of water for domestic supply-sedimentation, coagulation, filtration, sterilization, break point chlorination, hardness-different types of hardness, determination of hardness of water-demineralization of water by ion exchange process, zeolite process and reverse osmosis process.

Unit II

Cement: Manufacture of cement – dry and wet process, important process parameters for manufacturing a good cement clinker, setting mechanism of cement, different types of cement -special Cement, white Cement.

Unit III

Glass: Composition of glass - raw materials for manufacture of glass, manufacturing of glass-composition and uses of optical glass, colored glasses, lead glass and neutron absorbing glass.

Unit IV

Lubricants: Functions of lubricant, mechanism of lubrication, classification of lubricants, lubricating oil-Greases, properties of lubricating oil and greases, solid lubricants (graphite and molybdenum)-fluid or hydrodynamic lubrication, thin film or boundary lubrication & extreme pressure lubrication.

Unit V

Paints: Constituents, functions & mechanism of drying, varnishes and lacquers, surface preparation for metallic coatings, electroplating (gold) and electrodeless plating (Nickle), anodizing, phosphate coating, powder coating & antifouling coating.

Course Outcomes:

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

CO1: List out the quality parameter for water, cement, glass, lubricants and paints
CO2: Apply the concept of lubricants and protective coatings
CO3: Analyse the quality of cement and glass materials
CO4: Compare the various types of lubricants
CO5: Formulate the new additive for paints

Text Books:

1. R. P. Mani, K. N. Mishra, *Chemistry of Engineering Materials*, Cengage Learning, 3rd Edition, 2015.
2. S.S. Dara & S.S. Umare, *A Text Book of Engineering Chemistry*, New Delhi, S. Chand & Company Ltd, 2013.

Reference Books:

1. P.C. Jain, *Engineering Chemistry*, Dhanpat Rai Publishing Company Ltd., New Delhi, 2010.
2. Shikha Agarwal, *Engineering Chemistry*; Cambridge University Press, 2015.

Journals:

1. International Journal of Applied Chemistry
2. Russian Journal of Applied Chemistry
3. American Journal of Applied Chemistry

E-Resources:

1. https://www.bharathuniv.ac.in/colleges1/downloads/courseware_ece/notes/1%20BCH101%20%20-%20chemistry%201%20-%20NOTES.pdf
2. https://www.madeeasy.in/uploads/examsolution/Building-Materials-mpsc.pdf
3. http://www.forensicscience.pl/pfs/47_zadora.pdf
4. https://www.pdfdrive.com/search?q=Lubricants&pagecount=&pubyear=&searchin=&em=
5. https://www.pdfdrive.com/search?q=Glass%3A&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	1	3	3	1	1	**27**

CO2	9	3	3	3	9	3	3	**36**
CO3	9	3	9	3	9	9	9	**51**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	9	9	9	9	9	**57**
Total	**45**	**21**	**31**	**21**	**39**	**31**	**31**	**222**

Low-1 Medium-3 High-9

Core IX – Organic Chemistry-III

(For Students Admitted from 2022-23**)**

Semester: III **Hours/Week: 6**
Subject Code: HMCHC31 **Credit: 5**

Course Objectives:

1. To learn about the various principles involved in group theory
2. To understand characterization by physical and spectroscopic techniques

Unit I **(18 hours)**

Ultraviolet and Visible & Infrared Spectroscopy: Ultraviolet and Visible spectroscopy-introduction, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, Fieser-woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds, steric effect in biphenyls (problem to be discuss), calculating of $\lambda_{max.}$

Infrared spectroscopy- Introduction, factors influencing group frequencies, characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines, detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides and conjugated carbonyl compounds).

Unit II **(18 hours)**

Nuclear Magnetic Resonance & Carbon-13 NMR Spectroscopy: ^{1}H-chemical shift, spin-spin coupling, coupling constant, first order and second order spin-spin splitting, Influence of stereo chemical factors on chemical shift of protons, simplification of complex spectra, spin decoupling, double resonance-Shift reagents, CIDNP.

Carbon-13 NMR Spectroscopy-Basic principle of FT technique, relaxation time, assignment of the signals, off-resonance decoupling-2D NMR, structural problems based on all the above techniques-correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic alkyne, aromatic, hetero aromatic and carbonyl carbon) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines & amides).

Unit III **(18 hours)**

Mass Spectrometry: Introduction, principle, type of ions-base peak, parent ion, metastable ion and isotopic ions, fragmentation, general rules, pattern of fragmentation for various classes of organic compounds-Mc Lafferety rearrangement, Retro Diels - Alder reaction, Nitrogen rule, high resolution mass spectrometry, examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Unit IV **(18 hours)**

Small Ring Heterocycles: Three-membered and four-membered heterocycles - synthesis and reactions of azirodines, oxiranes, thiranes, azetidines, oxetanes and thietanes.

Benzo-fused five-membered heterocycles - synthesis and reactions including medicinal applications of benzopyrroles, bezofurans and benzothiophenes.

Unit V **(18 hours)**

Chemistry of natural products: Extraction, isolation purification and characterization of natural products. Stereochemistry, reaction and synthesis of terpenoids-zingiberine, carotenoids-α- cadinene, alkaloids-camptothecin, flavonoids-coumarins and steroids –cholesterol (without synthesis), bile acid, testosterone, estrone, progesterone and prostaglandins: PGE_2.

Course Outcomes:

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

CO1: Recall the knowledge of the natural products and understand their structure

CO2: Apply the Fieser woodward rules to calculate wavelength λ_{max} and use finger print region to identify the functional group

CO3: Analyse the mass spectral data to identify the composition of the compounds

CO4: Evaluate the raw materials to prepare different heterocycles

CO5: Construct the structural problems based on all the spectral techniques

Text Books:

1. William Kemp, *Organic spectroscopy*, 3rd Edition, 2019
2. P. M. Silverstein and F. X. Western, *Spectroscopic Identification of Organic Compounds*, John Wiley, New York, 8th Edition, 2014

Reference Books:

1. O. P. Agarwal, *Organic Chemistry - Natural Products*, GOEL Publishing House, Meerut, India, Vol. I, 2015.
2. I. L. Finar, *Organic Chemistry*, Pearson Education Pvt. Ltd, Vol 2, 25th Edition, 2011.
3. J. March and M. B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, Wiley, New York, 7th Edition, 2013.

Journals:

1. Royal Society of Chemistry
2. ACS Organic and Inorganic Journal
3. Journal of Natural Products

E- Resources:

1. http://www.upv.es files 4a...pdf Web results IR spectroscopy – upv
2. https://www.vanderbilt.edu ...pdf 1 Chapter 13: Nuclear Magnetic Resonance (NMR) Spectroscopy
3. https://www.ndsu.edu plsc411 pdf Web results Lecture 3 Mass Spectrometry - NDSU3.4.
4. https://www.wiley.com en-in Sm... Web results Small Ring Heterocycles, Part 1: Aziridines, Azirines, Thiiranes
5. http://www.uou.ac.in science pdf Natural products – UOU

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	3	3	1	3	**25**
CO2	9	3	3	3	9	9	9	**45**
CO3	9	3	9	3	9	9	9	**51**

CO4	9	3	9	3	9	3	9	**45**
CO5	9	9	1	9	9	1	1	**39**
Total	**45**	**21**	**25**	**21**	**39**	**23**	**31**	**205**

Low-1 Medium-3 High-9

Core X– Inorganic Chemistry-III

(For Students Admitted from 2022-23**)**

Semester: III **Hours/Week: 6**
Subject Code: HMCHC32 **Credit: 5**

Course Objectives:

1. To enable the student to learn the organometallic chemistry
2. To enable the student in-depth study of spectral applications to the structural elucidation of inorganic compounds

Unit I **(18 hours)**

Organometallic Chemistry-I: The 18-electron rule for organometallic compounds of transition metals, classification based on 18-electron rule, complexes of two, three, four, five six, seven, eight-electron π-ligands, nomenclature, exceptions to 18 electron rule, the 16-electron rule, isolable and isoelectronic relationship of complexes, agnostic interaction, metal-carbon-bonded compounds (compounds of the sigma electron ligands), metal-alkyl,-allyl, -carbene, -carbonyl,-carbide and cyclopentadienyl complexes, structure and bonding in η^2- ethylene and η^3-allylic compounds with typical examples, structure and bonding in metallocenes.

Unit II **(18 hours)**

Organometallic Chemistry-II: Organometallic reactions-ligand association and dissociation, oxidative addition and reductive elimination, insertion reactions, catalytic mechanism in the following reactions-hydrogenation of olefins (Willkinson catalyst), Tolman catalytic loops hydroformylation (Oxoprocess)-acetic acid from methanol, oxidation of alkenes to aldehydes and ketones (Wacker process)-synthesis gas and their applications using organometallic compounds as catalyst, olefin polymerization (Ziegler-Natta), cyclo oligomerisation of acetylenes (Reppe's or Wilke's catalysts), synthetic gasoline (Fischer Tropsch process and mobile process), Photodehydrogenation catalyst (Platinum POP).

Unit III **(18 hours)**

Application of IR, Raman and Mossbauer Spectroscopy to the Study of Inorganic Compounds: IR and Raman Spectroscopy-Application of IR and Raman spectra in the study of coordination compounds, application to metal carbonyls, nitrosyls and sulphate, detection of geometrical and linkage isomerism, detection of inter and intramolecular hydrogen bonding

Mossbauer Spectroscopy-Mossbauer Effect, resonance absorption, Doppler Effect, Doppler velocity, isomer shift, magnetic hyperfine splitting, application of Mossbauer spectroscopy in the study of iron and tin complexes.

Unit IV **(18 hours)**

Electronic Spectra and NMR Spectroscopy of Inorganic Compounds:

Electronic Spectra Spectroscopy-d-d transition, charge transfer transition, selection rules, mechanism of breakdown of selection rules, bandwidths and shapes, Jahn Teller effect, Orgel diagram - evaluation of $10D_q$ and β for octahedral and tetrahedral complexes.
NMR Spectroscopy-^{31}P and ^{19}F NMR spectroscopy-Introduction, application in structural problem, evaluation of rate constants, monitoring the course of reaction, NMR of fluxional molecules, NMR of paramagnetic molecules, contact shifts and shift reagents.

Unit V **(18 hours)**

Supramolecular Chemistry: Definition, nature of supra molecular interactions, supra molecular host-guest compounds, supramolecular devices and sensors, various types of supramolecular devices-supramolecular photochemistry, molecular and supramolecular photonic devices - light conversion and energy transfer devices, role of supramolecular chemistry in the development of nanoscience and technology.
Medicinal Bioinorganic Chemistry-Chemotherapy with compounds of certain non-essential elements, Platinum complexes in cancer therapy, Cisplatin and its mode of action, cytotoxic compounds of other metals, Gold containing drugs as anti-rheumatic agents and their mode of action, Lithium in pschycopharmocological drugs, radiopharmaceuticals technetium.
Unit IV (Integrated Online Course)

Course Outcomes:
After successful completion of this course, student will be able to
CO1: Define the 18 electron rule and understand the stability of organometallic compounds
CO2: Identify the H-bonding and linkage isomers using IR spectral data
CO3: Analyse the progress of the reaction and rate of reaction using NMR spectral data
CO4: Evaluate the usage of organometallic compounds as homogenous catalyst
CO5: Construct the principles involved in medicinal bioinorganic chemistry
CO6: Evaluate the driving force for bond activation

Text Book:

1. James E. Huheey, Ellen A. Keiter, Richard L. Keiter and Okhil K. Medhi, *Inorganic Chemistry – Principles of Structure and Reactivity*, Pearson Education, Indian Edition, New Delhi, India, 4th Edition, 2013.

Reference Books:

1. Weller, Overton, Rourke, Armstrong, *Inorganic Chemistry*, Oxford University Press 6th Edition, 2015.
2. E. H. Catherine, & G. S. Alan (2012*). Inorganic Chemistry* (IV Edition). England: Pearson Education Limited, Harlow.
3. J.W. Steed and J.L. Atwood, *Supramolecular Chemistry*, John Wiley &Sons, Chichester, 2012.

Journals:
1. European Journal of Inorganic Chemistry
2. International Journal of Inorganic Chemistry
3. Journal of Inorganic Chemistry

E-Resources:
1. organometallic chemistry basic principles.pdf

2. inorganic-chemistry-gary-l-miessler-donald-a-tarr-pdf.pdf
3. organometallic chemistry of transition metals- msc-iii-inorganic chemistry-s-1-11.12.13.pdf
4. gkpatra-ssthakur-sshukla-msc-iii-inorganic chemistry-s-1-11.12.13.pdf
5. organometallic & bioinorganic chemistry-dr. ramsharan-2-1-pdf-pdf.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	3	9	3	3	3	**39**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	3	9	3	9	9	9	**51**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	3	3	3	3	3	**27**
CO6	9	3	9	3	9	9	9	**51**
Total								

Low-1 Medium-3 High-9

Core-XI – Physical Chemistry-III

(For Students Admitted from 2022-23**)**

Semester: III **Hours/Week: 6**
Subject Code: HMCHC33 **Credit: 5**

Course Objectives:
1. To understand the principles of quantum chemistry
2. To enable the learners to acquire knowledge in corrosion chemistry

Unit I **(18 hours)**

Basics of Quantum Chemistry: Introduction of quantum chemistry, operators, postulates of quantum chemistry, eigen value and eigen function, normalization and orthogonality, Schrodinger wave equation. Application of quantum chemistry to simple systems translational motion-particle in one dimensional box, particle in three-dimensional box-rectangular and cubical box, particle with finite potential barrier, one finite potential barrier, two finite potential barrier vibrational motion-Hooke's law, harmonic oscillator, the quantum mechanical derivation for a harmonic oscillator model of a diatomic molecule.

Rotational motion-rigid rotator, derivation of energy and wave function of rigid rotator, rotation in one plane, rotation in space Hydrogen and Hydrogen like atoms-spherically symmetric potential and the Hamiltonian, spherical coordinates, Schrodinger wave equation in terms of r, θ, Φ, radial eigen functions.

Unit II **(18 hours)**

Approximate Methods: Variation principle-linear and non-linear variation theory, perturbation theory-first order, application of variation and perturbation theory to He atom

Theory of angular momentum-Angular momentum, quantum mechanical operator for angular momentum, ladder operator, eigen function and eigen values of angular momentum using ladder operator. Molecular orbital theory (MOT)-LCAO approximation, the H^{2+} ion, the LCAO-MO wave function of H^{2+} ion, electron

density and bonding in H^{2+}, physical representation, Huckel MOT of conjugated systems, Huckel rule of aromaticity, applications of Huckel MOT to ethylene, butadiene, elementary idea of extended Huckel theory.

Unit III **(18 hours)**

Corrosion Chemistry: Basic aspects of corrosion-classification of corrosion-dry corrosion and electrochemical corrosion, difference between chemical and electrochemical corrosion, corrosion control methods– protective coatings-metallic coating, non - metallic coating and organic coating, pre-treatment of the surface, metallic coatings-hot dipping, spraying, cladding, cementation, electroplating -process, types of electroplating, factors affecting electroplating, applications of electroplating, inorganic non-metallic coating-chromate coating, phosphate coating and oxide coating, organic coating-paints, requirements of good paint.

Unit IV **(18 hours)**

Computer Applications in Chemistry: Introduction to computers and computing-block diagram of a PC and the functions of the various units of computer, high- and low-level languages, Introduction to networking-LAN, WAN, Internet and Intranet, World Wide Web, Chem Web, E-journals-search engines for chemistry. Introduction to C language-structure of C program, control statements, loops -recursion.

Examples of simple chemistry programmes:

1. Calculation of pH
2. Determination on first order rate constant for the given reaction
3. Calculation of normality, molarity and molality of a given solution
4. Converting kelvin to Celsius temperature and vice versa
5. Determination of enthalpy of a given solution
6. Evaluation of cell constant

Unit V **(18 hours)**

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, point symmetry group, schonflies symbols, representations of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, D_{nh}), character of a representation.

Character table and their uses-The great orthogonality theorem and its importance, construction of character tables, reducible and irreducible representations, group theory and quantum mechanics, projection operator, using projection operator to construct symmetry adopted linear combinations (SALCs).

Course Outcomes:

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

CO1:Know the different motion of the subatomic particles and understand the principles of quantum chemistry

CO2: Apply the concepts of computer applications in chemistry and their stability for many practical uses

CO3: Analyse the material to find the cause for corrosion

CO4: Interpret the concepts in the group theory

CO5: Discuss knowledge of approximate methods for electron correlation

Text Book:

1. R.K. Prasad, *Quantum Chemistry*, New Age International Publishers, New Delhi, 4th Edition, 2020.

Reference Books:

1. I. N. Levine, *Quantum Chemistry* New Delhi: Pearson Education Pvt. Ltd. 7th Edition, 2016.

2. P. Atkins, & De Paula, J. Atkins *Physical Chemistry* Oxford University Press10th Edition, 2014.
3. K. Arora, *Computer Applications in Chemistry*, Anmol Publications Pvt. Ltd. 2004.

Journals:

1. The journal of Physical Chemistry
2. Journal of Physics and Chemistry Solids
3. Journal of Physical Chemistry

E-Resources:

1. https://www.slideshare.net/nnhsuk/chapter-03grouptheory-1
2. https://www.sciencedirect.com/topics/chemistry/quantum-chemistry
3. http://fabcol.free.fr/pdf/lectnotes3.pdf
4. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjrqNHtpZTxAhVY7XMBHcVaBZwQFnoECBEQAA&url=http%3A%2F%2Fsimons.hec.utah.edu%2FNewUndergradBook%2FChapter1.pdf&usg=AOvVaw26ywtTgXWVWqM7GZq-EKqZ
5.https://www.pdfdrive.com/search?q=Computer+Applications+in+Chemistry&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	3	3	3	3	3	**33**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	3	9	3	9	9	9	**51**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	9	3	3	9	3	3	**39**
Total	**45**	**36**	**33**	**15**	**39**	**33**	**33**	**225**

Low-1 Medium-3 High-9

Core-XII – Physical Chemistry Practicals

(For Students Admitted from 2022-23**)**

Semester: III **Hours/Week: 6**
Subject Code: HMCHC34P **Credit: 5**

Course Objectives:

1. To understand the basic principles of lab techniques adopted in physical chemistry laboratories
2. To apply related experiments for their research work

List of Experiments **(90 hours)**

1. Conductometric Experiments
   i) Double displacement & acid base titration

a. NH_4C1 – NaOH – Mixture of CH_3COOH & HCl
b. NH_4C1 – NaOH – Mixture of NH_4C1 & HCl

ii) Precipitation titration
a. KCl – $AgNO_3$ – KCl
b. K_2SO_4 – $BaC1_2$ – K_2SO_4

iii) Determination of dissociation constant of weak acids.

iv) Determination of equivalent conductance of weak electrolyte at infinite dilution using Kohlraush law.

2. Adsorption Experiments - Adsorption of Oxalic acid / Acetic acid on charcoal.
3. Kinetic Experiments
   i) Kinetics of alkaline hydrolysis of ester by conductometric method
   ii) Perdisulphate and iodide ion reaction: study of Primary salt effect and determination of concentration of given KNO_3.
4. Potentiometric methods
   i) Precipitation titration: Ag Vs halide mixture.
   ii) Redox titration: a) permanganate Vs iodide ion b) Ceric ammonium Sulphate Vs ferrous ion
   iii) Determination of dissociation constant of weak acids and pH of buffer solutions.
   iv) Determination of solubility product of sparingly soluble salts.
5. Titrations using pH meter - Determination of first, second and third dissociation constants of phosphoric acid.
6. Thermochemistry:
   (a) Determination of heat of neutralisation
   (i) NaOH vs. HCl
   (ii) NaOH vs. CH_3COOH
   (iii) NaOH vs. Oxalic acid
   (b) Determination of Heat of solution and Heat of hydration of $BaCl_2$ and $CuSO_4$
7. Surface tension
   To determine interfacial tension of two immiscible liquids
8. Distribution Law
   (i) To determine partition coefficient of benzoic acid between benzene and water
   (ii) To determine partition coefficient of Iodine between Carbon tetrachloride and water
   (iii) Determination of Equilibrium constant for $I_2 + I^- = I_3^-$

Course Outcomes:

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

CO1: Understand the basic principles of lab techniques adopted in physical laboratories and relate the practical applications of conductometry

CO2: Apply the potentiometric technique to find pH of the solution

CO3: Compare different acid base combinations with their conductance response

CO4: Estimate the measurement of various physical and chemical properties

CO5: Develop new method to identify acid contaminants

Reference Books:

1. B Viswanathan, P.S. Raghavan, *Practical Physical chemistry*, Viva Books Original, 2017
2. James Brierley Firth, *Practical Physical chemistry*, Andesite Press, 2015

Journals

1. Journal of Physical chemistry C
2. The Journal of Chemical Physics
3. Chemical Physics

E-Resources:

1. https://people.ok.ubc.ca/pphillips/DRAFT%20464%20Manual.pdf
2. https://web.iitd.ac.in/~nkurur/2015-16/Isem/cmp511/lab_handout_new.pdf
3. https://www.vpkbiet.org/pdf/FE/Lab_Manual_Chem.pdf
4. http://nie.lk/pdffiles/other/eALOM%20Chemistry%20Practical%20Handbook.pdf
5. https://www.pdfdrive.com/search?q=Potentiometric+methods&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	9	3	3	9	3	**45**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	9	9	3	9	3	1	**43**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**27**	**45**	**18**	**39**	**39**	**31**	**241**

Low-1 Medium-3 High-9

Disciple Specific Elective III (A) – Nanoscience and Nanotechnology

(For Students Admitted from 2022-23**)**

Semester: III **Hours/Week: 6**
Subject Code: HMCHE3A **Credit: 5**

Course Objectives:

1. To understand the concept of self-assembly and its applications to various nanostructures
2. To learn about the various theories of nanoscience and nanotechnology

Unit I **(18 hours)**

Introduction to Nanoscience and Nanotechnology: Background to nanotechnology scientific revolution, types of nanostructures, definition of a nanosystem, types of nanocrystals-one dimensional (1D), two dimensional (2D), three dimensional (3D) nanostructured materials, quantum dots, quantum wire-core/shell structures, nanomaterials and properties-carbon nanotubes (CNT), metals (Au, Ag), metal oxides (TiO_2, CeO_2, ZnO), semiconductors (Si, Ge, CdS, ZnSe), applications of nanomaterials.

Unit II **(18 hours)**

Synthesis of Nanomaterials: Bulk synthesis of bulk nanostructured materials, sol-gel processing, mechanical alloying and milling, inert gas condensation technique, bulk and nanocomposite materials, grinding, high energy ball milling, physical and chemical approaches self-assembly-self-assembled monolayers (SAM), vapour liquid solid (VLS) approach- chemical vapour deposition (CVD), introduction to vacuum technology, physical vapour deposition techniques.

Unit III **(18 hours)**

Characterization Techniques for Nanomaterials: Electron Microscopy- Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), scanning probe microscopic techniques, atomic force microscopy (AFM) and scanning tunneling microscopy, particle size analyzer (dynamic light scattering), X-ray diffraction (XRD), auger emission spectroscopy, electron spectroscopy for chemical analysis (ESCA).

Unit IV **(18 hours)**

Carbon Clusters, Inorganic and Organic Nanomaterials: Nature of carbon bond -new carbon structures, Carbon clusters- Discovery of C_{60}, Alkali doped C_{60}, Superconductivity in C_{60}, larger and smaller fullerenes.
Inorganic nanomaterials − nano TiO_2 / ZnO/CdO/CdS.
Organic nanomaterials – Rotaxanes and Catenanes.

Unit V **(18 hours)**

Nanomedicine and Nanodevices : DNA as a nanomaterial, DNA - knots and junctions, DNA-nanomechanical device, Force measurements in simple protein molecules and polymerase - DNA complexes, molecular recognition and DNA based sensor, protein nano array, nanopipettes, molecular diodes, self-assembled nano transistors, nanoparticle mediated transfection, Molecular nanotechnology -MEMS, NEMS, nanofluidics and microfluidics, self-assembly of nanoparticles for biomedical applications, nanomolecular diagnostics and biosensor nanodiagnostics. Smart delivery system in agriculture -Nanofertilizers- Nanourea and mixed fertilizers - Nanopesticides.

Course Outcomes:

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

CO1: Understand the developments in nanotechnology and know about the significance of 1D, 2D and 3D nanoparticles
CO2: Apply the theoretical concepts to study the properties of nano materials
CO3: Analyse the nanomaterials using different microscopic techniques
CO4: Compare the various types of carbon/inorganic nanoparticles
CO5: Discuss the recent development in nano-medicine

Text Book:

1. Dr. A.K. Bandyopadhyay, *Nano Materials*, 2nd Edition, 2020.

Reference Books:

1. G.Cao, Nanostructures and Nanomaterials: *Synthesis, Properties and Applications*, Imperical College Press, 2011.
2. K.K. Choudhary, *Nanoscience & Nanotechnology*, Narosa Publishing House Pvt.Ltd-New Delhi 2016.

Journals:

1. Journal of Nano science
2. International Journal of Nano Science and Nano Technology
3. Journal of Nano Science

E-Resources:

1. https://web.pdx.edu/~pmoeck/phy381/intro-nanotech.pdf
2. http://web.pdx.edu/~pmoeck/phy381/workbook%20nanoscience.pdf

3. https://lkouniv.ac.in/site/writereaddata/siteContent/20200412080803947 4anupam_tripathi_engg_Nanotechnology.pdf
4. http://www.ggu.ac.in/download/Class-Note13/Intriduction%20to%20Nanosc.24.10.13.pdf
5. https://www.pdfdrive.com/search?q=Synthesis+of+Nanomaterials&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	9	3	3	9	3	**45**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	1	9	1	9	9	9	**47**
CO4	9	3	3	3	3	3	3	**27**
CO5	9	9	3	3	3	1	3	**31**
Total	**45**	**25**	**33**	**13**	**27**	**33**	**27**	**201**

Low-1 Medium-3 High-9

Discipline Specific Elective III (B) – Material Chemistry

(For Students Admitted from 2022-23**)**

Semester: III **Hours/Week: 6**
Subject Code: HMCHE3B **Credit: 5**

Course Objectives:

1. To understand the basic concept of structure of matter and their various properties
2. Experimental techniques for controlling the chemical reactions

Unit I **(18 hours)**

Structure of Matter: Atomic structure -Wave mechanical model, electronic configurations, ionic, covalent, metallic and secondary bond, space lattices and crystallographic systems, influence of radius ratio on coronation, structure of common metallic, semi conducting, ionic, polymeric and ceramic materials.

Use of X-ray diffraction for determination of simple structures, point, line and surface defects, geometry of edge and screw dislocations, Burger's vector, grain and twin boundaries.

Unit II **(18 hours)**

Diffusion Behaviour: Mechanism of diffusion Fick's laws, solution to Fick's second law, surface and grain boundary diffusion, experimental determination of diffusion coefficient.

Phase behavior – solid solutions - intermediate phases and intermetallic compounds, phase rule, binary phase diagrams like Cu-Ni, Pb-Sn, Cu-Zn and Fe-C, transformation in steels, nucleation and growth phenomena, solidification including directional solidification, crystal growth, zone melting and purification.

Mechanical properties – Elastic, anelastic and viscoelastic behaviours of materials, atomic model of elastic behaviours, rubber – like elasticity, relaxation processes, displacement model for viscoelasticity, plastic deformation, slip systems in crystals, critical resolved shear stress, work hardening, strengthening mechanism, ductile and brittle fracture, Griffith's criterion, failure of materials due to creep and fatigues, deformation behaviours of polymers and ceramics.

Unit III **(18 hours)**

Electrical Properties: Electrical / Electronic behaviours of materials, electronic and ionic conductivity, free electron and band theory of solids, intrinsic and extrinsic semiconductors, conduction mechanisms, junctions and devices, viz-diodes, rectifiers, transistors and solar cells; super conductivity.

Dielectric Behaviours of Materials: Polarization phenomena, polarizability, frequency and temperature dependence of dielectric constant.

Unit IV **(18 hours)**

Magnetic Properties: Magnetic behaviours of materials– dia, para, ferro and ferri magnetisms, soft and hard magnetic materials including ceramic magnets.

Optical Properties: Optical properties of materials, elementary ideas about absorption, transmissions and reflection refractive index, lasers and their application, optoelectronic devices.

Thermal Properties: Thermal properties of materials, specific heat, thermal conductivity and thermal expansions.

Unit V **(18 hours)**

Thin Film Deposition Techniques: Introduction - CVD, PVD, Spray pyrolysis, sputtering, molecular beam epitaxy electroplating and electroless plates methods.

Materials characterization techniques - Materials characterization techniques such as XRD, ESCA, XPS, AES, FTIR and laser Raman spectroscopy. Microscopic techniques - SEM, AFM and TEM, Thermal analysis - TG/DTA and DSC.

Course Outcomes:

After successful completion of this course, students will be able to

CO1: Understand the basic concept of structure of matter and list their various properties

CO2: Apply the related experiments for their research work

CO3: Analyze the experimental techniques for controlling the chemical reactions

CO4: Determine the mechanism of chemical reactions for optimizing the experimental conditions

CO5: Discuss the thin film deposition techniques and their characterization

Text Book:

1. Klaus Friedrich, Gennady E. Zaikov , A.K Gahi, *Material Chemistry*, Apple Academic Press; 1st edition, 2016.

Reference Books:

1. Bipin Thakur, *Basics of Material Science & Engineering*, IES Master Publication, 2019.
2. G.K. Naru;a, K.A. Narula, V.K. Gupta, *Material Science*, Mc. Graw Hill Education, 2017.

Journals:

1. Materials Chemistry and Physics
2. Materials Today Chemistry
3. The Journal of Materials Science

E-Resources:

1. https://www.powershow.com/view/3c3c28-OGIxM/Materials_Chemistry_Structure_and_Properties_of_Solids_powerpoint_ppt_presentation

2. https://powerpoint.crystalgraphics.com/templates/search/material+chemistry-powerpoint-templates
3. https://www.pdfdrive.com/search?q=Magnetic+optical+and+thermal+properties+of+materials&pagecount=&pubyear=&searchin=&em=
4. https://www.pdfdrive.com/search?q=Diffusion+Behaviour+of+materials&pagecount=&pubyear=&searchin=&em=
5. https://www.pdfdrive.com/search?q=Structure+of+Matter&pagecount=&pubyear=&searchin=&em=

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	1	3	3	1	3	**29**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	9	9	3	9	3	3	**45**
CO4	9	1	9	1	9	9	9	**47**
CO5	9	3	3	3	3	1	1	**29**
Total	**45**	**25**	**31**	**13**	**33**	**23**	**25**	**201**

Low-1 Medium-3 High-9

Core-XIII– Project

(For Students Admitted from 2022-23**)**

Semester: IV **Hours/Week: 30**
Subject Code: HMCHC41PW **Credit: 15**

Course Objectives:

1. To gain the hands on experience of different instruments and will give the exposure of research potential
2. To enable students to measure various physical and chemical properties

The program encourages the students to experience the research in the field of chemistry. A project work to be done individually by the students either in the department laboratory or in a chemical industry or in institutions like CECRI, Agricultural research station, Water testing centres, pharmaceutical laboratories etc. The project work should help the students to create research attitude and apply that theory they have learnt throughout the course.

Evaluation Scheme: Project internal is evaluated on the basis of presentation of the project such as, follow review 75 marks, dissertation (record) 20 marks and 5marks for attendance.
The external 100 marks is distributed as follows, for dissertation and lab record 40 marks, for presentation 30 marks and for viva- voce 30 marks.

Course Outcomes:

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

CO1: Understand the basic concepts in chemistry project and list the literature background of the work

CO2: Apply the related protocol for their research work

CO3: Explain the optimization parameters to identify the reaction conditions

CO4: Evaluate the principles and procedures employed in the thesis writing
CO5: Synthesis the novel compound and study their properties

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	9	9	9	9	9	**63**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	9	9	9	9	9	9	**63**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**27**	**45**	**27**	**45**	**45**	**45**	**279**

Low-1 Medium-3 High-9

Extra Credit-IV – Agricultural Chemistry

(For Students Admitted from 2022-23**)**

Semester: IV **Credit: 2**
Subject Code: HMCHX4

Course Objectives:

1. To acquire the knowledge of soil fertility and soil productivity
2. To learn mode of action of soil and fertilizer phosphorus

Unit I

Soil Chemistry: Chemical (elemental) composition of the earth's crust and soils, elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics, Soil organic matter-classification, fractionation of soil organic matter and different fractions, genesis and nature of soil organic matter and humus formation, humus decomposition, separation of humus from soil particles, clay-organic interactions.

Unit II

Soil fertility and Soil Productivity: Nutrient sources-fertilizers and manures, essential plant nutrients – functions and deficiency symptoms, law of soil fertility soil and fertilizer nitrogen- sources, forms, immobilization and mineralization, nitrification, denitrification, biological nitrogen fixation, nitrogenous fertilizers and their fate in soils, management of nitrogenous fertilizers.

Unit III

Soil and Phosphorous Fertilizer: Forms, immobilization, mineralization, reactions in acids and alkali soils, factor affecting on availability in soils, phosphatic fertilizers- behaviour in soils and management under field conditions, potassium - forms, equilibrium in soils and its significance, mechanism of potassium fixation, management of potassium fertilizers under field conditions.

Unit IV

Sulphur, Calcium and Magnesium: Source, forms, fertilizers and their behaviour in soils, factors affecting their availability in soils, management of fertilizers, Micronutrients-critical limits in soils and plants, factors affecting their availability and correction of their deficiencies in plants, role of chelates in nutrient availability.

U**nit** V

Chemistry of acids soils: Active and potential acidity, lime potential, sub-soil acidity, chemistry of salt-affected soils and amendments, soil pH, ECE, ESP, SAR and important relations, soil management and amendments, chemistry and electrochemistry of waterlogged soils.

Course Outcomes:

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

CO1: Define soil chemistry and understand the concepts of soil fertility and productivity

CO2: Identify the suitable fertilizers available in soils

CO3: Analyse the soil samples for the nutrient contents

CO4: Compare the knowledge of insecticides, fungicides and herbicides

CO5: Discuss the importance of calcium, sulphur and magnesium

Text Book:

1. Ajay Singh, *Agricultural Chemistry*, Pushbanjali Prakashan, Ist Edition, 2019.

Reference Books:

1. K. Mengel and E. A. Kirkby, *Principles of Plant Nutrition*, International Potash Institute, Switzerland, 2001.
2. G.M. Pierzinsky, T. J. Sims and J. F. Vance, *Solis and Environmental Quality*, CRC Press, 2nd Edition, 2002.
3. Beaton D. James, Tisdale L. Samuel, Werner Nelson and L. John Havlin, *Soil Fertility and Fertilizers: An Introduction to Nutrient Management*, Pearson College Div. Publications, 7th Edition, 2004.

Journals:

1. Journal of Agricultural and Food Chemistry
2. The Journal of the Science of Food and Agriculture
3. Journal of Agricultural and Environmental Ethics

E-Resource:

1. https://www.slideshare.net/mzk57/agricultural-chemistry-147003348
2. https://www.pdfdrive.com/search?q=Soil+and+Phosphorous+Fertilizer&pagecount=&pubyear=&searchin=&em=
3. https://www.pdfdrive.com/search?q=Soil+fertility+and+Soil+Productivity&pagecount=&pubyear=&searchin=&em=
4. https://www.pdfdrive.com/search?q=Sulphur%2C+Calcium+and+Magnesium&pagecount=&pubyear=&searchin=&em=&more=true
5. https://www.pdfdrive.com/search?q=Chemistry+of+acids+soils&pagecount=&pubyear=&searchin=&em=

Course Outcomes	**Programme Outcomes**							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	1	3	3	1	1	**27**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	1	9	1	9	1	3	**33**
CO4	9	3	9	1	9	1	3	**35**

CO5	9	3	3	3	3	1	3	**25**
Total	**45**	**19**	**33**	**11**	**33**	**13**	**19**	**171**

Low-1 Medium-3 High-9

B. Sc. CHEMISTRY
(Three Years Regular Programme)
(For Student Admitted from 2022-23)

PSO1:Understand basic concepts of Organic, Physical, Inorganic, Environmental, Computational and Analytical chemistry.
PSO2:Develop skills in the safe-handling of chemicals, taking into account of their characteristic properties including any particular hazards.
PSO3:Ability to apply the basic principles of different analytical methods to identify the properties of the compounds.
PSO4:Establish and convey the relevance of chemistry to global issues towards sustainable future through effective written, virtual communications and interact productively with people from varied backgrounds.
PSO5:Students will be applying appropriate methods of qualitative and quantitative analysis to estimate inorganic salt mixtures and organic compounds in practical classes.
PSO6:Students will learn to synthesize the new compounds by making correct choice of the reagents and find the optimum reaction conditions.
PSO7:Develop practical skills and knowledge in chemistry which helps student in their employability.

Preamble

The following changes were introduced in the curriculum for the candidates to be enrolled from June 2022.

- Introduced new skill enhancement course in IV semester on Computer Fundamentals and C Programming.
- Changed the laboratory course on Industrial and inorganic chemistry combined with physical chemistry practicals.
- Physical Chemistry practicals has been modified as Advanced Physical Chemistry Practical allotted for the V Semester.
- Revised the syllabus content of the Skill Enhancement Course - II - Fundamentals of applied Chemistry (II Semester)
- Included Composite materials in Unit -III instead of Composite materials.
- Skill Enhancement Course-V- Selected topics in Applied Chemistry (V semester) – In Unit-V detail content of insecticides, fungicides and herbicides were replaced with vermiculture.
- In Unit-IV the content on Fertilizer Industry was replaced with Insecticides, Fungicides and Herbicides.
- Included the Journals list in the reference part for all the course content.

- ❖ Extra credit course-V-Chemistry of Consumer Products (III Semester) - reduced the course content in Unit-I on glass by removing the following topics, special glasses - optical glass, Borosilicate Glass, Soda Lime Glass, coloured Glass, Optical Glass, Opal Glass, Fiber Glass, Bullet Resistant Glass, Glass Wool, Photosensitive Glass, Photochromic Glasses and Insulating Glasses and reduced the syllabus content.

- ❖ Extra credit course-V - Chemistry of Consumer Products (III Semester)-Unit - II - removed the following content on ceramics - Firing, Glazing, Frits and Decoration, Application of color to pottery, porcelain and china - raw materials and manufacture of earthen wares and stone wares. Replaced the unit title Ceramic instead of Ceramic Industry.

- ❖ Extra credit course-V-Chemistry of Consumer Products (III Semester)-In Unit - III - Unit title Alkali and Chlorine was replaced with Chlor- Alkali.

- ❖ Extra credit course-V-Chemistry of consumer products (III Semester)-In Unit -IV- title was changed from "Petroleum and Petroleum Products" to "Petroleum Products". In addition to the title, Unit content on "Petroleum-preparation of petroleum for processing, distillation of crude petroleum, various fraction of composition and uses, Treatment of the residual liquid, Processing of liquid fuels such as petroleum and petroleum products" replaced with "origin, formation and evaluation of crude oil, refining of petroleum - atmosphere and vacuum distillation methods. Treatment method for the removal of sulphur compounds -solvent treatment process. Petroleum chemical product - DMT, MMA and formaldehyde."

- ❖ Extra credit course-V - Chemistry of consumer products (III Semester) - In Unit - V - The title "Cottage Industry" was replaced with "Cottage Industrial Products".

Programme Structure
Program code: UCH

Sem.	Part	Subject Code	Course	Subject Title	Hrs./ wk.	Credit	CIA	ESE	Total
I	I	IBLT11/ IBLA11/ IBLH11	Language - I	Tamil-I /Arabic-I / Hindi-I	5	3	40	60	100
	II	IBLEI12/ IBLEII12	Language -II	English I a or b	5	3	40	60	100
	III	IBCHC11	Core -I	General Chemistry	5	4	40	60	100
		IBCHC12	Core -II	Inorganic Chemistry - I	6	5	40	60	100
		IBCHA13/ IBCHA14	AECC - I	Mathematics-I/ Biochemistry-I	5	4	40	60	100
	IV	IBCHS15P	SEC - I	Preparation of Consumer Products practicals	2	2	-	50	50
				Library/Browsing	1	-	-	-	-

				Games/Remedial	1				
				Total	**30**	**21**	**200**	**350**	**550**
II	I	IBLT21/ IBLA21/ IBLH21	Language -I	Tamil-II /Arabic-II /Hindi-II	5	3	40	60	100
	II	IBLEI22/ IBLEII22	Language-II	English II a or b	5	3	40	60	100
	III	IBCHC21P	Core -III	Inorganic Qualitative Analysis and Volumetric Analysis practicals	6	5	40	60	100
		IBCHC22	Core -IV	Physical Chemistry-I	4	4	40	60	100
		IBCHA23/ IBCHA24	AECC-II	Mathematics-II/ Biochemistry-II	5	4	40	60	100
	IV	IBCHS25	SEC-II	Fundamentals of Applied Chemistry	2	2	-	50	50
		IBES2	General Interest Course - I	Environmental Science	2	2	-	50	50
		IBCHX2/ IBCHX2O	Extra Credit-I	Food Chemistry/online course*	-	2	-	100	100
				Games/Remedial	1	-	-	-	-
				Total	**30**	**23 + 2**	**200**	**400 + 100**	**600 + 100**
III	I	IBLT31/ IBLA31/ IBLH31	Language - I	Tamil III /Arabic - III / Hindi-III	5	3	40	60	100
	II	IBLEI32/ IBLEII32	Language -II	English III a or b	5	3	40	60	100
	III	IBCHC31	Core-V	Organic Chemistry - I	4	4	40	60	100
		IBCHC32P	Core -VI	Organic Analysis & Organic Estimation practicals	4	4	40	60	100
		IBCHA33	AECC - I	Pharmaceutical Chemistry-I	4	4	40	60	100
	IV	IBCHS34	SEC-III	Introduction to Marine Chemistry - # internship	2	2	-	50	50
			OEC-I		2	2	-	50	50
		IBHR3	General Interest Course -II	Human Rights	2	2	-	50	50
		IBXTN3	Extension Activities	NSS/CSS	2	2	100	-	100
		IBCHX3/ IBCHX3O	Extra Credit-II	Chemistry of Consumer Products/online course*	-	2	-	100	100
					30	**26**	**300**	**450**	**750**

				Total		**+ 2**		**+ 100**	**+ 100**
	I	IBLT41/ IBLA41/ IBLH41	Language -I	Tamil IV /Arabic IV /Hindi-IV	5	3	40	60	100
	II	IBLEI42/ IBLEII42	Language -II	English IV a or b	5	3	40	60	100
IV	III	IBCHC41	Core -VII	Inorganic Chemistry -II	5	4	40	60	100
		IBCHC42	Core-VIII	Organic Chemistry - II	4	4	40	60	100
		IBCHA44	AECC-II	Pharmaceutical Chemistry-II	5	4	40	60	100
	IV	IBCHS45	SEC - IV	Computer Fundamentals and C Programming	2	2	-	50	50
		IBLVE4	General Interest Course-III	Life Skills and Value Education	2	2	-	50	50
			OEC-II		2	2	-	50	50
		IBCHX4/ IBCHX4O	Extra credit-III	Dairy Chemistry/online course*	-	2	-	100	100
				Total	**30**	**24 + 2**	**200**	**450 + 100**	**650 + 100**
V	III	IBCHC51	Core-IX	Physical Chemistry – II • Integrated with online course	6	5	40	60	100
		IBCHC52	Core-X	Organic Chemistry - III	6	5	40	60	100
		IBCHC53P	Core-XI	Advanced Physical Chemistry practicals	6	5	40	60	100
		IBCHE5A/ IBCHE5B	DSE-I	a. Industrial Chemistry/ b. Biological Chemistry	4	4	40	60	100
		IBCHE5C/ IBCHE5D	DSE-II	a. Textile Chemistry/ b. Analytical Methods - # internship	4	4	40	60	100
	IV	IBCHS54	SEC - V	Selected topics in Applied Chemistry	2	2	-	50	50
		IBWE5	General Interest Course -IV	Women Entrepreneurship	2	2	-	50	50
		IBCHX5/ IBCHX5O	Extra Credit-IV	Employability Skills /online Course*	-	2	100	-	100
				Total	**30**	**27 + 2**	**200 + 100**	**400**	**600 + 100**
		IBCHC61PW	Core-XII	Project	6	5	40	60	100
		IBCHC62	Core-XIII	Inorganic Chemistry – III	5	4	40	60	100

VI	III			• Integrated with online course					
		IBCHC63	Core -XIV	Physical Chemistry - III	6	4	40	60	100
		IBCHC64P	Core-XV	Gravimetric Analysis and Organic preparation practicals	6	5	40	60	100
		IBCHE6A/ IBCHE6B	DSE-III	a. Introduction to Green Chemistry and Nano Chemistry/ b. Polymer Chemistry	4	4	40	60	100
	IV	IBCHS65P	SEC-VI	Industrial Chemistry practicals	2	2	-	50	50
		IBCHX6/ IBCHX6O	Extra credit-V	Industrial Training Report/online course*	-	2		100	100
				Library/ Browsing	1	-	-	-	-
				Total	**30**	**24 + 2**	**200**	**350 + 100**	**550 + 100**
				Grand Total	**180**	**145 + 10**	**1300 + 100**	**2400 + 400**	**3700 + 500**

AECC - Ability Enhancement Compulsory Course; SEC - Skill Enhancement Course; DSE - Discipline Specific Elective; OEC - Open Elective Course ∗For online certification credit alone will be assigned on submission of certificate obtained through appearing for online examination from Spoken Tutorial, SWAYAM, EDX, NPTEL, or Coursera. #- CIA internship program will be arranged for the student with Aquagri/CECRI/MKU/NITT

Core-I - General Chemistry

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 5**
Subject Code: IBCHC11 **Credit: 4**

Course objectives:

1. To understand basic concepts of nuclear chemistry, organic chemistry and thermodynamics
2. To gain knowledge on atomic structure and sub atomic particles

Unit I **(15 hours)**

Atomic Structure: Historical Development, Dalton's atomic theory, Limitation of Dalton's atomic theory. Electron - its discovery and properties, e/m ratio of an electron by Thomson's method, Charge on an electron

by Milliken's oil drop method. Proton - its discovery and properties, Thomson's Atomic model and its drawbacks, Rutherford's alpha particles scattering experiments, Rutherford's atomic model and its drawbacks, Prouty's hypothesis, Moseley experiment, and its importance. Neutron-its discovery and properties, Atomic spectra, Ritz-combination principle. Bohr's model of Hydrogen atom-Postulates, derivation for its radius and energy, and limitations of Bohr's theory, Quantum number, Pauli's Exclusion principle, Hund's principles of maximum multiplicity and Aufbau's principle. Application - spectra and ionization potential of hydrogen.

Unit II **(15 hours)**

Basic Concepts of Organic Chemistry: IUPAC-Nomenclature of organic compounds; Molecular weight determination of organic acids and bases-Silver salt and platonic chloride methods; Problems arriving empirical and molecular formula using percentage composition of elements and molecular weight. Fundamental concepts-homolytic fission and heterolytic fission of carbon-carbon bonds. reaction intermediates-formation and stability of free radicals, carbonium ions, carbanions, nucleophilic and electrophilic reagents. Types of reactions-substitution, addition, elimination, rearrangement and polymerization with suitable examples. Inductive effect and Electrometric effect-explanation with suitable examples.

Unit III **(15 hours)**

Nuclear Chemistry: Constitution of nuclei, stability of nuclei and (n-p) ratio, Magic number, Mass defect, and Binding energy, Mass - Energy relationship. Radioactivity -Natural radioactivity, Soddy's group displacement law, Radioactivity equilibrium, rate of radioactive disintegration, Half-life period and average life period, radioactive disintegration series.

Nuclear fission - Theory, applications, principle of the atom bomb. Nuclear fusion-theory, solar and stellar energy, Principle of a Hydrogen bomb. Applications of radioactivity–medicine, agriculture, industry, rock dating, and Carbon dating, particle accelerators - linear accelerator and cyclotron.

Unit IV **(15 hours)**

Thermodynamics: Definition of thermodynamics term, system, surroundings, types of systems, intensive and extensive properties, State and path functions and their differential, thermodynamic processes, concept of heat, and work. First law of thermodynamics -statement and mathematical form, definition of internal energy and enthalpy, calculation of w, q, ΔE and ΔH for the expansion of ideal gases under isothermal and adiabatic conditions for a reversible process, Bond dissociation energy and its calculation from thermochemical data, Work obtained during adiabatic and isothermal change; Heat capacity - Heat capacities at constant volume and pressure and their relationship $C_p - C_v = R$; Joule's law- Joule Thomson coefficient and inversion temperature (only definition). Zeroth Law of Thermodynamics - Mathematical treatment of Zeroth law and its limitation and various statements of law.

Unit V **(15 hours)**

Acid-Base Reactions and Computer Programming: Acid-base Concept - Arrhenius concept, Theory of solvent system in H_2O, NH_3, SO_2, and HF, Bronsted - Lowry's concept, relative strength of acids, Pauling rules, amphoterism, Lux-Flood concept, Lewis concept, super acids, HSAB principle, acid-base equilibria in aqueous solution and pH. Acid-base neutralization curves - indicator, Choice of indicators.

Introduction to BASIC programming - Application of BASIC computer programming in the computation of some simple parameters such as Half-life period, Normality and Molarity of a solution.

Course Outcomes:

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

CO1: Recollect the historic development subatomic particles and comprehend the IUPAC-nomenclature of organic compounds

CO2: Identify the acid base nature of the solution medium with insight gained from the theories

CO3: Analyse atomic structure theories and make inferences

CO4: Determine the Enthalpy of the reaction by applying acquired knowledge on thermodynamics

CO5: Create awareness about radioactive elements and ill effects on human and environment

Text Books:

1. Arun Bahl, B. S. Bahl, G.D. Tuli**,** *Essentials Of Physical Chemistry***,** S. Chand & Company Ltd., New Delhi, 2020**.**
2. Arun Bahl and B. S. Bahl, *Text book of Organic Chemistry* S. Chand & Company Ltd., New Delhi, 2019. [Chapter 1, 2, 4, 7, 8 & 27]

Reference Books:

1. M.S. Chouhan, *Organic Chemistry (*New edition) for JEE (Main & Advanced) Wiley's Solomons & Fryhle, 3rd Edition, 2018.
2. M. K. Jain and S. C. Sharma**,** *Modern organic chemistry***,** Vishal Publishing & co, 2020.
3. Hari Jeevan Arnikar, *Nuclear chemistry Through Problems***,** New Age International Private limited, 2016.

Journals:

1. Russian Journal of General Chemistry
2. Journal of general chemistry
3. Journal of chemistry Education

E-Resources:

1. https://www.univie.ac.at/zbph/broda/dokumente/160-Nuclear_Chemistry.pdf
2. http://www.phys.ens.fr/~ebrunet/Thermo-en.pdf
3. https://docplayer.net/amp/20852352-Chemistry-3202-Unit-2-acids-and-bases.html
4. https://chem.libretexts.org/Bookshelves/General_Chemistry/
5. https://chemistrydocs.com/essentials-of-physical-chemistry-by-arun-bahl-b-s-bahl-g-d-tuli/

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	1	3	3	3	**25**
CO2	9	3	9	1	3	9	3	**37**
CO3	9	3	9	1	3	3	3	**31**
CO4	9	3	9	1	3	9	3	**37**
CO5	9	9	3	9	3	9	3	**45**
Total	**45**	**21**	**33**	**13**	**15**	**33**	**15**	**175**

Low-1 Medium-3 High-9

Core-II - Inorganic Chemistry–I

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 6**
Subject Code: IBCHC12 **Credit: 5**

Course objectives:

1.To enable students to understand the periodic properties of ionic radii, covalent radii, electronegativity
2. To learn principles of volumetric and qualitative analysis

Unit I **(18 hours)**

Periodic Properties: Atomic and ionic radii, determination of covalent radii, ionic radii, radius ratio, factors influencing the magnitude of ionic radii, periodic variation of atomic and ionic radii, ionisation potential and its periodic variations, applications to the concept of ionization potential; electron affinity-factors influencing the magnitude of electron affinity, periodic variation of electron affinity, impact of electron affinity on chemical behaviour, electronegativity-scales of electronegativity, Pauling's bond energy scale, Mulliken scale, Allred Rochow electrostatic approach, correlation of ionization potential and electron affinity with electronegativity, relation between oxidation state of the element and its electronegativity, applications of electronegativity concept.

Unit II **(18 hours)**

Chemical Bonding: Ionic bond - lattice energy and its determination using Born-Haber Cycle. Covalent bond- Fajan's rule and its applications. Theories of covalent bonding - Heitler-London theory and Pauling theory, types of overlapping, Sigma and Pi bonds, Formation of simple molecules like H_2, HF, F_2, N_2 and O_2.The geometry of molecules and hybridization- hybridisation of orbitals. sp, sp^2, sp^3 - hybridisation with examples- shapes of the hybridized molecule. VSEPR theory – geometry of H_2O and NH_3 molecular orbital theory–M.O diagram of H_2, O_2, N_2, F_2, CO, and HF. Metallic bond - introduction, properties of metallic bond. Non covalent interactions- elementary ideas of hydrogen bonding, Van der Waal's forces, Keesom forces, Debye and London forces.

Unit III **(18 hours)**

Hydrogen, H_2O_2, H_2O, O_2 & O_3: Hydrogen – Hydrides - Ionic, Covalent, Metallic and polynuclear hydrides, $LiAlH_4$ and $NaBH_4$. Hydrogen peroxide - preparation, reactions and estimation. Water - hardness of water, water softening processes, ion-exchange & reverse osmosis process, preparation, properties & uses of heavy water.

Oxygen – Oxides, classification of oxide. Ozone -preparation.

Unit IV **(18 hours)**

Metallurgy & IA Group Elements: Metallurgy - definition of metallurgy, minerals, and ores, grinding, pulverizing, ore dressing - gravity separation, hydraulic washing, froth floatation, magnetic separation and chemical separation, roasting, and calcination, reduction of minerals to metal - Carbon, Hydrogen, amalgamation process, refining of metals - Electrolytic refining, chromatography, Ion exchange method. I A Group- general properties, diagonal relationship of Li with Mg, comparison with other members of family, extraction, properties, and uses of Li.

Unit V **(18 hours)**

Principles of Volumetric and Qualitative Analysis: Principles of volumetric analysis - Definition of molarity, molality, normality and mole fraction; definition and examples for primary and secondary standards, theories of Iodometric, redox, acid-base, and Iodimetric titrations. Principles of qualitative analysis - inorganic semi-micro Analysis, Semi-Micro Techniques, Principles involved in Sodium Carbonate Extract preparation, Common Ion Effect and Solubility Product and their applications in Qualitative Analysis.

Course Outcomes:

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

CO1: Outline the understanding of chemistry behind the metallurgical process for hydrogen and IA elements

CO2: Identify trends observed along period and group-based periodic properties of elements in the periodic table

CO3: Explain the principles of volumetric & qualitative analysis to find molarity, molality, and normality of given solutions

CO4: Evaluate the MO and VSEPR theory understand nature of the chemical bonding and geometry in the organic and inorganic compounds

CO5: Adapt the correct method for preparation, of hydrogen, hydrogen peroxide, water, oxygen, ozone

Text Books:

1. Joseph William Mellor, *Modern Inorganic Chemistry***,** Palala Press, 2015.
2. B.R. Puri, L.R. Sharma and K.C. Kalia**,** ***Principle of Inorganic Chemistry*****,** Vishal Publication Co., 2020.

Reference Books:

1. P.L. Soni and Mohan Katyal, *Text Book of Inorganic Chemistry*, Sultan Chand & Sons, New Delhi, 2017.
2. A.I. Vogel, *Text Book of Qualitative Inorganic Analysis*, ELBS Longman, London, 2012.
3. F. Albert Cotton, Geoffrey Wilkinson, A. Murillo Carlos & Manfred Bochmann, *Advanced Inorganic Chemistry***,** A Wiley Interscience Publication, New York, 2021.
4. James E. Huheey, Ellen A. Keiter, L. Keiter Richard and K. Medhi Okhil, *Inorganic Chemistry*, Pearson India, 2019.

Journals:

1. Inorganic Chemistry Frontiers
2. Journal of Inorganic chemistry
3. Journal of Chemistry Education

E-Resources:

1. Concise-Inorganic-Chemistry-5th-Edition-pdf.pdf
2. H1-chemical-bonding -Hybridisation.pdf
3. Hydrogen, D2O, H2O2, Water.pdf
4. Ozone preparation.pdf
5. Metallurgy.pdf

Course Outcomes	Programme Outcomes							
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	Total

CO1	9	3	9	3	3	9	3	**39**
CO2	9	3	9	3	3	9	3	**39**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	3	**39**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**15**	**45**	**27**	**207**

Low -1 Medium-3 High-9

Skill Enhancement Course - I – Preparation of Consumer Products Practicals

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 2**
Subject Code: IBCHS15P **Credit: 2**

Course objectives:

1. To acquire knowledge on preparation of consumer products
2. To understand scaling up procedure for consumer products

List of Experiments **(30 hours)**

A Practical Course on the preparation of the following Consumer Products in the Cottage Industry Scale.

1. Preparation of White Phenyl
2. Preparation of Black Phenyl
3. Preparation of Detergent Powder
4. Preparation of Detergent Cake
5. Preparation of Vessel Cleaning powder
6. Preparation of Candles
7. Preparation of Ink
8. Preparation of Talcum Powder
9. Preparation of Chalk.
10. Preparation of Nail Polish

Evaluation Scheme: At the end of the semester, a practical examination for two hours will be conducted for 50 marks.

Course Outcomes:

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

CO1: Recall the principles and relate the preparative procedures for consumer products
CO2: Apply the practical skills in handling chemicals
CO3: Analyse consumer products based on physical characteristics of materials
CO4: Evaluate the scaling up of process required for specific products
CO5: Propose the new additives in arriving new consumer products

Text Book:

1. John Kenkel, *Chemistry An Industry-Based Laboratory*, Taylor & Francis Publisher, 2020

Reference Books:

1. Ranjan Kumar Mohapatra, *Engineering Chemistry with Laboratory Experiments*, PHI Learning, 2015.

2. Shashi Chawla, *Textbook of Engineering Chemistry with Lab Manual Of Chemistry & Environmental Studies*, Publisher, Dhanpat Rai & Co., 2017.
3. Manoj Kumar Solanki, *Engineering Chemistry Laboratory Manual*, Edu creation Publishing, 2019.

Journals:

1. African Journal of Educational Studies in Mathematics and Sciences
2. Journal of Chemistry Education
3. Journal of cosmetic dermatology

E- Resources:

1. https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.aphis.usda.gov/animal_health/emergency_management/downloads/sop/sop_cd.pdf&ved=2ahUKEwjZrvTEvpzxAhWRA3IKHfZxDYcQFjAAegQIAxAC&usg=AOvVaw3hU7e5hL-hJz6Vu0-SkhYC
2. https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.naturesgardencandles.com/mas_assets/media/pdf/manual.pdf&ved=2ahUKEwiZ2pOYv5zxAhW_yzgGHfDmA64QFjAAegQIAxAC&usg=AOvVaw1hwVIp0-YTGIwl7LdraOJp
3. https://www.google.com/url?sa=t&source=web&rct=j&url=https://chem.ku.edu/sites/chem.ku.edu/files/docs/CHEM190/printing_ink.pdf&ved=2ahUKEwiM2M7Uv5zxAhXLxzgGHaFyCMcQFjAMegQIGRAC&usg=AOvVaw0wveersqP8h_7GlKwGUQqS
4. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/cosmeticsfornail.pdf
5. https://www.allaboutchemistry.net/preparation-soaps-nail-polish-boot-polish-varnish-nail-remover-shampoo-perfumes-isc-chemistry-project/

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	3	9	**39**
CO2	9	3	9	9	3	9	9	**51**
CO3	9	3	9	9	3	9	9	**51**
CO4	9	3	9	9	3	9	9	**51**
CO5	9	3	9	9	3	9	9	**51**
Total	**45**	**15**	**45**	**39**	**15**	**39**	**45**	**243**

Low-1 Medium-3 High-9

Core-III - Inorganic Qualitative Analysis and Volumetric Analysis Practicals

(For Students Admitted from 2022-23)

Semester: II **Hours/Week: 5**
Subject Code: IBCHC21P **Credit: 5**

Course objectives:

1. To gain practical skills in handling apparatus to minimize errors
2. To apply principles of qualitative and quantitative analysis in identify and quantify salt in solutions

List of Experiments

1. Inorganic Qualitative Analysis: (30 hours)

(Any five Combination of cations and anions)

Mixtures containing two cations and two anions (one interfering ions).

Cations: Lead, Bismuth, Copper, Cadmium, Arsenic, Antimony, Iron (II and III), Aluminium, Chromium, Zinc, Manganese, Cobalt, Nickel, Barium, Strontium, Calcium, Magnesium and Ammonium.
Anions: Carbonate, Sulphide, Nitrate, Sulphate, Bromide, Iodide, Arsenate and Chromate.
Interfering ion: Fluoride, Oxalate, Borate and Phosphate.

2. Volumetric Analysis: **(45 hours)**
(Any Six Titrimetry)

a. Acid – Base:

1. Estimation of Sodium Hydroxide or Potassium Hydroxide (Standard AR Sodium Carbonate)
2. Estimation of Hydrochloric acid or Sulphuric acid (Standard AR Oxalic acid)
3. Estimation of a mixture of Sodium Hydroxide and Sodium Carbonate

b. Permanganometry:

4. Estimation of Ferrous ion
5. Estimation of Calcium (direct Method)
6. Estimation of Hydrogen Peroxide

c. Dichrometry:

7. Estimation of Ferrous ion
8. Estimation of Ferric ion using external indicator (demonstration only)

d. Iodometry and Iodimetry:

9. Estimation of Potassium dichromate
10. Estimation of Potassium permanganate
11. Estimation of Copper
12. Estimation of Arsenous oxide

e. Argentimetry:

13. Estimation of Potassium Chloride (standard AR Sodium Chloride) - demonstration only

Evaluation Scheme: 3 hrs. for volumetric analysis and 3hrs. for qualitative analysis for 30 marks each. Duration of Examination - 6 hrs.

Course Outcomes:

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

CO1: List the principle behind qualitative of inorganic compounds and understand the nature of interfering ions
CO2: Illustrate the volumetric law to quantify the solute in solutions.
CO3: Examine the inorganic salt mixture for their cations and anions
CO4: Compare the volumetric analysis based on the type of reaction and identify indicator requirements
CO5: Design the volumetric procedure based on the nature of the solution

Reference Books:

1. V. Venkateswaran, R. Veeraswamy & A. R. Kulandaivelu, *Basic Principles of Practical Chemistry*, Sultan Chand & Sons Publications, New Delhi, 2017.
2. Y. Shi**,** *Text Book of Quantitative Chemical Analysis*- Auris Publishing**,** 2017.

Journals:

1. African Journal of Educational Studies in Mathematics and Sciences
2. Journal of chemistry Education
3. International Journal of Science and Qualitative Analysis

E-Resource:

1. http://www.rbmcollege.ac.in/sites/default/files/files/reading%20material/inorganic-qualitative-analysis.pdf
2. https://www.sciencedirect.com/topics/chemistry/volumetric-analysis
3. https://www.pharmaguideline.com/2021/10/cerimetry-iodimetry-iodometry-bromometry-dichrometry.html
4. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Qualitative_Analysis
5. https://pubs.acs.org/doi/10.1021/ed081p725

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	3	**39**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**15**	**45**	**39**	**219**

Low-1 Medium-3 High-9

Core-IV - Physical Chemistry–I

(For Students Admitted from 2022-23)

Semester: II **Hours/Week: 4**
Subject Code: IBCHC22 **Credit: 4**

Course objectives:

1. To gain basic knowledge on laws those govern thermodynamics.
2. To understand the fundamental concepts in quantum chemistry, gaseous state, adsorption and phase rule

Unit I **(12 hours)**

Quantum Chemistry & Gaseous State: Quantum theory of radiation, The Sommerfield extension of Bohr theory, Planck's theory, Photoelectric effect, Compton effect, Wave mechanical concept of the Atom, De-Broglie's Relationship, Davisson and Germer Experiment, wave nature of electron, Heisenberg's Uncertainty Principle, Schrodinger Wave Equation (Without Derivation), Significance of Wave Functions, ψ^1 and ψ^2, Probability distribution of electrons, radial probability distribution curves. Gaseous state– Kinetic gas equation, derivation, gas laws from the kinetic gas equation, kinds of velocities - Mean, RMS, Most probable velocities, calculation of molecular velocities, Maxwell's distribution of molecular velocities (no derivation).

Unit II **(12 hours)**

Second Law of Thermodynamics: Second Law of Thermodynamics-need for the II law, Spontaneous process, criteria of spontaneity, different forms of statements of the second law, cyclic process, Heat Engines, Carnot's cycle, Efficiency - Carnot's theorem (statement only), Concept of entropy- definition and mathematical statement, randomness, and entropy; standard entropy -derivation of entropy from carnot cycle, entropy change of an ideal gas during isothermal process, entropy changes in cyclic - reversible and

irreversible processes, entropy changes in physical transformations, calculation of entropy changes with changes in T, V and P, entropy of mixing of ideal gases; free energy and work function, gibbs free energy, Helmholtz work function-their variations with temperature, pressure, and volume, criteria for spontaneity, Gibbs-Helmholtz equations - derivation and applications.

Unit III **(12 hours)**

Third Law of Thermodynamics & Liquid Crystals: Third law of thermodynamics - entropy at Absolute zero, planck's formulation of third law, Nernst heat theorem, statement of III law of thermodynamics, evaluation of absolute entropy from heat capacity measurements, exceptions to III law, application of III law; partial molar properties, chemical potential, Gibbs-Duhem Equation, effect of temperature and pressure on chemical potential. liquid crystals - classification and molecular arrangements, liquid state, density, diffusion, viscosity, evaporation; surface tension, effect of temperature on surface tension, parachor - definition and applications only, coefficient of viscosity-effect of temperature and effect of pressure.

Unit IV **(12 hours)**

Colligative Properties & Adsorption: Colligative Properties - lowering of vapour pressure, osmosis, and osmotic pressure, relation between osmotic pressure and vapour pressure of an ideal solution, reverse osmosis; elevation of boiling point and depression of freezing point - derivations and determinations, Vant Hoff Factor . Adsorption - distinction between chemical and physical adsorption, adsorption isotherms, Freundlich adsorption isotherm, Langmuir adsorption isotherm - derivation, Brunauer Emmett Teller (BET) - measurement of surface area.

Unit V **(12 hours)**

Phase Rule: Definition – phase, number of components and number of degrees of freedom, Gibbs phase rule (derivation). One component system - water system, two-component system -reduced phase rule, simple eutectic systems - Pb-Ag system. Systems involving compound formation - congruent and incongruent melting points-Zn-Mg system and dehydration of $CuSO_4.5H_2O$. Distribution law - statement, conditions for the validity of distribution law, thermodynamic derivation, applications of the distribution law.

Course Outcomes:

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

CO1: Recall the meaning of various terms involved in quantum chemistry and relate the physical phenomena

CO2: Apply the concepts of thermodynamics & gaseous state to find thermodynamic parameters

CO3: Assume the concepts of liquid Crystals to derive physical parameters

CO4: Interpret the knowledge about colligative properties & adsorption

CO5: Construct the phase diagram by applying phase rule

Text Books:

1. B.R. Puri, L.R. Sharma and S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co, New Delhi, 2018.
2. Peter Atkins, *Atkins Physical Chemistry*, Oxford University Press, New York, 11th Edition, 2018.

Reference Books:

1. A. S. Nagi and S.C. Anand, *A Text Book of Physical Chemistry*, New age international private Ltd, New Delhi, 2016
2. Donald A. Macquarie, *Quantum Chemistry*, 2016.

3. K. L. Kapoor, *A Textbook of physical chemistry-Quantum Chemistry*, 2020

Journals:

1. Journal of Physical Chemistry A
2. Russian Journal of Applied Chemistry
3. Journal of chemistry Education

E-Resources:

1. DARIN J ULNESS -Physical-Chemistry-Quantum-Chemistry.pdf
2. Gurtu-J-N-Khera-H-C-Physical-chemistry-Vol-III-Pragati-Prakashan-2009-pdf.pdf
3. THERMODYNAMICS-pdf.pdf
4. DARIN J ULNESS -Physical-Chemistry-Quantum-Chemistry.pdf
5. https://chem.libretexts.org/Courses/Pacific_Union_College/Quantum_Chemistry

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	3	**39**
CO2	9	3	9	3	3	9	3	**39**
CO3	9	3	9	3	3	9	3	**39**
CO4	9	3	9	3	3	9	3	**39**
CO5	9	3	9	3	3	9	3	**39**
Total	**45**	**15**	**45**	**15**	**15**	**45**	**15**	**195**

Low-1 Medium-3 High-9

Skill Enhancement Course II - Fundamentals of Applied Chemistry

(For Students Admitted from 2022-23)

Semester: II **Hours/Week: 2**
Subject Code: IBCHS25 **Credit: 2**

Course objectives:

1. To gain basic knowledge on cement and fuels
2. To understand the reason behind corrosion, importance of alloys, paints and composite materials

Unit I **(6 hours)**

Fuels: Definition, types fuels, characteristics, properties, solid fuels (wood and coal) liquid fuels, disadvantages of solid fuels over liquid and gaseous fuels, nuclear fuels, difference between nuclear and chemical fuels.

Unit II **(6 hours)**

Alloys: Introduction, physical and chemical properties of alloys, purpose of making alloys, types of alloys, Ferrous alloys, Copper alloys, Nickel alloys, Nickel-Iron alloys, super alloys, hard alloys, preparation of Alloys.

Unit III **(6 hours)**

Cement: Cement - Manufacture - wet process and dry process, types, analysis of major constituents, setting of cement, reinforced concrete. Cement industries in India.
Composite Materials – Constitution -Matrix, dispersed phase, classification, composite manufacturing methods.

Unit IV **(6 hours)**
Paints & Pigments: Introduction, white pigments, manufacture characteristic of pigments, Lithopone, physical properties of pigments, uses. Paints-classification, constitution and its manufacturing process.

Unit V **(6 hours)**
Corrosion: Introduction, disadvantages of corrosion, Types of corrosion-Galvanic, pitting, stress and erosion; corrosion fatigue, corrosive agents, prevention of corrosion-cathodic and anodic protection, surface coating and inhibitors and corrosion rate measurement-polarization techniques.

Course Outcomes:
After successful completion of this course, student will be able to
CO1: Recall properties of fuels, alloys, paints & pigments to explain their applications
CO2: Identify the choice of materials based on the composition
CO3: Classify the cement and composite material based on the method of preparation
CO4: Evaluate the environmental effect of fuels
CO5: Predict the effective corrosion minimization method

Text Books:
1. P.C Jain and Monica Jain**,** *Engineering Chemistry*, Dhanpat Rai Publishing Company Ltd., New Delhi, 17th Edition, 2019
2. B.K. Sharma, *Industrial Chemistry* Part 1&2 ,2020

Reference Books:
1. Edwin. E. Slosson, *Chemistry for chemical Industries***,** Medtech publisher, 2017.
2. Shasi chawla, *A Text Book Of Engineering Chemistry*, 2017.
3. B.N.Srinivas, *Engineering chemistry*, Laxmi publication, First Edition, 2016.

Journals:
1. Journal of applied chemistry springer
2. Annual review of physical Chemistry
3. Journal of chemistry Education

E-Resource:
1. https://www.slideshare.net/mschumann/applied-chemistry-powerpoint
2. https://chem.libretexts.org/Bookshelves/General_Chemistry/Chemistry_(OpenSTAX)/17%3A_Electrochemistry/17.6%3A_Corrosion
3. https://nzic.org.nz/app/uploads/2017/10/10D.pdf
4. https://www.icevirtuallibrary.com/isbn/9780727739452
5. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Book%3A_Introduction_to_Inorganic_Chemistry/

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	3	9	**39**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	9	3	9	9	**51**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**21**	**15**	**39**	**45**	**225**

Low-1 Medium-3 High-9

Extra Credit-I - Food Chemistry

(For Students Admitted from 2022-23)

Semester: II
Subject Code: IBCHX2 **Credit: 2**

Course objectives:

1. To acquire knowledge on chemistry behind colouring agent and possible food adulterant
2. To understand the reason behind food spoilage, significance of food texture and chemical reactions in food chemistry

Unit I

Introduction to Food Chemistry: Introduction, terminology used in food chemistry–biosynthetic reaction, oxidation reaction, elimination reaction, reduction, condensation, photosynthesis - general chemical reaction involved in photosynthesis.

Unit II

Food texture: Nutritive value, pigments, carotenoids, chlorophylls, flavonoids, pectin substance, changes in cooking and processing, browning reaction, fruits preservation.

Unit III

Food adulteration: Contamination, list of food Items and their contaminants, detection of adulteration–by simple techniques, prevention of food adulteration.

Unit IV

Food Spoilage: Preservation method - Low temperature and high - temperature methods; asepsis – filtration, centrifugation; wood smoking and antibiotics - use of chemical preservatives.

Unit V

Natural and artificial colouring agents: Role in cookery, sweetening agents, artificial sweeteners, legal safeguards, adulteration in food (adulterants) chemistry of cooking.

Course Outcomes:

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

CO1: Define the chemical reaction observed in food products and comprehend the food spoilage

CO2: Compare and analyse constituents of food samples

CO3: Identify the chemistry behind texture of food samples

CO4: Evaluate the required method for identifying food adulteration

CO5: Elaborate the role of colouring agent nature in food samples

Text Books:

1. D.C. Sharma, *Nutritional Biochemistry*, CBS Publisher private Ltd, 2017
2. A. Sharma, *Textbook of Food Science and Technology*, CBS Publisher & distributors private Ltd, 2019

Reference Books:

1. H.K. Chopra and P.S. Panesar, *Food Chemistry*, Narosa Publishing House, New Delhi, 2017
1. B. Srilakshimi, *Food Science*, Multi-Colour Edition, 2018.
2. B. Sri Lakshmi, *Nutrition Science*, New Age International Publisher, New Delhi,7th Edition, 2022.

Journals:

1. Food Chemistry - Journals
2. Journal of Food Chemistry and Nutrition
3. Journal of Food Technology and Food Chemistry

E-Resources:

1. http://154.68.126.6/library/Food%20Science%20books/batch1/Principles%20of%20Food%20Chemistry%203rd%20Edition.pdf
2. https://drive.google.com/file/d/1w1EaOJv0OOzmRZ2BsRMYbIbzpFintIzE/view?usp=sharing
3. https://www.sciencedirect.com/science/article/pii/B978012811518300003X
4. https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/2015-2016/october-2015/food-colorings.html
5. https://fmtmagazine.in/food-adulteration/

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	3	9	**39**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	9	3	9	9	**51**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**21**	**15**	**39**	**45**	**225**

Low-1 Medium-3 High-9

Core-V - Organic Chemistry–I

(For Students Admitted from 2022-23)

Semester: III **Hours/Week: 4**
Subject Code: IBCHC31 **Credit: 4**

Course Objectives:

1. To enable students to gain knowledge on preparation and reactions of alkyl halides, aliphatic hydrocarbon, alcohol, phenol, ethers and epoxides
2. To know the significance of representations used in isomerism

Unit I **(12 hours)**

Optical and Geometrical Isomerism: Definition – Classification. Optical isomerism - Optical activity, Optical, and Specific rotations, Conditions for optical activity, Asymmetric centre, Chirality, Achiral molecules-Meaning of (+) and (-) and D and L notations; Elements of symmetry -Projection formulae, Fischer, and Newman projection formulae, Notation of Optical isomers, Cahn- Ingold - Prelog rules, R-S; notations for optical isomers with one and two asymmetric Carbon atoms, Erythro and Threo representations; meso compounds, racemic mixtures and resolution, optical isomerism of compounds without asymmetric Carbon atoms, allenes and biphenyls, asymmetric synthesis.Geometrical isomerism–Cis-Trans, Syn-Anti, and E-Z Notations, geometrical isomerism in Maleic and Fumaric acids and unsymmetrical ketoximes, methods of distinguishing geometrical isomers using melting point, dipole moment, Dehydration, Cyclization and Heat of Hydrogenation.

Unit II **(12 hours)**

Aliphatic Hydrocarbons: Aliphatic Saturated Hydrocarbons - General methods of preparation, properties and reactions of alkanes, methane and ethane; free radical substitution, halogenation of methane and ethane, petroleum products, cracking, octane number, and flashpoint. Aliphatic unsaturated hydrocarbons–General methods of preparation, properties and reactions of alkenes -ethylene and propene, Markovnikov's rules and peroxide effect, mechanism of addition to carbon, carbon double bond; alkynes –preparation, properties, and reactions of acetylene. Alkadienes - isolated, conjugated and cumulated double bond systems with examples - Thiele's theory of partial valency.

Unit III **(12 hours)**

Halogen Compounds: Nomenclature of alkyl and aryl halides, preparation of alkyl halides, from alcohols and alkenes, radical halogenation, alkylic bromination of alkenes, preparation of aryl halides. reactions of alkyl halides-substitution reactions, S_N1& S_N2, mechanism, kinetics, and energy profile diagram & stereochemistry. Reactions of vinyl and allyl halides-elimination of alkyl halides, E_1 & E_2 mechanism, Saytzeff rule. Reactions of aryl halides-nucleophilic aromatic substitution reaction with mechanism, bimolecular displacement mechanism, elimination-addition mechanism, and addition-elimination mechanism, benzyne intermediate; electrophilic addition reaction -mechanism of addition of hydrogen halides and halogen to alkenes, Markownikoff's rule, peroxide effect mechanisms.

Unit IV **(12 hours)**

Organometallic Compounds and Alcohols: Organometallic compounds - preparation of grignard reagent, organolithium compounds, organozinc compounds, organocopper compounds- Reformatsky reaction, synthesis of organic compounds using grignard reagent and alkyl lithium. Alcohols - nomenclature, preparation of alcohols, by reduction of carbonyl compounds, reaction of carbonyl compounds with grignard reagent, properties of alcohol, hydrogen bonding, reactions of alcohols, dehydration, conversion to Tosylates-

oxidation. aliphatic alcohol -General methods of preparation, properties, and reactions of monohydric Alcohol. Unsaturated alcohol - allyl alcohol. Polyhydric alcohol – Glycol, Glycerol, and Nitro-glycerin, Estimation of hydroxy groups.

Unit V **(12 hours)**

Phenols, Ethers, and Epoxides: Phenols - preparation (from Cumene, Aromatic Sulphonic Acid, Chlorobenzene), properties - acidity of phenol, uses, reactions (oxidation) to quinines, Riemer-Tiemann reaction, Bromination, Nitration, Liebermann's Nitroso reaction, preparation of phenolphthalein, Kolbe's reaction, Pinacol-Pinacolone rearrangement.

Ethers- Nomenclature, preparation (from Williamsons synthesis and alkoxy mercuration of alkenes), reactions of ethers, acidic cleavage, Claisen rearrangement, Zeisel's method of estimation of methoxy groups, crown ether structure, and importance in organic synthesis.

Epoxides - nomenclature, preparation from alkenes and halohydrins, reactions, ring opening reactions, acid catalyzed and base catalysed reactions.

Course Outcomes:

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

CO1: Recall preparative methods for hydrocarbons, halogen, organometallic compounds and understand their physical properties

CO2: Apply the basic concepts to represent and identify the isomerism in organic compounds

CO3: Aanalyse chemical reactions of organic and organometallic compounds to find the reaction pathway (SN^1 & SN^2 and E_1 & E_2)

CO4: Determine the type of reaction in preparation of drugs and petrochemical products

CO5: Propose the type of reagent for a specific organometallic reactions

Text Book:

1. Arun Bahl & Bahl , *A Text Book of Organic Chemistry*, S. Chand & Company, 2016.

Reference Books:

1. P.L. Soni and H. M. Chalwa, *Text Book of Organic Chemistry*, 29th Edition, Sultan Chand & Sons, New Delhi, 2019.
2. M. K. Jain and S.C. Sharma, *Modern Organic Chemistry*, Vishal Publishing Co, New Delhi, 2020.
3. Robert Thorhton, Morrison Robert and Robert Neilson Boyd, *Organic Chemistry*, Pearson India, Sixth Edition, 2016.
4. Michael B. Smith, *Jerry March's Advanced Organic Chemistry (Reactions, Mechanisms and Structure)*, Eighth Edition, Wiley Eastern Limited, New Delhi, 2020.

Journals:

1. The Journal of Organic Chemistry
2. European Journal of Organic Chemistry.
3. Asian Journal of Organic Chemistry

E-Resources:

1. https://www.researchgate.net/profile/Dr_Sumanta_Mondal/publication/329415872_UNIT_-
2. https://www.allamaiqbalcollege.edu.in/uploads/download_2004191004.pdf
3. https://www.allamaiqbalcollege.edu.in/uploads/download_2004191004.pdf
4. https://crab.rutgers.edu/~alroche/Ch14.pdf

5. https://chem.libretexts.org/Courses/Sacramento_City_College/

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	1	3	3	3	**31**
CO2	9	3	9	3	3	3	3	**33**
CO3	9	3	9	3	3	9	3	**39**
CO4	9	3	9	3	3	9	3	**39**
CO5	9	3	9	3	3	9	3	**39**
Total	**45**	**15**	**45**	**13**	**15**	**33**	**15**	**181**

Low-1 Medium-3 High-9

Core-VI - Organic Analysis and Organic Estimation Practicals

(For Students Admitted from 2022-23)

Semester: III **Hours/Week: 4**
Subject Code: IBCHC32P **Credit: 4**

Course Objectives:

1. To develop skills in testing and analysing of organic compounds

2. To build skills required in chemistry such as the proper handling of apparatus and chemicals of organic compounds

List of Experiments

1. Organic Analysis: (30 hours)

Analysis of following functional groups (anyone) organic substance (Aliphatic or Aromatic) starting saturation or unsaturation and confirmation by the preparation of a solid derivation. Acids, Phenols, Aldehydes, Ketones, Esters, Nitro Compounds, Amines, (Primary, Secondary and tertiary), Amides, Anilides, and Halogenated Hydrocarbons (side chain and nuclear). Determination of Melting point (using Melting point instrument) and boiling points.

2. Organic Estimation: (30 hours)

1. Estimation of Phenol
2. Estimation of Aniline
3. Estimation of Glucose (Bertrand's Method)

Evaluation Scheme: 2 hours for Organic Analysis and 2 hours for Organic Estimation for 30 marks each.

Course Outcomes:

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

CO1: List the basic principles of organic chemistry to comprehend functional group
CO2: Build skills in preparing derivate of organic compounds
CO3: Analyze the organic compounds for aromatic/aliphatic/saturation/unsaturation
CO4: Determine the physical properties of organic compounds

CO5: Estimate the phenol, aniline, and glucose content of organic compounds

Textbook:

1. V. Venkateswaran, R. Veeraswamy and A. R. Kulandaivelu, *Basic Principles of Practical Chemistry*, New Delhi, Sulthan Chand & Sons Publications, 2017.

Reference Books:

1. K.K. Rehani, N.K. Verma, B.K. Vermani, *Comprehensive Practical Chemistry* Laxmi Publications, First Edition, 2019.
2. Furniss and Brian S and Hannaford and Antony J, *Vogels* Textbook Of Practical Organic Chemistry, 5th Edition by, Pearson India, 2016.
3. A. I. Vogel, *Text Book of Practical Organic Chemistry*, ELBS, London, 5th Edition, 2010.

Journals:

1. Journal of Organic Chemistry
2. Organic letter
3. Trace Organic Analysis Journal

E-Resources:

1. https://drive.google.com/file/d/1BtYs8N32iUeifkHLCkeBQpdqYwUIWuQI/view?usp=sharing
2. https://drive.google.com/file/d/1EEPKWIkHIhB5PkgOhiav4Cq2ZlW2ADW3/view?usp=sharing
3. https://drive.google.com/file/d/1hemR8ajU0JR_SGkSJzBxYZ4l3qgehyNy/view?usp=sharing
4. https://www.csub.edu/chemistry/organic/manual/Lab14_QualitativeAnalysis.pdf
5. http://wwwchem.uwimona.edu.jm/lab_manuals/c10expt25.html

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	1	3	9	3	**37**
CO2	9	3	9	1	3	9	9	**43**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**11**	**15**	**45**	**39**	**215**

Low-1 Medium-3 High-9

Ability Enhancement Compulsory Course - I-Pharmaceutical Chemistry – I

(For Students Admitted from 2022-23)

Semester: III **Hours/Week: 4**
Subject Code:IBCHA33 **Credit: 4**

Course Objectives:

1. To enable the students to understand the concepts in pharmaceutical chemistry and drugs design
2. To gain knowledge on analytical separation, assay of drugs and metabolism of drugs

Unit I **(12 hours)**

Introduction to pharmaceutical chemistry, classification, and nomenclature of drugs: Pharmaceutical chemistry - definition, important aspects of pharmaceutical chemistry, role of chemistry in pharmacy, pharmacopoeia; terms used in chemistry of drugs-classification of drugs based on chemical structure and therapeutic actions, nomenclature, IUPAC naming of simple heterocyclics, stereo chemical notations.

Unit II **(12 hours)**

Theories of drug action and factors affecting drug action: Biological defenses, chemical defenses, isosterism in drugs; drug receptors - nature, isolation, modification and localization of receptors; theories of drug Action - nature of pharmacological action, occupancy theory, rate theory, induced fit theory; mechanism of drug action, action of drugs on enzymes, drugs acting on biological membranes, nonspecific action of drugs and pharmacogenomics - personalized medicine.

Unit III **(12 hours)**

Assay of Drugs and Metabolism of Drugs: Chemical assay, biological assay, immunological assay; metabolism of drugs– factors affecting metabolism, phases of metabolism, phase-I reactions– microsomal reductions, non-microsomal metabolism, hydrolysis, phase-II reactions–major path way of metabolism.

Unit IV **(12 hours)**

Quantitative Structure-Activity Relationship: Quantitative structure-activity relationship between chemical structure and pharmacological activity, effects of unsaturation, chain length, isomerism, halogens, Amino group Nitro and Nitrite Compound, Nitrile group, Acidic group, Hydroxyl group, Alkyl groups, Hansh Equation, Craig plot, Topliss scheme, achievements of QSAR-limitations of QSAR.

Unit V

Analytical Separation & Drug Design: **(12 hours)**

Analytical Separation methods - liquid-liquid extraction, distribution coefficient, and distribution ratio, factors influencing solvent extraction, elementary idea on chromatography – TLC, HPLC, and GC and applications.
Drug Design -introduction, methods of lead discovery, application of biosterism in drug design, prodrug design and computer-aided drug design

Course Outcomes:

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

CO1: Recall the basic concepts of pharmaceutical chemistry
CO2: Apply appropriate chromatography techniques in TLC, HPLC, and GC in isolation of drugs
CO3: Analyze the assay and metabolism of drugs to find the major pathway
CO4: Determine the application of pharmaceutical chemistry is concerned with the drug design and synthesis of biologically active molecules
CO5: Design potential candidate for drug molecule using the QSAR analysis

Text Books:

1. Ashutosh Kar, *Medicinal Chemistry*, New Age International Publishers, 2018.
2. V.K. Ahluwalia, and Madhu Chopra, *Textbook of Medicinal Chemistry*, 1st Edition, Anne Book's Pvt. Ltd., New Delhi, 2015.

Reference Books:

1. R.P. Budhiraja, *Separation Chemistry*, Newage International Ltd, New Delhi, 2016.

2. G.R. Chatwal, *Organic Pharmaceutical Chemistry*, New Delhi, Himalaya Publishing House, 2016.

Journals:

1. Pharmaceutical Chemistry Journal
2. Journal of Pharmaceutical Chemistry and Chemical Science
3. The Pharmaceutical and Chemical Journal

E-Resource:

1. https://www.slideshare.net/RupalAgarwal5/pharmaceutical-chemistry-72953136
2. https://www.sciencedirect.com/topics/medicine-and-dentistry/drug-metabolism-assay
3. https://www.researchgate.net/profile/Chanin-Nantasenamat-2/publication/28358424_A_Practical_Overview_of_Quantitative_Structure-Activity_Relationship/links/00463534b9ff4d92a3000000/A-Practical-Overview-of-Quantitative-Structure-Activity-Relationship.pdf
4. https://analyticalsciencejournals.onlinelibrary.wiley.com/doi/abs/10.1002/jssc.201900656
5. https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/drug-nomenclature

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	3	3	**33**
CO2	9	3	9	3	3	9	3	**39**
CO3	9	3	9	3	3	9	3	**39**
CO4	9	3	9	3	3	9	3	**39**
CO5	3	3	9	3	3	9	9	**39**
Total	**39**	**15**	**45**	**15**	**15**	**39**	**21**	**189**

Low-1 Medium-3 High-9

Skill Enhancement Course - III - Introduction to Marine Chemistry

(For Students Admitted from 2022-23)

Semester: III **Hours/Week: 2**
Subject Code: IBCHS34 **Credit: 2**

Course Objectives:

1. To gain knowledge on basic understanding on marine science and chemical equilibrium
2. To enable students to know the importance of seaweeds and sea water battery

Unit - I **(6 hours)**

Introduction: Introduction- chemical oceanography, ocean basins; properties of fresh water and seawater, temperature, salinity, density, micro & macro nutrient analysis of sea water, life in the oceans and the chemical connection.

Unit - II **(6 hours)**

Chemical Equilibrium: Chemical equilibrium - ion complexes, acid-base reactions, carbonate chemistry (Alkalinity, DIC), REDOX chemistry, seawater composition changes, marine sediments, radioactive tracers, and stable isotopes.

Unit - III **(6 hours)**

Salinity: The Salts -The ocean salinity and dissolved salts, sources of salts & salt balance, resistance time, The gases-types, depth distribution, CO_2 as buffer, carbon cycle and other substances.

Unit - IV **(6 hours)**

Heavy Metals in Sea Water and Sea Water Battery: Heavy metals contribution in seawater and sediments and their intoxication oil slick, suitable adsorbents for oil slick; sea water battery -types of battery, marine corrosion and anti-corrosion coating material.

Unit - V **(6 hours)**

Seaweeds: Classification, uses of seaweeds in various fields, biofuels, nutritional and medicinal value of sea weeds, humans and the sea and the impacts of humans on the marine environment.

Course Outcomes:

After successful completion of this course, students will be able to

CO1: Recall the characteristics of seawater and understand the sea battery
CO2: Classify the acid-base reaction and stable isotopes
CO3: Analyze the micro and macronutrient in seawater
CO4: Compare carbon cycle and chemical equilibria in marine chemistry
CO5: Test the seaweed cultivation with knowledge acquired

Text Book:

1. Frank J. Millero, *Chemical Oceanography*, CRC Press, Fourth Edition, 2016.

Reference Books:

1. Jean-Pierre Gattuso and Lina Hansson Ocean acidification OUP Oxford, 2011.
2. The Open University *Seawater: Its Composition, Properties and Behaviour*, Oceanography Series, Pergamon, 2nd Edition, 1995.
3. J.K. Grasshoff, K.Kremling, M.Ehrhardt, *Methods of Seawater Analysis*, 3 completely revised and extended Edition, Wiley-VCH, 1999.

Journals:

1. Marine Chemistry - Journals
2. Journal of Marine Science Research and Oceanography
3. International Journal of Research in Marine Sciences

E- Resources:

1. https://www.soest.hawaii.edu/oceanography/courses/OCN623/Spring%202015/Salinity2015web.pdf
2. https://www.ocean.washington.edu/courses/oc400/Lecture_Notes/CHPT5.pdf
3. https://www.slideshare.net/norolaynsaid/heavy-metals-66977026
4. https://www.newworldencyclopedia.org/entry/Seaweed
5. https://nsidc.org/cryosphere/seaice/characteristics/brine_salinity.html

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	9	3	3	9	3	**45**
CO2	9	9	3	3	3	3	3	**33**
CO3	9	9	9	3	3	9	9	**51**
CO4	9	9	3	3	3	9	3	**39**
CO5	9	9	9	3	3	9	9	**51**
Total	**45**	**45**	**33**	**15**	**15**	**39**	**27**	**219**

Low-1 Medium-3 High-9

Extra Credit-II - Chemistry of Consumer Products

(For Students Admitted from 2022-23)

Semester: III
Subject Code: IBCHX3 **Credit: 2**

Course Objectives:
1. To understand the basic concepts of consumer products and their properties
2. To gain knowledge about manufacturing process of Glass and Chlor-Alkali

Unit I
Glass: Definition of glass, basic concepts of glass structure, batch materials and minor ingredients and their functions, elementary concept of glass manufacturing process, different types of glasses and application of glasses.

Unit II
Introduction to Ceramic: Definition and scope of ceramics materials, classification of ceramic materials – conventional and advanced, areas of application.

Unit III
Chlor-Alkali: Introduction, Common Salt - manufacture, caustic soda - manufacture of caustic Soda and chlorine using diaphragm cells, costner killer cell, lime soda process for the manufacture of caustic soda, soda ash, Leblanc process, Solvay's ammonia soda process, Sodium hypochlorite and manufacture by electrolysis of NaCl, baking powder and baking soda - preparation and uses.

Unit IV

Petroleum Products: Origin, formation and evaluation of crude oil, refining of petroleum - atmosphere and vacuum distillation methods. Treatment method for the removal of sulphur compounds -solvent treatment process. Petroleum chemical product - DMT, MMA and formaldehyde.

Unit V

Cottage Industrial Product: Methods of preparation of the following in the cottage Industry - soap, detergent, detergent powder, tooth paste, shampoo, tooth powder, phenol, fountain pen ink, shoe polish, wax candle and chalk crayons, gum paste and naphthalene ball practical work - (No external examination). preparation of phenol and wax candle.

Course Outcomes:

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

CO1: Recall the composition of consumer products and recognize their properties

CO2: Apply the knowledge on consumer products to understand structure activity of the materials

CO3: Analyze the hazards of the consumer products in the market

CO4: Evaluate the current development in the field of industrial chemistry

CO5: Formulate novel preparative methods for consumer products

Text Books:

1. O.P. Vermani, *Applied Chemistry: Theory and Practice*, New Age International Private Limited, 2017.
2. Monika Jain and P. C. Jain, *Engineering Chemistry*, Dhanpat Rai Publishing Company Ltd., New Delhi, 2019.

References Books:

1. S. S. Dara, and S. S. Umare, *A Text Book of Engineering Chemistry*, S. Chand & Company Ltd., New Delhi, 2013.
2. O.P. Palanna, *Engineering Chemistry*, McGraw Hill Education, 2017.
3. A. Ravikrishnan, *Engineering Chemistry*, Sir Krishna Hitech Publishing Company Pvt. Ltd., chennai, 2021.

Journals:

1. Chemical Review
2. Chemical Sciences Review
3. Journal of Chemical Education

E-Resources:

1. https://www.lehigh.edu/imi/teched/AtModel/Lecture_1_Micoulaut_Atomistics_Glass_Course.pdf
2. http://link.springer.com/content/pdf/bfm%3A978-94-017-5257-2%2F1.pdf
3. https://en.wikipedia.org/wiki/Chlorine_production
4. https://en.wikipedia.org/wiki/Petroleum_product
5. https://www.researchgate.net/publication/325023106_Textbook_of_Cosmetic_Formulations

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	3	**39**

CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	3	3	9	3	3	9	9	**39**
CO5	9	3	9	3	3	9	9	**45**
Total	**39**	**15**	**45**	**15**	**15**	**45**	**39**	**213**

Low-1 Medium-3 High-9

Core-VII - Inorganic Chemistry–II

(For Students Admitted from 2022-23)

Semester: IV **Hours/Week: 5**
Subject Code: IBCHC41 **Credit: 4**

Course Objectives:

1. To understand the principles and process of metals and non-metals isolation
2. To understand the properties and uses of group IB, IIA, IIIA, IV, V & VI elements

Unit I **(15 hours)**

IB, IIA & IIIA Group Elements: I B Group- extraction, properties, and uses of Cu, alloys of Cu and their application. II A Group -diagonal relationship of Be with Al, comparison of Be with Mg, extraction, properties, and uses of Be IIIA Group - general characteristics, extraction of aluminium, anhydrous aluminium trichloride, boranes, diborane - preparation, properties, and structure.

Unit II **(15 hours)**

Dipole Moment & Magneto Chemistry: Dipole moment - definition, experimental determination, calculation of percentage ionic character of HF and HCl, dipole moment and molecular structure - CO_2, H_2O, NH_3, and CH_4. magneto chemistry - introduction (magnetic field, magnetic pole, intensity of magnetization). Magnetic induction, permeability, intensity of magnetism, magnetic susceptibility, molar magnetic susceptibility. Magnetic behaviour - diamagnetism, paramagnetism, ferromagnetism and antiferromagnetism, effect of temperature on magnetic behaviour of substances, determination of magnetic susceptibility by Gouy method. Applications of magnetic susceptibilities - number of unpaired electrons in a molecule, structure of Coordination compounds, formation of free radicals.

Unit III **(15 hours)**

IV, V & VI Group Elements: Group IV - metallurgy of lead, allotropy of carbon, carbides, silicates, silicones,permonocarbonic acid, perdicarbonic acid. Group VA - Nitrogen, active Nitrogen, Hydrides of Nitrogen, ammonia - manufacture, properties and uses, Oxides of Nitrogen, Fixation of Nitrogen, manufacture of Nitric and Arsenic acid, distinction between Arsenite and Arsenate, Antimony trioxide, tartar emetic, and sodium bismuthate. Group VI - Oxides, Oxyacids and Oxyhalides of Sulphur, Permonosulphuric acid, Perdisulphuric acid & Potassiumpersulphate.

Unit IV **(15 hours)**

Halogens & Noble Gas: Halogens - isolation of Fluorine, Moissan's method and Denis method, distinction of Fluorine from other elements, manufacture & properties of Chlorine, Bromine and Iodine, manufacture of bleaching powder by Bachmann method, structure & properties of bleaching powder. Interhalogen compounds - Naming of the compounds, types, preparation, properties, structure and uses of ICl, BrF_3, IF_5, IF_7. Basic properties of Iodine. Pseudohalogens - definition, similarities and dissimilarities between Halogen, Pseudohalogen and Cyanogen. Thiocyanogen-preparation, properties and uses. Noble gases - isolation, general properties, clathrates, Fluorides, Oxides and Oxyfluorides of Xenon.

Unit V **(15 hours)**

Transition Elements and Group Study: Transition elements- Position in the periodic table, general characteristics of d-block elements, occurrence, extraction, and uses of Titanium, Vanadium, Molybdenum, and Tungsten, chemistry of Titanium Dioxide, Titanium Tetrachloride, Vanadium Pentaoxide, ammonium Molybdate, Zirconium halide, Molybdenum Blue, Tungstic Oxide, Tungsten Bronze and Chloroplatnic acid, group study of Ti, V, Cr groups, comparative study of Fe, Co, Ni, preparation, properties, and uses of Potassium Ferricyanide, Potassium Ferrocyanide, Cobaltous Nitrate and Nickel (II) Chloride.

Course Outcomes:

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

CO1: Recall the mineral source and understand the chemistry behind extraction of group IB, IIA, IIIA, IV, V & VI elements.

CO2: Identify the periodic trend observed in IB, IIA, IIIA, IV, V & VI group elements.

CO3: Classify the inorganic compounds based on the bonding property.

CO4: Compare the periodic property to understand the chemical reactivity of halogens and nobel gases.

CO5: Elaborate the periodic properties of transition element to account for catalytic property

Text Book:

1. R.D. Madan, *Modern Inorganic Chemistry*, S. Chand and Company Private Limited, New Delhi, 2019.

Reference Books:

1. B.R. Puri, L.R. Sharma and K.C. Kalia, *Principle of Inorganic Chemistry*, Vishal Publishing Co., New Delhi, 2020.
2. E. James Huheey, A. Keiter Ellen, L. Keiter Richard and Okhil K. Medhi, *Inorganic Chemistry Principles of Structure and Reactivity*, Pearson India, 2019.
3. Mark Weller, Tina Overton, Jonathan Rourke and Fraser Armstrong, *Inorganic Chemistry*, Oxford University Press, 2018.
4. Alan Weller, *Inorganic Chemistry*, Oxford University Press, 2018.

Journals:

1. Inorganic - Chemical Communications
2. European Journal of Inorganic Chemistry
3. Coordination Chemistry Review

E-Resources:

1. http://www.digimat.in/nptel/courses/video/104101090/L44.html
2. http://www.digimat.in/nptel/courses/video/104101090/L43.html
3. https://onlinecourses.nptel.ac.in/noc20_cy19/preview
4. https://digimat.in/nptel/courses/video/104101090/L02.html

5. https://www.digimat.in/nptel/courses/video/104101090/L01.html

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	3	3	3	3	**27**
CO2	9	3	9	3	3	9	3	**39**
CO3	9	3	9	3	3	9	3	**39**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**15**	**39**	**15**	**21**	**39**	**27**	**201**

Low-1 Medium-3 High-9

Core-VIII - Organic Chemistry –II

(For Students Admitted from 2022-23)

Semester: IV **Hours/Week: 4**
Subject Code: IBCHC42 **Credit: 4**

Course Objectives:

1. To understand the structure and reactions of cycloalkanes, aromatic hydrocarbon, aldehydes and ketones
2. To gather knowledge on pericyclic reactions and organic photochemistry

Unit I **(12 hours)**

Cycloalkanes and Aromatic Hydrocarbons: Conformational analysis - introduction of terms, conformers, dihedral angle, torsional strain, conformational analysis of ethane and n-butane including energy diagrams, conformers of cyclohexane (chair, boat and skew boat forms), axial and equatorial bonds, ring flipping showing axial equatorial interconversions.

Cycloalkanes -nomenclature, general methods of preparation and reactions of cycloalkanes, Baeyer's strain theory and its modifications, conformational analysis of cyclohexane. Benzene - preparation, reactions, and structure of benzene, aromaticity and Huckels (4n+2) rule, aromatic substitution -orientation in benzene ring, Relative and absolute method, mechanism of aromatic electrophilic mono-substitution and di-substitutions such as i) halogenation ii) Friedel Crafts reaction iii) Nitration iv) Sulphonation aromatic nucleophilic substitution - unimolecular and bimolecular substitution.

Unit II **(12 hours)**

Aldehydes and Ketones: Nomenclature, nature of carbonyl group, preparation -oxidation of alcohols, Ozonolysis, reactions- oxidation (with CrO_3, Ag_2O, and $KMnO_4$), reduction - Wolf Kisner, Clemenson reduction, Metal hydride reduction, Nucleophilic addition (Hydration, bisulfite addition, HCN addition) Hemiacetal and acetal formation, Carbonyl alpha substitution reaction - Keto-Enol Tautomerism, Enolate ion formation, Haloform reaction, carbonyl condensation reaction, Perkin reaction, Clavin-Schmidt Reaction, Stobbe Condensation, study of name reactions with mechanisms - Aldol Condensation, Cannizaro Reaction, Claisen Condensation, Benzoin, and Beckmann rearrangement, synthesis of Caprolactum, preparation of Vanillin and Acrolein, general methods of preparation, properties and reactions of formaldehyde and acetone. The distinction between aldehydes and ketones.

Unit III **(12 hours)**

Carboxylic acids and acids derivatives: Nomenclature, effect of substituent on acidity of aliphatic and aromatic carboxylic acids, preparation of monocarboxylic acids - oxidative cleavage of alkenes hydrolysis of nitriles, carboxylation with Grignard reagent, Side chain oxidation of alkyl benzenes, and reaction of carboxylic acids, preparation and reactions of acid derivatives - acid chlorides, esters, amides and anhydrides, dicarboxylic acids - preparation and reactions of Malonic acid, Adipic acid, Phthalic acid, and Citric acid.

Unit IV **(12 hours)**

Heterocyclic Compounds & Aromatic Nitro Compounds: Heterocyclic compounds - general classification, aromatic and non-aromatic heterocyclic, preparation, properties and uses of Furan, pyrrole & thiophene, synthesis, and reactions of Pyridine, comparative study of basicity of pyrrole, pyridine with amines. Preparation of indole, quinoline, isoquinoline & indigotin. The relative basic character of aromatic amines - derivatives of aniline, preparation and uses of acetanilide, sulphanilic acid and sulphanilamide. Benzene diazonium chloride -synthetic and applications of benzene diazonium chloride. Aromatic nitro compounds - conversion of nitrobenzene into o-, p- and m-dinitro benzenes, reduction reactions of nitrobenzene in neutral, acidic, and basic media, preparation and uses of TNT and Amatol.

Unit V **(12 hours)**

P**ericyclic reactions and organic photochemistry**: Pericyclic reactions -features, MOs of conjugated π systems, FMOS, electrocyclic reaction, mode of rotations, analysis of odd and even number of electron pair(s) systems with FMO method, cycloaddition reaction, modes of addition, Diels-Alder reaction, analysis with FMO method, sigmatropic rearrangement, [1,3] and [1,5] rearrangements, Cope and Claisen rearrangements-mechanisms organic photochemistry -types of photochemical reactions, photodissociation, gas-phase photolysis, isomerisation, cyclisation, dimerisation, and oxetane formation. norrish-I and II reactions. Barton reaction, photo fries rearrangement, photochemical formation of smog, photochemistry of vision.

Course Outcomes:

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

CO1: Recall the conformation in cycloalkanes and aromatic hydrocarbons and explain the conformational analysis

CO2: Classify the aromatic and non-aromatic heterocyclic compounds based on preparation, properties & uses

CO3: Examine the products obtained in oxidation, reduction, and nucleophilic addition reactions

CO4: Evaluate the pericyclic and photochemical reactions with acquired basics

CO5: Modify the raw material in preparation of carboxylic acids and heterocyclic compounds

Text Book:

1. M. K. Jain, and S.C. Sharma, *Modern Organic Chemistry*, Vishal Publishing Co., New Delhi, 2020.

Reference Books:

1. Michaei B. Smith, *Marchs Advanced Organic Chemistry Reactions Mechanisms and Structure*, John Wiley Limited, New Delhi, 2020.
2. O.P. Agarwal, *Organic Chemistry Natural Products (Volume II)*, Krishna Prakashan media Pvt. Ltd, India, 2015.
3. Jagdamba singh and Jaya singh, *Photochemistry and Pericyclic Reactions*, New Age International Publishers Fourth Edition, 2019.

Journals:

1. Asian Journal of Organic Chemistry
2. European Journal of Organic Chemistry
3. Russian Journal of Organic Chemistry

E-Resources:

1. ORGANIC CHEMISTRY - CUM INORGANIC CHEMISTRY.pdf
2. Morris-David-Morris-Stereochemistry-Tutorial-C-B-ok-xyz.pdf
3. Finar-OrganicChemistryVol1-Text.pdf
4. Aldehydes-Ketones-.pdf
5. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Book%3A_Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/24%3A_Organonitrogen_Compounds_II_-_Amides_Nitriles_and_Nitro_Compounds/24.06%3A_Nitro_Compounds

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	3	3	3	3	**27**
CO2	9	3	9	3	3	3	3	**33**
CO3	9	3	9	3	3	9	3	**39**
CO4	9	3	9	3	3	9	3	**39**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**39**	**15**	**15**	**33**	**21**	**183**

Low-1 Medium-3 High-9

Ability Enhancement Compulsory Course II - Pharmaceutical Chemistry– II

(For Students Admitted from 2022-23)

Semester: IV **Hours/Week: 5**
Subject Code: IBCHA44 **Credit: 4**

Course Objectives:

1. To understand the various diseases in human beings and their treatment methods
2. To widen the knowledge on antiseptics, disinfectants, cancer, antineoplastic and antibiotics

Unit I **(15 hours)**

Organic Pharmaceutical Aids and Organic Diagnostic Agents: Organic pharmaceutical aids– preservatives, anti-oxidants, sequestrants, emulsifying agents, colouring, flavouring, sweetening, stabilizing and suspending agents, ointment bases and related agents

organic diagnostic agents–drugs used as X-ray contrast media, drugs used to organ function, drugs used to determine blood volume and hemopoietic function, drugs used for miscellaneous diagnostic tests.

Unit II **(15 hours)**

Analgesics, antipyretics, anti-inflammatory agents and anaesthetics: Analgesics, antipyretics and anti-inflammatory agents - Narcotic analgesics- methadone and morphine, Non-narcotic analgesics-salicylic acid derivatives, para amino phenol derivatives, Pyrazole derivative, indolyl, and aryl acetic derivatives
Anesthetics - general anaesthetics - ether chloroform, halothane, trichloroethylene, ethyl chloride, Nitrous oxide, and cyclopropane, intravenous anaesthetics- thiopental sodium methohexitone, local anaesthetics-esters, amides.

Unit III **(15 hours)**

Antiseptics, Disinfectants, and Antibiotics: Antiseptics and disinfectants - distinction between antiseptics and disinfectants, standardizations of disinfectants and antiseptics- examples of phenol, halogen compounds, dyes, organic mercurial, formaldehyde and its derivatives and cationic surface-active agents. Antibiotics - classification, structure, properties and uses of chloramphenicol, penicillin, streptomycin, tetracycline, and erythromycin.

Unit IV **(15 hours)**

Cancer, antineoplastic and cardiovascular drugs: Cancer and antineoplastic drugs - malignant and non-malignant tumour- causes, treatment, antineoplastic drugs- alkylating or cytotoxic agents, antimetabolites - plant products, hormones, adrenocorticosteroids
Diabetes and hypoglycemic drugs–diabetes, types, insulin and hypoglycemic agents. Cardiovascular drugs - cardiac glycosides, antiarrhythmic drugs, quinidine, procainamide, propanol hydrochloride, cholinergic drugs, antihypertensive agents, alpha methyldopa and reserpine.

Unit V **(15 hours)**

Aids, Anticonvulsant Drugs and Medicinally Inorganic Compounds: AIDS-HIV, symptoms, and treatment of AIDS. Anticonvulsant drugs - barbiturates, hydantoin, oxazolidine diones, acetyl urea derivative and succinimides. Medicinally important inorganic compounds - Compounds of Aluminium- Alum, Aluminium Hydroxide Gel, Bentonite, and Aluminium Monostearate; Compounds of phosphorus - phosphoric acid and hypophosphoric acid; Compounds of Iron–Ferrous Fumarate, Ferrous Gluconate, Ferrous Sulphate, and Ferric Ammonium Citrate; compounds of Mercury- Mercuric Oxide, Oleated Mercury, Mercurous Chloride, Mercury Amido Chloride and Mercury with Chalk.

Course Outcomes (CO):

After successful completion of this course, student will be able to
CO1: Label the common drugs and interpret the basic concepts of organic pharmaceutical aids
CO2: Identify the general antipyretics, anti-inflammatory, and anaesthetics agents
CO3: Analyze the various diseases in human beings and their treatment methods
CO4: Evaluate importance of the Indian medicinal plants
CO5: Predict antiseptics, disinfectants, cancer, antineoplastic and antibiotics drugs

Text Book:

1. Jeyashree Gosh, *Text Book of Pharmaceutical Chemistry*, S. Chand and company, New Delhi, 2017.

Reference Books:

1. R. Chatwal, *Organic Pharmaceutical Chemistry*, Himalaya Publishing House, New Delhi, 2018.
2. V. Rajasekaran, *Text Book of Pharmaceutical Inorganic Chemistry Theory & Practical*, Sun Publications, 2019.

3. David Plummer, *Practical Biochemistry*, Tata McGraw-Hills Publishing Company, New Delhi, 2017.

Journals:

1. Pharmaceutical and Chemical Journal
2. Journal of Medicinal Chemistry
3. Journal of Pharmaceutical science

E-Resources:

1.https://drive.google.com/file/d/12mV2qvVBajGNF1RdhWGrtZ4SfjGbLaCV/view?usp=sharing
2.https://drive.google.com/file/d/1f_SygAkoMXSEoQfVnyn4PIzDkPnQpRTV/view?usp=sharing
3. https://drive.google.com/file/d/1BvmelseOclJLJhLolSOy71joYH5DsAN4/view?usp=sharing
4. https://onlinelibrary.wiley.com/doi/abs/10.1002/0471238961.0114011214210705.a01
5.https://books.google.co.in/books/about/A_Textbook_of_Pharmaceutical_Chemistry.html?id=QwobEAAAQBAJ&redir_esc=y

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	3	3	9	3	**33**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**15**	**39**	**15**	**21**	**45**	**39**	**219**

Low-1 Medium-3 High-9

Skill Enhancement Course - IV-Computer Fundamentals and C programming

(For Students Admitted from 2022-23)

Semester: IV **Hours/week: 2**
Subject Code: IBCHS45 **Credit: 2**

Course Objectives:

1. To demonstrate a basic understanding of computer hardware and software.
2. To apply logical skills to programming in a variety of languages.

Unit I **(6 hours)**

Introduction to Computer: Introduction-types of computer-characteristics of computer-input devices-output devices. **Networking Fundamentals:** introduction to computer network – network component

Unit II **(6 hours)**

Introduction to C Programming: C character Set - writing first program of C - identifiers and Keywords - a more useful C Program – entering the program into the computer - Data types -Constants - variables and arrays -declarations -expressions -statements - symbolic constants.
Operators and Expressions: Arithmetic operators -unary operators - relational and logical operators - assignment operators - the conditional operators - library functions.

Unit III **(6 hours)**
Data Input and Output: Preliminaries-the getchar function-the putchar function-the scanf function-the printf function-gets and puts function.
Control Statements: Preliminaries - branching: the If-else Statement - looping - while statement - do-while statement -for statement - nested control structures – switch statement -break statement - continue statement.

Unit IV **(6 hours)**
Functions: A brief overview **–** defining a function – accessing a function - function prototype - passing arguments to a function - recursion
Program Structure: Storage classes **–** automatic variables - external variables - static variables**:** defining an array - processing an array -passing arrays to functions.

Unit V **(6 hours)**
Strings: Defining a string - NULL character - initialization of strings - reading and writing a string – processing strings -character arithmetic - searching and sorting of strings -**Pointers:** fundamentals -pointer declarations - operations on pointers.

Course Outcomes:
After successful completion of this course, student will be able to
CO1: Summarize the concept of Computer System, Network components, c programming functions
CO 2: Describe the basic programming knowledge of C and list operators and expressions
CO 3: Demonstrate data input and output and illustrate control statements & functions
CO 4: Analyse unary operators, program structure and categorize arrays
CO 5: Evaluate strings and operations on pointers

Text Books:

1. Pradeep pkohriyal, *Computer Networking,* published by S.B Nangia APH Publishing corporation, 2010.
2. Byron Gottfried, *Programming with C*, Tata McGraw Hill Education, New Delhi, Fourth Edition, 23 July 2018.

Reference Books:

1. Andrew S Tanenboum, *Computer Networks,* Prentice Hall of India Pvt. Ltd., New Delhi, Fourth Edition, 2007.
2. Byron Gottfried, *Programming with C*, Tata Mc Graw Hill Education, New Delhi, Third Edition, 2011.
3. Anita Goel, *Computer Fundamentals***,** Pearson Education Published by Dorling Kindersley (India) Pvt. Ltd., New Delhi,1st Edition, 2010.

Journals:

1. Journal of Cheminformatics

2. Software and Systems Modelling
3. Software Testing, Verification, & Reliability

E - Resources:

1. https://www.coursera.org/courses?query=computer%20fundamentals
2. https://onlinecourses.swayam2.ac.in/ugc19_cs10/preview\
3. Dr. SatyadevNandakumar, Department of Computer Science and Engineering. IIT Kanpur, Available online from: 29 July 2019, https://onlinecourses.nptel.ac.in/noc19_cs42/preview
4. https://techvidvan.com/tutorials/c-programming-language-introduction/
5. https://www.studytonight.com/c/c-input-output-function.php

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	3	3	3	9	3	1	1	23
CO2	9	1	9	9	3	3	3	37
CO3	9	3	9	3	3	9	9	45
CO4	9	3	3	9	3	3	3	42
CO5	9	3	3	9	3	9	3	39
Total	39	13	27	39	15	25	19	186

Low-1 Medium-3 High-9

Extra Credit-III - Dairy Chemistry

(For Students Admitted from 2022-23)

Semester: IV
Subject Code: IBCHX4 **Credit: 2**

Course Objectives:

1. To know about the proteins, enzymes, lactose, vitamins and minerals of milk
2. To widen the knowledge on processing of milk and milk products

Unit I

Milk: Composition of milk - milk Fat, milk proteins, Casein, whey proteins, milk sugars, ash or mineral matters; minor constituents of milk -phospholipids, cholesterol, pigments enzymes, vitamins, gases and non-protein nitrogenous substances of flavour and aroma of milk, physical properties of milk. (Short notes only).

Unit II

Proteins of Milk: Fractionation of milk proteins - Caseins, alpha caseins, beta casein, and k casein, factors influencing stability of casein micelle, casein micelle aggregation - Enzyme coagulation, acid coagulation, heat, age-gelation, proteolytic breakdown of casein, whey proteins, beta lacto globulins and alpha Lactalbumins. (Short notes only).

Unit III

Enzymes, Lactose, Vitamins, and Mineral of Milk: Enzymes - lipoprotein lipase - plasmin, alkaline phosphatase. Lactose, vitamins and minerals. The density of milk -experiment to measure the density of milk, properties of milk - viscosity & freezing point. (Short notes only).

Unit IV

Processing of milk: Effect of heat on milk, milk processing - clarification and pasteurization; The holding or batch system, high-temperature short time method or the continuous system, ultra high-temperature system, role of phosphates in pasteurization, effects of pasteurization, homogenization.(Short notes only).

Unit V

Milk Products: Introduction, Cream, Butter, Ghee, Ice Cream, Various Ingredients Used in the Manufacture of Ice Creams - Milk Fat, Milk Solids-Not-Fat, Lactose Crystallization, Sweeteners, Stabilizers, and Emulsifiers; Dairy Milk as Milk Powder - Types and Uses of Dry Milk. (Short notes only).

Course Outcomes:

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

CO1: Know the composition of dairy products and understand their properties
CO2: Identify the biochemical components in milk
CO3: Analyze the proteins of milk and milk products.
CO4: Determine the Pasteurization and Homogenization of Milk Processing
CO5: Develop new recipes of milk products

Text Book:

1. P.F. Fox and P. L. H. Mc Sweeney, Diary *Chemistry and Biochemistry* 2nd Edition Springer 2015.

Reference Books:

1. P. L. H. Mc, Sweeney *Advanced Diary Chemistry Proteins Applied Aspects* vol 1B 4th Edition Springer 2016.
2. Y. H. Hui, *Dairy Science and Technology Hand book*- Wiley-VCH, 2014.

Journals:

1. Internal Dairy Journal
2. Asian Journal of Dairy and Food Research
3. Indian Journal of Dairy Chemistry

E-Resources:

1. https://books.google.co.in/books?id=MGG0ZcHXUuQC&pg=PA28&source=gbs_selected_pages&cad=3#v=onepage&q&f=false
2. http://www.agrimoon.com/wp-content/uploads/CHEMISTRY-OF-MILK.pdf
3. https://www.thestronginside.com/proteins-from-milk/types-of-proteins-from-milk/
4. http://milkfacts.info/Nutrition%20Facts/Nutritional%20Components.htm
5. https://www.dairy.com.au/products/milk/how-milk-is-made

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	3	9	**39**
CO3	9	3	9	3	3	9	9	**45**

CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**15**	**39**	**45**	**219**

Low-1 Medium-3 High-9

Core-IX - Physical Chemistry–II

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 6**
Subject Code: IBCHC51 **Credit: 5**

Course Objectives:

1. To understand the laws and principles applied in chemical equilibrium electrochemistry, solutions, group theory and chemical kinetics
2. To understand the concepts of molecular symmetry elements and symmetry operators in group theory and its application in solid state.

Unit I **(18 hours)**

Chemical Equilibrium: Chemical Equilibrium - Law of Mass Action, Law of Chemical Equilibrium, Thermodynamic Derivation of Chemical Equilibrium, Vant Hoff Reaction Isotherm, Standard Free Energy Change, Temperature Dependence of Equilibrium Constant, Vant Hoff Isochore, Le Chatelier Principle and its Applications. Enzyme Catalysis - Mechanism and Kinetics of Enzyme Catalysis, Michaelis Menton Equation, Effect of Temperature on Enzyme Catalysis.

Unit II **(18 hours)**

Solutions: Solutions -Raoult's Law, Ideal Solution, Henry's Law, Temperature Composition Diagrams, Ideal Liquid Mixture (Toluene - Benzene), Non Ideal Mixture (Water- Ethanol and Water - Hydrogen Chloride), Azeotropic Mixtures, Distillation of Immiscible Liquids; Partially Miscible Liquids (Phenol - Water and Triethylamine - Water systems), Nernst Distribution Law, Thermodynamic Derivation, Limitations, Applications of Nernst Distribution Law, Solvent Extraction and Determination of Hydrolysis Constant.

Unit III **(18 hours)**

Group Theory: Group Theory - Molecular Symmetry Elements and Symmetry Operations, Products of Symmetry Operations, Properties of a Group, Classes and Sub Groups, Group Multiplication Table (C_2V Table only), Point Groups, Classification of Molecules into Point Groups, Vector and Matrix Algebra, Symmetry Operations and Transformation Matrices, Inverse Matrices. Solid State - Crystal Lattices, Laws of Crystallography, Elements of symmetry, Crystal Systems, Unit cell, Space Lattice, Bravais' Lattices, Structure of NaCl, Structure of CsCl, Miller's Indices.

Unit IV **(18 hours)**

Chemical Kinetics: Rate of Reactions - Rate Constant, Order and Molecularity of Reactions, First Order and Pseudo Unimolecular Reactions (Definition and Examples) - Derivation of Rate Constant for the Inversion of Cane Sugar. Second Order Reactions - Definition and examples, Derivation of Rate Constant (Same Concentration and Different Concentration) and Half Life Period, Application to Saponification of Ester. Third Order Reactions - Definition and examples, Application to the Reaction between $FeCl_3$ and $SnCl_2$, Methods of Determination of Order of Reactions. Zero Order Reactions - Definition and examples, Derivation

of Rate Constant. Theory of Reaction Rates -Collision Theory of Bimolecular Reactions, Unimolecular Reactions, Lindemann's Hypothesis, Theory of Absolute Reaction Rates.

Unit V **(18 hours)**

Electrochemistry–I: Conduction in Metals and in Electrolyte Solutions, Specific Conductance and Equivalent Conductance, Measurement of Equivalent Conductance, Variation of Equivalent and Specific Conductance with Dilution, Ostwalds Dilution Law, Debye Huckel Theory of Strong Electrolytes, Onsagar Equation (no derivation) - Significance and Limitations, Kohlrausch Law and its Applications, Migration of Ions, Ionic Mobility, Transport Number and its Determination, Hittorff Method and Moving Boundary Method, Abnormal Transport Number, Applications of Conductometric Measurements, Determination of Degree of Dissociation of Weak Electrolytes, Ionic Product of Water, Solubility Product of a Sparingly Soluble Salt, Conductometric Titrations, pH Concept, Buffer Solutions, Buffer Activity-Henderson Equation, Applications of Buffer Solutions.

Course Outcomes:

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

CO1: Remember the laws of chemical equilibrium and understand the principles applied in electrochemistry and group theory
CO2: Identify the mechanism of chemical equilibrium and kinetics of electrochemistry
CO3: Categorize the chemical equilibrium, kinetics in solutions and electrochemistry
CO4: Interpret the kinetic aspects of enzyme catalysis
CO5: Solve the point group symmetry for solid state materials

Text Book:

1. B. R. Puri, Madan S. Pathania and L. R. Sharma, *Principles of Physical Chemistry*,Vishal Publishing Co, New Delhi, 2020.

Reference Books:

1. Peter Atkins, and Julio de Paula, Atkins *Physical Chemistry*, Oxford University Press YMCA Library Building, New Delhi, 2014.
2. F. Albert Cotton, *Chemical Applications of Group Theory*, An Indian Adaptation, Wiley Eastern Ltd., New Delhi, New York, 2020.

Journals:

1. Journal of Applied Electrochemistry
2. Journal of Physical Chemistry A
3. Physical Chemistry Chemical Physics

E-Resources:

1. https://www.chem1.com/acad/pdf/solut.pdf
2. http://www.lcwu.edu.pk/ocd/cfiles/Chemistry/Min%20/%20Chem-102/Solutions.pdf
3. https://www.slideshare.net/nnhsuk/chapter-03grouptheory-1
4. https://images.app.goo.gl/tJELwrSu3moSTTdVA
5. http://web.iyte.edu.tr/~serifeyalcin/lectures/chem306/cn_1.pdf

Course Outcomes	Programme Outcomes							
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	Total

CO1	9	3	9	3	3	9	3	**39**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**15**	**45**	**15**	**27**	**45**	**39**	**231**

Low-1 Medium-3 High-9

Core-X - Organic Chemistry–III

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 6**
Subject Code: IBCHC52 **Credit: 5**

Course Objectives:

1. To understand polynuclear hydrocarbons, oils, fats, dyes and chemistry of natural products
2. To acquire insight on basic concepts of amino acids, proteins, nucleic acids, carbohydrates, vitamins, antibiotics and aromatic sulphonic acids

Unit I **(18 hours)**

Polynuclear Hydrocarbons, Oils, Fats and Dyes: Polynuclear Hydrocarbons - Preparation, Properties, Structure and Uses of Naphthalene, Anthracene and Phenanthrene. Preparation and Uses of Naphthylamine, Naphthols, Naphthaquinone and Anthraquinone. Preparation of Biphenyl, Benzidine and Stilbene. Oils and Fats- Definition, Determination and Application. Dyes - Definition, Otto-Witt theory of color and constitution, Classification of dyes according to structure and applications, Preparation and uses of following dyes - Methyl orange, Malachite green, Phenolphthalein, Indigo and Alizarin.

Unit II **(18 hours)**

Amino Acids, Proteins and Nucleic Acids: Definition, Classification, Preparation of Alpha Amino Acids - Glycine, Alanine and Tryptophan, General Properties of Amino Acids - Zwitter ions, Isoelectric Point, Peptides - Bergmann Method, Structure Determination of Polypeptides, End Group Analysis. Proteins – Definition, Classification Based on Physical and Chemical Properties, Primary and Secondary structure of Proteins - Helical and Sheet Structures (Elementary Treatment Only). Nucleic acid – Nucleoside, Nucleotide, R.N.A, and D.N.A. (General Structure).

Unit III **(18 hours)**

Carbohydrates, Vitamins, Antibiotics, and Aromatic Sulphonic Acids: Carbohydrates - Classification, Glucose and Fructose - Osazone formation, Configuration - Open Chain Structure and Ring Structure, Conformation - Haworth's Projection Formulae, Epimerisation -Conversion of Aldose to Ketose and Vice Versa, Disaccharides - Structural Elucidation of Sucrose, Polysaccharides - Structure of Cellulose (no Structural Elucidation). Vitamins - Definition and Classification, Structural Elucidation of Ascorbic Acid. Preparation, Properties and Uses of Benzene Sulphonic Acid, Preparation and Uses of Saccharin, Chloramine-T and Dichloramine-T.

Unit IV **(18 hours)**

Molecular Rearrangements and Tautomerism: Molecular Rearrangements - Classification as Anionotropic, Cationotropic, Intermolecular and Intramolecular, Mechanisms - Pinacol - Pinacolone, Beckmann, Benzidine, Hofmann, Curtius, Lossen, Schmidt. Tautomerism -Definition, Prototropy, and Anionotropy, Detailed Study of the Following- Types of Tautomerism, Keto-Enol Tautomerism, Nitro – aci-nitro Tautomerism, Lactam-Lactim Tautomerism.

Unit V **(18 hours)**

Chemistry of Natural Products: Alkaloids - Classification, Isolation, General Methods of Determination of Structure of Alkaloids, Synthesis and Structural Elucidation of Piperine, Atropine, and Nicotine. Terpenoids - Classification, Isolation, Isoprene rule, Synthesis and Structural Elucidation of Citral, Geraniol and Alpha-Pinene.

Course Outcomes:

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

CO1: List the preparation, properties of bioorganic compounds and understand their structure
CO2: Apply basics to understand rearrangement reactions
CO3: Classify the molecular rearrangement and tautomerism
CO4: Compare the general methods of alkaloids and terpenoids
CO5: Elaborate the synthesis and structural elucidation of alkaloids and terpenoids

Text Book:

1. M. K. Jain, and S.C. Sharma, *Modern Organic Chemistry*, Vishal Publishing Co., New Delhi, 2020.

Reference Books:

1. Robert Thorhton Morrison and Robert Neilson Boyd, *Organic Chemistry*, Pearson India Private Limited, New Delhi, 2016.
2. Michaei B. Smith, *Marchs Advanced Organic Chemistry Reactions Mechanisms and Structure*, John Wiley Limited, New Delhi, 2020.
3. O.P. Agarwal, *Organic Chemistry Natural Products* (Volume II), Krishna Prakashan Media Pvt. Ltd, India, 2015.

Journals:

1. Current Organic Chemistry
2. Journal of Natural Products
3. Organic and Biomolecular Chemistry

E-Resources:

1. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi5qPbXsZLxAhVN4zgGHbgSDPoQFnoECBEQAA&url=https%3A%2F%2Fworldwidescience.org%2Ftopicpages%2Fb%2Fbenzene%2Bnaphthalene%2Bphenanthrene.html&usg=AOvVaw0dmGbA1QMoKwKnBEJeAT6w
2. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwijYedtpLxAhWJ63MBHa4XCTUQFnoECBYQAA&url=https%3A%2F%2Fcourses.lumenlearning.com%2Fwm-biology1%2Fchapter%2Freading-types-of-carbohydrates%2F&usg=AOvVaw1T1kJrScwn6oEUdC0yf6T8

3. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi3z4SAt5LxAhUl8HMBHWXLBckQFnoECBIQAA&url=https%3A%2F%2Fchemistrypage.in%2Fbenzenesulfonic-acid-structure-and-formula%2F&usg=AOvVaw30ytosvNoIQJvkX-2WxHi2
4. https://nptel.ac.in/courses/104103068
5. https://www.sciencedirect.com/science/article/pii/S1110062114200237

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	3	**39**
CO2	9	3	9	3	3	9	3	**39**
CO3	9	3	9	3	3	9	3	**39**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**15**	**45**	**15**	**21**	**45**	**27**	**213**

Low-1 Medium-3 High-9

Core-XI – Advanced Physical Chemistry Practicals

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 6**
Subject Code: IBCHC53P **Credit: 5**

Course Objectives:

1. To gain hands on experience in handling of conductometric titration, potentiometric titration, phase diagram, pH, partition coefficient experiments, viscosity and critical solution temperature
2. To learn principles and procedures employed in determination of corrosion, electrochemical analysis, and chromatography, separation of components from binary mixture and extraction of natural products

List of Experiments: **(60 hours)**

1. Physical Chemistry Experiments

i. Determination of Molecular Weight by Cryoscopic Method –Rast Method –Camphor and Naphthalene
ii. Phase diagram involving (a) Simple Eutectic and (b) Compound Formation
iii. Critical Solution Temperature Estimation of Sodium Chloride by studying the CST of Phenol and Water System
iv. Viscosity - Determination of the Composition of an Unknown Mixture
v. Partition Coefficient Experiments - Study of Equilibria by studying the Partition Coefficient of Iodine between Water and CCl_4
vi. $KI + I_2 \longrightarrow KI_3$
vii. Kinetics – Determination of Relative Strength of Acids by Acid Catalyses Hydrolysis of Ester
viii. Conductivity Titration between an Acid and a Base (HCl Vs NaOH)
ix. Potentiometric Titration between an Acid and a Base (HCl Vs NaOH)
x. Determination of pH of the Soil by pH meter.

2. Industrial Chemistry Experiments **(30 hours)**

i. Corrosion Experiment (Weight loss method)
ii. Analysis of Electrochemical Systems - Copper Electroplating

iii. Separation of Mixtures of Dyes and Mixture of Cobalt, Manganese, Nickel, and Zinc using Paper Chromatographic
iv. Separation of a Mixture of Potassium Permanganate and Potassium Dichromate using Column Chromatography
v. Determination of Rf. Values and Identification of Organic Compounds by Thin Layer Chromatography (TLC)
vi. Separation of Components of a Binary mixture - Benzoic acid and Naphthalene/Toluene.
vii. Extraction of Natural Products - Isolation of Lactose from Milk, Isolation of Caffeine from Tea and Isolation of Citric acid from Lemon
viii. Preparation of Inorganic Complexes and Identification of Counter Ion using conductometric Titration.
ix. Simulation of Electronic Structure for Inorganic Complexes using DFT Methods.

Evaluation Scheme: 3 hrs for Physical Chemistry Experiments and 3hrs for Industrial Chemistry Experiments for 30 marks each.

Course Outcomes:

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

CO1: Know the effect of electrolyte on CST of partially miscible liquids and understand the principle behind viscometry

CO2: Experiment with conductometric and potentiometric titration

CO3: Analyze the separation in components of a binary mixture and preparation of inorganic complexes to identify counter ion

CO4: Determine Rf values and choose eluent for organic compounds to be used in paper, column, and thin-layer chromatography

CO5: Develop the extraction procedure for natural products

Text Book:

1. J. B. Yadav, *Advanced Practical Physical Chemistry*, Krishna Prakashan Media Limited, 2016.

Reference Books:

1. Kamala Rani Bhattacharyya, *Physical Chemistry Practical*, New Academic Publications, 2016.
2. A.R. Kulandaivelu, V. Venkateswaran & R. Veeraswamy, *Basic Principles of Practical Chemistry*, Sultan Chand and Sons, New Delhi, 2017.
3. B. Viswanathan, & P. S. Raghavan, *Practical Physical Chemistry*, New Delhi, Viva Book Private Limited, 2014.
4. J. B. Yadav, *Advanced Practical Physical Chemistry*, Krishna Prakashan Media Limited, 2016.

Journals:

1. Biophysical Chemistry
2. Journal of Physical Letters
3. Annual Review of Physical Chemistry

E-Resource:

1. http://rbvrrwomenscollege.net/wpcontent/uploads/2018/06/physical_Chemistry_manual.pdf
2. https://egyankosh.ac.in/bitstream/123456789/15866/1/Unit-8.pdf

3. https://www.nitt.edu/home/academics/departments/chem/programmes/btech/curriculum/sem4/cl214/Lab%20Manual.pdf
4. https://www.colby.edu/chemistry/CH142/lab/CH142Exp8Electroplating.pdf
5. https://diyhpl.us/~nmz787/pdf/DFT_flavor_of_coordination_chemistry.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**21**	**45**	**45**	**231**

Low-1 Medium-3 High-9

Disciple Specific Elective I (A) - Industrial Chemistry

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 4**
Subject Code: IBCHE5A **Credit: 4**

Course Objectives:

1. To acquire knowledge on fermentation, pulp and paper industries
2. To understand the concepts in silicate, rubber, fertilizers, soaps and detergents industry

Unit I **(12 hours)**

Pulp & Paper Industry: Raw materials for Pulp & Paper (Fibrous &Non-Fibrous raw materials). Pulping - Definition, Uses of Pulp, Pulping Methods for Paper Manufacture: (1) Mechanical or Ground Wood Process - Chemical Nature of Wood-Wood Pulping - Object and Use - Ground Wood Process - Improvements (2) Chemical Processes- (a) Kraft or Alkaline Sulphate Process in detail including Recovery of Chemicals, (b) Acid Sulphite Process in detail (3) Semi-Chemical Process - Short Time (NSSC) Process Comparison of Kraft, Sulphite & NSSC Pulping Processes, Stock Preparation, Furnishing, Beating, Bleaching, Sizing, Fillers and Colouring; Paper Making Processes - Fourdrinier Machine in detail with flow chart - Cylinder Machine – Short account with advantages & disadvantages.

Unit II **(12 hours)**

Fermentation Industries: Introduction, Definition, Factors Influencing Fermentation Reactions, Types of Fermentation Process -Aerobic and Anaerobic processes (Microorganisms), Microbial Nutrients, Merits of Fermentation Process and Fermentation Products; Fermentation Industries - Manufacture of Ethyl Alcohol with flow sheet - Manufacture of Butyl Alcohol - Manufacture of Vinegar - Manufacture of Lactic acid - Manufacture of Citric Acid.

Unit III **(12 hours)**

Silicate and Rubber Industry: Cement - Manufacture of Cement, Setting & Curing, RCC and Cement Industries in India; Glass -Types of Glasses, Manufacture of Optical Glass, Borosilicate Glass, Coloured

Glass, Glass Wool & Applications; Rubber - Natural and Synthetic rubber, Manufacture and Applications of SBR, Neoprene, PUF and Silicone rubber.

Unit IV **(12 hours)**

Fertilizers: Introduction, Classification of Soil Nutrients - Micronurtients and Macronutrients, Fundamentals of N, P and K, Role of Primary and Secondary Nutrients in Plant Growth, Natural and Chemical Fertilizers, Manufacture of Ammonium Sulphate, Calcium Cyanamide, Urea, Calcium Super Phosphate, DAP and Potassium Nitrate, Mixed Fertilizers, Fertilizer Industry in India.

Unit V **(12 hours)**

Soaps and Detergents: Introduction, Classification of Soaps, Raw Materials Required, Manufacture of Soaps, Cleansing Action of Soaps; Detergents - Principal Groups of Synthetic Detergents, Classification of Detergents, Anionic Surfactants, Cationic, and Ampholytic Surfactants, Non-Ionic Surfactants, Detergent Builders and Additives-Sludge Regulators, Principle of Cleansing Action of Detergents or Detergency, Comparison of Soaps and Detergents.

Course Outcomes:

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

CO1: Recall the raw materials for commercial materials and understand the chemical processes
CO2: Identify the type of fermentation based on composition of products
CO3: Classify the paper, cement, fertilizers, glass, rubber, soaps, and detergents
CO4: Explain the cleaning action of soaps and detergents
CO5: Modify pulping methods for paper manufacture

Text Book:

1. B.K. Sharma, *Industrial Chemistry*, Krishna Prakashan Media Pvt. Ltd., Meerut, 2016.

Reference books

1. Edwin E. Slosson, *Chemistry for Chemical Industries*, Medtech Private Limited, 2017.
2. O.P. Veramani, *Applied Chemistry*: *Theory and Practice*, New Age International Private Limited, New Delhi, 2017.
3. Jaya Shree Anireddy, *Textbook of Engineering Chemistry*, Wiley Pvt. Ltd., New Delhi, 2018.

Journals:

1. Journal of Industrial and Engineering Chemistry
2. International Journal of Industrial Chemistry
3. American Journal of Applied and Industrial Chemistry

E-Resources:

1. https://www.researchgate.net/publication/282709774_Pulp_and_Paper_Industry_Chemicals
2. https://www.researchgate.net/publication/281716235_Industrial_fermentation
3. https://www.slideshare.net/AttittudeBlogger/amal-ppt-41637599
4. https://www.researchgate.net/publication/331132826_The_Impact_of_Chemical_Fertilizers_on_our_Environment_and_Ecosystem
5. https://nzic.org.nz 2017/10PDF Soap and Detergent Manufacture - NZ Institute of Chemistry

Course	Programme Outcomes

Outcomes								
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**15**	**45**	**45**	**225**

Low-1 Medium-3 High-9

Disciple Specific Elective I (B) - Biological Chemistry

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 4**
Subject Code: IBCHE5B **Credit: 4**

Course Objectives:

1. To learn about various methods of treatment and analysis of blood, nutrients digestion, hormones and enzymes
2. To acquire knowledge on biological functions of micro-minerals and vitamins

Unit I **(12 hours)**

Blood: Blood-Composition, Plasma Proteins, RBCs, Blood Groups, The Rh Factors, Blood Transfusions, Blood Pressure, Hypertension, Hypotension.

Unit II **(12 hours)**

Nutrients Digestion and Absorption: Introduction, Digestion, Absorption, Process of Digestion, Digestion in the Oral Cavity, Digestion in the Stomach, Digestion in the Small Intestine, Absorption and Digestion of Carbohydrates, Fatty acids, Amino acids, and Proteins.

Unit III **(12 hours)**

Hormones and their Physiological Effects: Introduction, Preparation, and Functions of Hormones, Chemical Nature of Hormones, Structure a Physiological Function of Some Hormones, Adrenaline, Thyroxine, Oxytocin, Insulin and The Sex Hormones (Androgens and Oestrogens).

Unit IV **(12 hours)**

Micronutrients and their Biological Role: Introduction, Biological Function of Some Micro Minerals, Iron, Copper, Fluorine and Zinc and Iodine, etc.; Vitamins - Water Soluble Vitamins, Lipid Soluble Vitamins - a detailed study.

Unit V **(12 hours)**

Enzymes: Introduction, Properties, Nomenclature, Classification, Chemical Nature of Enzyme, Co-Factors, and Co-Enzymes, Mechanism of Enzyme Catalysis, Factors Affecting - Enzyme Activity, Enzyme Action, Regulation of Enzyme Activity, Inhibitors -Reversible and Irreversible Inhibitors.

Course Outcomes:

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

CO1: List the biochemical changes during digestion and understand absorption of nutrients

CO2: Apply the possible physiological effects to hormone functional changes
CO3: Analyse the biological role of micronutrients
CO4: Classify the vitamins, hormones & enzymes
CO5: Design the function mimics inhibitors

Text Books:

. 1. Jeyashree Gosh, *Text Book of Pharmaceutical Chemistry*, S. Chand and company, New Delhi, 2017
2. Robert Thorhton Morrison and Robert Neilson Boyd, *Organic Chemistry*, Pearson India Private Limited., New Delhi, 2016.

Reference Books:

1. Michael L. Bishop, Edward P. Fody and Larry. E. Schoeff, *Clinical Chemistry*, Wolters Kluwer, 2017.
2. K.V. Krishna Das, *Textbooks of medicine*, Jaypee Brothers Medical Publication, New Delhi, 2017.
3. Jayashree Ghosh, *Fundamental Concepts of Applied Chemistry*, S. Chand & Company Ltd. New Delhi, 2010.

Journals:

1. Journal of Biological Chemistry:
2. ACS Chemical Biology
3. Chemical Biology & Drug Design

E-Resources:

1. https://drive.google.com/file/d/13yrniBSZiXZthg-zB2tPoEp-v5mssG0w/view?usp=sharing
2. https://drive.google.com/file/d/14cFrFUenz231C_xxhij1Guop4lxXw7hc/view?usp=sharing
3. https://med.libretexts.org/Courses/Manchester_Community_College_(MCC)/Manchester_Community_College_-_Introduction_to_Nutrition/03%3A_Digestion_Absorption_and_Transport_of_Nutrients
4. https://www.researchgate.net/publication/335222483_Plant_Hormones_and_Their_Physiological_Effects
5. https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/04%3A_Nutrition/4.2%3A_Nutrients

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**15**	**45**	**15**	**21**	**45**	**45**	**231**

Low-1 Medium-3 High-9

Disciple Specific Elective II (A) - Textile Chemistry

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 4**
Subject Code: IBCHE5C **Credit: 4**

Course Objectives:

1. To acquire knowledge on textile fibres, operation of singeing and dyes
2. To understand chemistry behind dyeing and printing and their applications

Unit I **(12 hours)**

Textile Fibres: Definition and Classification of Textile Fibres according to their Nature and Origin, Essential and Desirable Properties of Textile Fibres; Cotton Fibres- Chemical Composition and Morphology; Bast Fibres - Jute, Hemp, Ramie and Linin (Flax); Regenerated Fibres - Viscose Rayon; Protein Fibres – Silk and Wool, Sericulture and Reeling of Silk, Grading of Wool, Morphology of Wool Fibre, Regenerated Protein Fibres - Soyabean, Ardile, Casein, Vicara and Mineral Fibres (Asbestos).

Unit II **(12 hours)**

Operation of Singeing: Study of the Operation of Singeing, Various Method of Singeing Such as Plate, Gas and Rotary Cylinder Machines, Precautionary Measures to be taken during Singeing Operation, Study of Operations of Desizing using Hydrolytic and Oxidative Method (Any Two Methods) Scouring Method using Vertical Kier, General methods of Bleaching using Sodium Chlorite, Bromite, Hypochlorites, and Hydrogen Peroxide.

Unit III **(12 hours)**

Dyes: Colour and Chemical Constitution, Chromosphere, Auxochrome, Theories, History of Natural and Synthetic Dye, Classification of Dyes based on Chemical Constitution and Method of Application. Application of Direct, Reactive, Acid and Basic. Vat Dyes on Cotton and Protein Fibres.

Unit IV **(12 hours)**

Dyeing and Printing: Definition, Difference between Dyeing and Printing, Block Printing, Batik Printing, Screen Printing, Roller Printing, Direct Printing Styles, Printing with Vat Dyes, Azoic Dyes, and Modern colors; Finishing Processes - Purpose, Classification, Brief Details of Finishing Operations, Straightening, Sanforizing, Stiffening, Mercerizing in Detail, Calendering, Water Proofing, Mildew Proofing, Fire Proofing, and Moth Proofing.

Unit V **(12 hours)**

Printing of Synthetic Fibres: Development in Printing of Synthetic Fibres and their Blends. Bubble Dyeing, Foam Technology, Transfer Printing, Capsule / Speckle Printing; Aqueous Pigment Printing-Dylan and Celestron Dyes; Foam - Discharge Style, Burnt -Out Style, etc.

Course Outcomes:

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

CO1: Recall the principle that involve in dying and understand morphology of fibres
CO2: Choose the methods in operation of singeing
CO3: Classify application of textile fibers, operation for singeing and dyes
CO4: Compare dyeing and printing with its applications
CO5: Design the printing of synthetic fibres for their applications

Text Books:

1. Tyronel L. Vigo, *Textile Processing & Properties*, Elsevier Publishing Company, Netherland, 2002.
2. Rastogi Deepali, and Chopra Sheetal, *Textile Science*, Orient Blackswan Private Limited, 2017.

Reference books:

1. K. Hunger, *Industrial Dyes: Chemistry, Properties, Applications*, Wiley-VCH. New Delhi, 2003.
2. R. Nietzki, *Chemistry of Organic Dyestuffs*. Gurney & Jackson, University of Michigan. 2019.
3. Georg Von Georgievics, *The Chemical Technology Of Textile Fibres - Their Origin Structure Preparation Washing Bleaching Dyeing Printing And Dressing*, Read Books Publisher, 2008.

Journals:

1. International Journal of Textile Science
2. Journal of Modern Textile Science and Engineering
3. Journal of Textile science and technology

E-Resources:

1. https://textechdip.wordpress.com/contents/textile-fiber/
2. https://www.slideshare.net/parmeetkaur17/singeing-process
3. http://www.meerutcollege.org/mcm_admin/upload/1586585321.pdf
4. https://vdocuments.mx/defects-in-dyeing-and-printing.html
5. https://www.textileebook.com/2019/09/synthetic-fibres-nylon-polyester-acrylic-polyolefin-edited-by-j-e-mcintyre.html

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	9	3	9	9	9	**51**
Total	**45**	**15**	**45**	**15**	**27**	**45**	**45**	**237**

Low-1 Medium-3 High-9

Displine Specific Elective II (B) - Analytical Methods

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 4**

Subject Code: IBCHE5D **Credit: 4**

Course Objectives:

1. To understand concepts on the principle and instrumentation of TGA, DTA, DSC, TMA, DMA and gas chromatography
2. To acquire basics on principle, and instrumentation of atomic absorption, flame emission, X - ray emission, ultraviolet and visible and infrared spectroscopy

Unit I **(12 hours)**

Introduction of Analytical Chemistry: The Scope of Analytical Chemistry, Functions and Applications of Analytical Chemistry, Definition and Basic Concepts of Mean, Median, Degree of Freedom, Deviation, Standard Deviation Variance, Q Test, T-Test, Accuracy, Absolute Method and Comparative Method,

Precision, Errors, Classification of Errors – Methods of Minimizing Errors, Significant Figures and Computative Rules.

Unit II **(12 hours)**

Thermal Techniques: Thermogravimetry-Principle, Instrumentation, Application of TGA, Differential Thermal Analysis (DTA) -Principle, Instrumentation, and application of DTA.

Differential Scanning Calorimetry-Principle, Instrumentation, Applications of DSC, Thermo Mechanical Analysis (TMA) and Dynamic Mechanical Analysis (DMA) - Principle, Instrumentation, and Applications of TMA and DMA; Pyrolysis-gas chromatography, Principle, Instrumentation.

Unit III **(12 hours)**

Atomic Spectrometry: Atomic Absorption Spectrometry-Absorption of Characteristic Radiation Instrumentation, Sample Vapourisation, Quantitative Measurements, and Interferences and Applications. Flame emission spectrometry-Principle, Instrumentation, Flame characteristics Flame Process, Emission Spectra, Quantitative Measurements, and Interferences and Applications. X-Ray Emission Spectrometry-X-Ray Process, Instrumentation, and Applications.

Unit IV **(12 hours)**

Ultraviolet and Visible Spectroscopy: Introduction, Absorption laws, Formation of Absorption bands, Theory of Electronic Spectroscopy, Types of Electronic Transitions, Transition Probability, Chromophore, Auxochrome, Absorption, and Intensity Shifts, Types of Absorption Bands, Solvent Effects, Conjugated Diene, Woodward-Fieser rules for Calculating Wavelength Maxima in Diene, Distortion of the Chromophore-Polyenes and Polyenes, Benzene and its Derivatives, Absorption Spectra of Condensed Ring Systems, Steric Hindrance, and Coplanarity, Fluorescence and Phosphorescence – Applications.

Unit V **(12 hours)**

Infrared Spectroscopy: Introduction, Theory of Molecular Vibrations, Vibrational Frequency, Number of Fundamental Vibrations, Factors Influencing Vibrational Frequencies, Fingerprint Region, Application of IR Spectroscopy, Detection of Alkanes, Alkenes, Alkynes, Cycloalkanes, Aromatic Hydrocarbon, Phenols and Alcohols, Ethers, Carbonyl Compounds, Aldehydes and Ketones, Esters Lactones, Carboxylic Acid, Acid Halides, Acid Anhydrides, Amides, Amino Acid, Amines, and Nitro Compounds.

Course Outcomes:

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

CO1: List the sources for atomic spectroscopy and understand inference from quantitative measurements

CO2: Apply the instrumentation knowledge in handling spectral, chromatography techniques with precautions

CO3: Classify the molecular transition in various spectral techniques.

CO4: Evaluate the Woodward-Fieser rules and understand λ_{max} observed in UV-Vis spectra

CO5: Suggest the application of chromatography and spectral technique for the identifying and isolating compounds

Text Books:

1. A. Skoog Douglas, F. James Holler and R. Crouch Stanley, *Principles of Instrumental Analysis*, Cengage Learning India Pvt. Ltd., 2020.
2. D. K. Sarkar, *Fundamentals of Analytical Chemistry*, Pharma Med Press / BSP Books, 2021.

Reference books:

1. F.W. Fifield, and D. Kealey, *Principle and Practice of Analytical Chemistry*, Blackwell Science Ltd., New Delhi, 5th Edition, 2004.
2. G. R. Chatwal and Sham Anand, *Instrumental Methods of Chemical Analysis*, New Delhi, Himalaya Publishing House, 2011.
3. Miguel Valcarcel, *Principles of Analytical Chemistry*, Springer Publisher, 2014

Journals:

1. Journal of Analytical methods in Chemistry
2. Analytical methods Journal
3. Analytical Methods

E-Resources:

1. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwitiZv6u5LxAhWM7HMBHSZWA7AQFnoECCcQAA&url=https%3A%2F%2Feng.libretexts.org%2FBookshelves%2FIndustrial_and_Systems_Engineering%2FBook%253A_Chemical_Process_Dynamics_and_Controls_(Woolf)%2F13%253A_Statistics_and_Probability_Background%2F13.01%253A_Basic_statistics-_mean%252C_median%252C_average%252C_standard_deviation%252C_z-scores%252C_and_p-value&usg=AOvVaw2AaT30ekoX_8ozOQacHAxc
2. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi7svXOvJLxAhWB7XMBHVwuDIYQFnoECBQQAA&url=http%3A%2F%2Finstrument-specialists.com%2Fthermal-analysis-applications%2Fdifferential-scanning-calorimetry-dsc%2F&usg=AOvVaw3TWPWEBp4JyudIycwcOpK2
3. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiUk-CsvZLxAhXXFbcAHSnOCfkQFnoECCAQAA&url=https%3A%2F%2Fwww.tau.ac.il%2F~chemlaba%2FFiles%2FFlame%2520supplement.pdf&usg=AOvVaw3MU3kd6BHzk4gMwmILaY6z
4. https://onlinecourses.nptel.ac.in/noc19_cy18/preview
5. https://www.digimat.in/nptel/courses/video/104105084/L51.html

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	9	9	9	**51**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**21**	**45**	**45**	**231**

Low-1 Medium-3 High-9

Skill Enhancement Course V- Selected Topics in Applied Chemistry

(For Students Admitted from 2022-23)

Semester: V **Hours/Week: 2**

Subject Code: IBCHS54 **Credit: 2**

Course Objectives:

1. To widen the knowledge in leather, dairy and polymer chemistry
2. To impart knowledge on organophosphorus, carbamates, organochlorine and vermiculture

Unit I **(6 hours)**

Leather Chemistry: Introduction, Chief Processes Used in Leather Manufacture-Before Tannage, After Tannage, Composition of a Hide, Preparing Skins and Hides-Cleaning and Soaking, Liming and Degreasing and Fleshing and Shaving. Tanning Process-Tannage Materials, Vegetable Tanning.

Unit II **(6 hours)**

Dairy Chemistry: Milk **–** Composition of Milk, Physical Properties of milk, Effect of Heat on Milk, Coagulation by Heat, Effect of Heat on Fat, Sugar Protein Mixture, Acidity, Viscosity, Minerals, Colour, Flavour & Digestibility, Microorganism, Screen Formation and Scorching of Milk, Pasteurization, Homogenization.

Unit III **(6 hours)**

Polymer Chemistry: Introduction, Classification of Polymer-Natural & Synthetic, Thermoplastic & Thermosetting, Plastics, Elastomers, Fibers & Liquid resins, Homopolymer & Co-Polymers (Definition & Examples only). Polymerization: Definition, Types of Polymerization, Addition & Condensation Polymerization, Examples –Polyethylene, Polyvinyl Chloride, Terylene and Nylon 6, 6. Natural Rubber– Synthetic Rubber, Buna N and Buna S Rubber.

Unit IV **(6 hours)**

Organophosphorus, Carbamates and Organochlorine Compounds: Pesticides-Classification-Insecticides, Fungicides and Herbicides-General Methods of Application, Safety Measures, Preservation of seeds and Toxicity. CIB Quality requirements. Natural Insecticide-Nicotine, Pyrethrin, Inorganic pesticides – Borates and Organic pesticides - D.D.T. and BHC. Fungicide-Dithiocarbamates, Copper Compounds and Bordeaux mixture. Herbicides, Acaricides, Rodenticides. Attractants – Repellents.

Unit V **(6 hours)**

Vermiculture: Introduction, definition, classification, Physio - chemical parameters of vermicompost, Different Methods: Bed method, Pit method, Conventional commercial composting. Harvesting, packaging, transport and storage of Vermicompost. FCO quality requirements.

Course Outcomes:

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

CO1: List the various insecticides, herbicides, fungicides and understand safety measures
CO2: Select the suitable method for vermiculture
CO3: Analyse dairy products based on properties
CO4: Classify the natural & synthetic polymer
CO5: Develop practical skills to the new materials with acquired knowledge on leather

Text Books:

1. Jeyashree Gosh, *Text Book of Pharmaceutical Chemistry*, S. Chand and company, New Delhi, 2017.
2. B.K. Sharma, *Industrial Chemistry*-I, Anu Books, New Delhi, 2020.

Reference Books:

1. K. Bagavathi Sundari, *Applied Chemistry*, MJP publications. New Delhi, 2019.

2. A. Ravikrishnan, *Engineering Chemistry*, Sir Krishna publication, Chennai, 2021.
3. B.K. Sharma, *Industrial Chemistry-II*, Anu Books, New Delhi, 2020.

Journals:

1. International Journal of Applied Chemistry
2. Russian Journal of Applied Chemistry
3. American Journal of Applied Chemistry

E-Resource:

1. https://books.google.co.in/books?id=MGG0ZcHXUuQC&pg=PA28&source=gbs_selected_pages&cad=3#v=onepage&q&f=false
2. http://wwwchem.uwimona.edu.jm/courses/CHEM2402/Textiles/Leather.html
3. https://pubmed.ncbi.nlm.nih.gov/21071550/
4. http://agri.and.nic.in/vermi_culture.htm
5. https://dairyprocessinghandbook.tetrapak.com/chapter/chemistry-milk#:~:text=The%20principal%20constituents%20of%20milk,fatlike%20properties)%2C%20and%20gases.

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	9	3	9	9	**51**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	9	3	9	9	**51**
Total	**45**	**15**	**45**	**27**	**15**	**45**	**45**	**237**

Low-1 Medium-3 High-9

Core –XII: Project

(For Students Admitted from 2022-23)

Semester: VI **Hours/Week: 6**
Subject Code: IBCHC61PW **Credit: 5**

Course Objectives:

1. To understand the practical skill of chemistry project
2. To learn principles and procedures employed in thesis writing of Chemistry

(90 hours)

Project work to be done by a group of five students in collaboration with central/state institute/R&D laboratory. The Project work should help the students to create a research attitude and apply the theory they have learnt throughout the course.

Evaluation Scheme: Project internal is evaluated based on the presentation of the project - 15 marks, background knowledge - 20 marks, and 5marks for attendance. The external 60 marks are distributed as follows, for dissertation 35 marks, for presentation 15 marks, and viva- voce10 marks.

Course Outcomes (CO):

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

CO1: Choose and discuss the basic concepts in the chemistry project

CO2: Illustrate the principles and procedures employed in thesis writing of chemistry

CO3: Examine the skillsets required of chemistry project

CO4: Choose the appropriate procedures in handling of apparatus and chemicals

CO5: Formulate the designer materials with ecofriendly starting materials

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	9	9	9	**51**
CO3	9	9	9	3	9	9	9	**57**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	9	3	9	9	**51**
Total	**45**	**21**	**45**	**21**	**27**	**45**	**45**	**249**

Low-1 Medium-3 High-9

Core-XIII - Inorganic Chemistry–III

(For Students Admitted from 2022-23)

Semester: VI **Hours/Week: 5**

Subject Code: IBCHC62 **Credits: 4**

Course Objectives:

1. To acquaint with the importance of inner transition elements - Lanthanides and Actinide
2. To understand the concept of co-ordination chemistry, organometallic compounds, solids bio-inorganic compounds and inorganic polymers

Unit I **(15 hours)**

Lanthanides and Actinides: Lanthanides-Position in the Periodic Table, General Characteristic of Lanthanides, Lanthanide Contraction and its Consequences, Isolation of Lanthanides from Monazite (including the Ion Exchange Resin Method). Actinides - Position in the Periodic Table, General Characteristic of Actinides, Occurrence, Separation of Actinide, Synthesis of Trans uranium elements. Comparison of Lanthanides and Actinides, Comparison of d- and f- block elements.

Unit II **(15 hours)**

Coordination Chemistry- I: Introduction-Definition and Terminology, Ligands, Monodentate and Polydentate Ligands, Coordination Number, Chelation, Nomenclature of Coordination Compounds, Structural & Stereo Isomerism, Werner's Co-Ordination Theory, Sidgwick's Electronic Concept, EAN Rule, Metal Carbonyl Complexes, Bonding in Carbonyls-Mono and Binuclear Carbonyls of Ni, Fe, Cr, Co and Mn–Hybridisation and Structure, VB theory, Shortcomings of Valence Bond theory.

Unit III **(15 hours)**

Coordination Chemistry- II: Crystal Field Theory-Crystal Field Splitting of Energy Levels, Crystal Field Splitting of Octahedral and Tetrahedral Complexes, Crystal Field Stabilization Energy, Crystal Field Splitting in Tetragonal and Square Planar Complexes, Factors Affecting the Magnitude of Crystal Field Splitting, Magnetic Properties of Complexes, Ligand Field Theory, Evidence of Covalent Bonding in Metal-Ligand Bonding, Molecular orbital theory of Complexes.

Unit IV **(15 hours)**

Bioinorganic Chemistry and Solids: Bioinorganic Chemistry-Essential and Trace Elements in Biological processes - Biological role of Haemoglobin, Myoglobin, Metalloprophyrins and Chlorophyll (Elementary idea of Structure and Mechanism of their Action), Biological Functions and Toxicity of Some Elements, Biological Fixation of Nitrogen. Solids-Band Theory of Conductors, Semiconductors and Insulators. Imperfections in a Crystal-Outline of Schottky Defects, Frenkel defects, Metal Excess and Metal Deficiency Defects and Line Defects. Nanomaterials - an Elementary Study.

Unit V **(15 hours)**

Organometallic Compounds and Inorganic Polymers: Organometallic Compounds-Definition, Classification-Ionic, σ-bonded and π-bonded Organometallic compounds, Preparation, properties and uses of Organometallic compounds, Olefin Complexes-Synthesis and Structure of Zeisels salt, Cyclopentadienyl Complexes - Preparation, properties, structure and uses of Ferrocene. Inorganic Polymers-Introduction, Classification, Preparation of Borazine, Substituted Borazine, Poly-Phosphonitritic Chloride, Poly-phosphoric acid, Borophosphate glasses, Tetrasulphur Tetranitride, Trithiazyl trifluoride, Imides of Sulphur.

Course Outcomes:

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

CO1: Recall the periodic property of lanthanides and actinides and understand the general characteristics of inner transition elements

CO2: Utilize the Valence Bond theory, Crystal Field theory & Molecular orbital theory to arrive geometry and structure of coordination compounds

CO3: Categorize the solid state crystal based on imperfections observed in light of band theory

CO4: Compare the stability of coordination complexes with organometallic compounds

CO5: Develop the basic understanding on the biological role of hemoglobin, myoglobin, metalloporphyrins, and chlorophyll

Text Book:

1. R.D. Madan, *Modern Inorganic Chemistry*, S. Chand and Company Private Limited, New Delhi, 2019.

Reference Books:

1. B.R. Puri, L.R. Sharma and K.C. Kalia, *Principle of Inorganic Chemistry*, Vishal Publishing Co, New Delhi, 2020.

2. R. Methrotra and A. Singh, *Organometallic Chemistry*, New Age International Pvt. Ltd. Publishers, New Delhi, 2020.
3. James E. Huheey, Ellen A. Keiter, L. Keiter Richard & Okhil K. Medhi, *Inorganic Chemistry Principles of Structure and Reactivity*, Pearson India, 2019.

Journals:

1. Journal of Coordination Chemistry
2. Journal of Inorganic Biochemistry
3. Journal of Organometallic Chemistry

E-Resources:

1. https://www.alchemyst.co.uk/pdf/Inorganic/lanthanides_and_actinides.pdf
2. https://ncerthelp.com/cbse%20notes/class%2012/chemistry/Chemistry%20Notes%20for%20class%2012%20Chapter%209%20Coordination%20Compounds%20.pdf
3. https://chem.libretexts.org/Courses/Saint_Marys_College_Notre_Dame_IN/CHEM_342%3A_Bio-inorganic_Chemistry/Readings/Week_4%3A_Ligand_Field_Theory_(Octahedral_Complexes)/4.1%3A_Ligand_Field_Theory_(LFT)_and_Crystal_Field_Theory_(CFT)_of_Octahedral_Complexes
4. https://www.slideshare.net/mobile/Vishali29/structure-of-chlorophyll-haemoglobin
5. https://www.microscopemaster.com/chlorophyll.html

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	3	**39**
CO2	9	3	9	3	9	9	3	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	3	**39**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**21**	**45**	**27**	**213**

Low-1 Medium-3 High-9

Core-XIV - Physical Chemistry–III

(For Students Admitted from 2022-23)

Semester: VI **Hours/Week: 6**
Subject Code: IBCHC63 **Credit: 4**

Course Objectives:

1. To gain knowledge about of photochemistry, electrochemistry and colloidal state
2. To widen knowledge about spectroscopy – IR, UV, Raman, Electronic spectra & NMR

Unit I **(18 hours)**

Photochemistry: Photochemistry - Interaction of Radiation with Matter, Differences between Thermal and Photochemical processes, Laws of Photochemistry - Grothus-Draper Law, Stark-Einstein Law; Jablonski Diagram Depicting Various Processes Occurring in the Excited State (Internal Conversion, Intersystem Crossing) Qualitative Description of Fluorescence, Phosphorescence, Chemiluminescence, Quantum Yield, Photosensitized Reactions. Kinetics of Photochemical Combinations - H_2-Cl_2 and H_2-Br_2 reactions.

Unit II **(18 hours)**

Electrochemistry – II: Electromotive Force, Electrolytic and Galvanic Cells, Daniel Cell, Standard Weston Cadmium Cell, Reversible and Irreversible Cells, Conventional Representation of Electrochemical Cells, EMF of a Cell and its Measurement, Computation of Cell EMF, Nernst Equation, Types of Reversible electrodes –Single Electrode Potential, Standard Hydrogen Electrode, Reference Electrodes, and Standard Electrode Potential, Fuel Cells (H_2-O_2 Cell), Lead Storage Battery. Statistical Thermodynamics– Postulates of Macroscopic Thermodynamics, Maxwell's Derivation of the Molecular Velocity Distribution, Maxwell-Boltzmann Statistics.

Unit III **(18 hours)**

The Colloidal State: Introduction, Classification of Colloidal Solutions, Characteristics of Hydrophilic and Hydrophobic Sols, Preparation of Colloidal Solution, Lyophilic & Lyophobic Solution, Preparation methods, Condensation Methods such as by Double Decomposition, Hydrolysis, Reduction, Oxidation, Exchange of Solvent, Controlled Condensation, Change of Physical State, in Short, Dispersion Methods such as Bredig's Method, by Grinding, Peptization, in Short, Purification of Colloidal Solution – Dialysis, Ultrafiltration, Ultra centrifuging, Properties of Colloidal Solutions, Optical Properties such as Tyndall Effect, Brownian Effect, Color, Electrical Properties such as Electrical Charge, Electrical double layer & Zeta Potential, Cataphoresis, Electro-Osmosis. The Protective Colloid (Gold Number), Application of Colloidal State.

Unit IV **(18 hours)**

Spectroscopy-I: Introduction-Electromagnetic Radiation, Different Regions, Absorption Spectroscopy, Molecular spectra, Types of Molecular Spectra. IR Spectroscopy-Principle, Molecular Vibrations, Finger-Print Region, Applications of IR Spectroscopy (Qualitative & Quantitative Analysis and Determination of Molecular weight), Interpretation of IR Spectra.

UV Spectroscopy-Introduction, Origin of Electronic Spectra, Laws of Absorbance. Types of Electronic Transitions, Chromophores, and Auxochromes, Effect of Conjugation, Applications of UV Spectroscopy (Qualitative & Quantitative Analysis and Measurement of Beer-Lamberts Law), Woodward-Fieser rules.

Unit V **(18 hours)**

Spectroscopy-II: Raman Spectra-Raman Effect, Stokes and Anti Stokes Lines, Basic ideas of IR and Raman spectra. Electronic spectra-Franck-Condon Principle. NMR Spectroscopy-Introduction, Spinning of Proton in a Magnetic field, Various aspects of NMR Spectrum, Position of Signals and Chemical Shift, Factors Affecting Chemical Shift, Number of Peaks in the NMR Spectra, Equivalent and Non-Equivalent Protons, Peak Area and Proton Counting, Splitting of Signals, Interpretation of the NMR Spectrum of Ethanol, Acetaldehyde.

Course Outcomes:

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

CO1: List the basic principle and laws applied in photochemistry, electrochemistry, statistical thermodynamics, colloidal state, and spectroscopy

CO2: Compare the photophysical and photochemical processes of photochemistry

CO3: Classify the characteristics, preparations and purification of colloidal matter

CO4: Assess the electrolytic and electrochemical cells working

CO5: Solve transition assignment correspond to IR, Raman, NMR and UV spectral peaks

Text Books:

1. B.R. Puri, L.R. Sharma, and S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., New Delhi, 2016.
2. B.S. Bahl, G.D. Tuli and Arun Bahl, *Essentials of Physical Chemistry*, Schamd, 2020.

Reference Books:

1. P.L. Soni, *Text Book of Physical Chemistry*, New Delhi, Sultan Chand & Co., 2014.
2. C.N. Banwell, & E.M. McCash, *Fundamentals of Molecular Spectroscopy*, McGraw Hill Education, New Delhi, 2017.
3. Robert M. Silverstein, Francis X. Webster, David J. Kiemle and David L. Bryce, *Spectrometric Identification of Organic Compounds*, Wiley Pvt. Ltd., 2014.

Journals:

1. Journal of Photochemistry
2. Journal of Applied Electrochemistry
3. Journal of Applied Spectroscopy

E-Resources:

1. https://www.google.com/search?q=photochemistry+pdf&oq=photochemistry+pdf&aqs=chrome..69i57j0l4.10270j0j7&client=ms-android-vivo&sourceid=chrome-mobile&ie=UTF-8
2. http://www.ecs.umass.edceePDF Web results in BASIC CONCEPTS IN ELECTROCHEMISTRY
3. https://www.lkouniv.ac.insite PDF Web results B. Sc. II-Sem Colloidal state (1) The foundation of colloidal chemistry
4. https://nptel.ac.in pdf mod2PDF Module 2 Spectroscopic techniques Lecture 3 Basics of ... – NPTEL
5. https://www.fulviofrisone.com ...PDF Introductory Raman Spectroscopy - Fulvio Frisone

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	45
CO2	9	3	9	3	3	9	9	45
CO3	9	3	9	3	3	9	9	45
CO4	9	3	9	3	3	9	9	45
CO5	9	3	9	3	9	9	9	51
Total	**45**	**15**	**45**	**15**	**21**	**45**	**45**	**231**

Low-1 Medium-3 High-9

Core-XV - Gravimetric Analysis and Organic Preparation Practicals

(For Students Admitted from 2022-23)

Semester: VI **Hours/Week: 6**
Subject Code: IBCHC64P **Credit: 5**

Course Objectives:

1. To learn methods and principles of gravimetric analysis
2. To gain skills relating to the preparation of organic compounds

List of Experiments

1. Gravimetric Analysis: **(45 hours)**

i. Estimation of Lead as Lead Chromate
ii. Estimation of Barium as Barium Chromate
iii. Estimation of Calcium as Calcium Oxalate Mono Hydrate
iv. Estimation of Copper as Cuprous Thiocyanate

v. Estimation of Nickel as DMG Complex
vi. Estimation of Chloride as Silver Chloride (demonstration only)

2. Preparation of Organic compounds **(45 hours)**

a) **Nitration**:
   i. Meta Dinitrobenzene from Nitrobenzene
   ii. Picric Acid from Phenol

b) **Bromination**:
   i. Para Bromo Acetanilide from Acetanilide

c) **Hydrolysis:**
   i. Salicylic Acid from Methyl Salicylate
   ii. Benzoic Acid from Benzamide

d) **Oxidation:**
   i. Benzoic Acid from Benzaldehyde

e) **Condensation:**
   i. Glucosone from Glucose

f) **Benzoylation**:
   i. Benzoylation of Amines
   ii. Benzoylation of Phenols
   iii. Benzoylation of β-Naphthol

Evaluation Scheme: 3 hrs for Gravimetric Analysis and 3hrs for Organic Preparation for 30 marks each.

Course Outcomes:

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

CO1: List the principles and find procedures involved in gravimetric analysis and organic preparation

CO2: Apply gravimetric analysis to estimate lead, barium, calcium, copper, nickel and chloride

CO3: Analyse the preparation of organic compound using nitration, bromination, hydrolysis, oxidation, condensation, and benzoylation

CO4: Evaluate the skills acquired in proper handling of apparatus and chemicals of organic compounds

CO5: Develop practical skills in testing and analyzing organic compounds

Text Books:

1. A.R. Kulandaivelu, V. Venkateswaran and R. Veeraswamy, *Basic Principles of Practical Chemistry*, Sultan Chand and Sons, New Delhi, 2017.

Reference Books:

1. F.G. Mann and B.C. Saunders, *Practical Organic Chemistry*, Pearson India, 2011.
2. O. P. Pandey, D. N. Bajpai and S. Giri, *Practical Chemistry*, S. Chand, New Delhi, 2010.
3. Sonia Ratnani, Swati Agrawal and Sujeet Kumar Mishra, *Practical Chemistry*, McGraw Hill Education, New Delhi, 2020.
4. N.S. Gnanpragasam, and G. Ramamurthy, *Organic Chemistry: Lab Manual*, S.Viswanathan, Printers & Publishers Pvt Ltd, 2009.

Journals:

1. Journals on Titration | Gravimetric Analysis
2. Gravimetric Analysis

3. RSC Advance

E-Resource:

1. https://srcollege.edu.in/temp/lms/Manuals/UGOrganicAnalysis.pdf
2. https://edu.rsc.org/practical/gravimetric-analysis-practical-videos-16-18-students/4012297.article
3. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_General_Chemistry_(Petrucci_et_al.)/27%3A_Reactions_of_Organic_Compounds/27.09%3A_Synthesis_of_Organic_Compounds
4. https://egyankosh.ac.in/bitstream/123456789/15906/1/Experiment-17.pdf
5. https://vlab.amrita.edu/index.php?sub=2&brch=193&sim=348&cnt=1

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**15**	**15**	**45**	**45**	**225**

Low-1 Medium-3 High-9

Disciple Specific Elective-III (A) - Introduction to Green Chemistry and Nanochemistry

(For Students Admitted from 2022-23)

Semester: VI **Hours/Week: 4**
Subject Code: IBCHE6A **Credit: 4**

Course Objectives:

1. To know the basics principle of green chemistry and its developments
2. To know the basic ideas of synthesis, purification, properties and application of nanoparticles

Unit I **(12 hours)**

Introduction to Green Chemistry: Introduction, Basic Principles of Green Chemistry with Explanation and Examples, Green Chemistry in Day to Day Life, Dry Cleaning of Clothes, Versatile Bleaching Agent.

Unit II **(12 hours)**

Synthesis and Reactions involving Basic Principles of Green Chemistry: Introduction, Green Synthesis of the Following Compounds Advantages Over the Conventional Methods-Styrene, Adipic Acid, Urethane, 4-Aminodiphenylamine and Acetaldehyde, Alkylation of Active Methylene Group, Free Radical Bromination of Toluene, Preparation of Furfural from Biomass, Synthesis of Paracetamol and Citral, Use of Molting Accelerators in Place of Insecticides, Environmentally Safe Marine Antifoulant.

Unit III **(12 hours)**

Green Reagent and Green Catalysts: Dimethyl Carbonate for Methylation of Active Methylene Compounds, Green Catalysts-Definition of Titanium Silicate as Catalyst for Hydroxylation of Phenol, Microencapsulated Scandium Trifluoro Methane Sulphonate as Catalyst for Friedel Crafts Acylation, Phase Transfer Catalyst-Application of PTC in Synthesis of Nitrile from Alkyl Halides, Saponification by Crown Ethers, Aqueous Phase Reactions-Aldol Condensation, Strecker Synthesis-Organic Synthesis in Solid State, Claisen Rearrangement of Allyl Phenyl Ether to O-Allylphenol

Unit IV **(12 hours)**

Nano Particles Synthesis and Characterization: Introduction, General Method of Synthesis– Top-Down Method, Bottom-Up Method, Chemical Synthesis - Reduction of Metal Atoms, Thermal Decomposition Methods, Photolysis, Radiolysis, Laser Vaporization, etc., General Properties of Nanoparticles, Methods of Characterizing Nanoparticle: SEM, TEM, STEM, Scanning Probe Microscope, Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM).

Unit V **(12 hours)**

Certain Class of Nanoparticles and their Application: Synthesis, Purification, Properties and Application of Fullerenes, Carbon Nanotubes, Au and Ag Nanoparticles. Sensors-Chemical Sensors, Biosensors and Optical Sensors-Synthesis, Characterization and their Use. Application of Nanoparticles-Biology and Medicine, Core-Shell Nanoparticles, Catalysis, Sensing, Chemical Reactivity and Targeted Drug Delivery. Particle Size Analysis and Surface Area Measurements of Nanoparticles.

Course Outcomes:

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

CO1: Recall the basic principle of green chemistry and understand the green chemistry observed in everyday life

CO2: Apply the appropriate synthesis, purification methods for nanoparticles

CO3: Compare the green reagent and green catalysts synthesis

CO4: Explain the general method of nanoparticles synthesis

CO5: Develop practical skills for preparing novel drug delivery nanoparticles

Text Book:

1. A. Ravikrishnan, *Engineering Chemistry*, Sir Krishna Hitech Publishing Company Pvt. Ltd., Chennai, 2021.

Reference Books:

1. S. Shanmugam, *Nanotechnology*, MJP Publishers, Chennai, 2019.
2. Robert W. Kelsall, Ian. W. Hanley & Mark Geoghegan, *Nano Scale Science, and Technology,* John Wiley & Sons Ltd., USA, 2007.
3. Subbiah Balaji, *Nanobiotechnology,* MJP Publishers, Chennai, 2019.
4. V. Kumar, *An introduction to green chemistry*, Vishal Publishing Co., 2013.
5. Tarun Kumar Upadhyay and Sushil Kumar Sharma, *A Textbook on Geoinformatics*, *Nanotechnology and Precision Farming*, New Delhi Publishers, 2020.

Journals:

1. Green Chemistry
2. Green Chemistry Letters and Reviews
3. Journal of Nanostructure in Chemistry

E-Resources:

1. https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf
2. https://application.wiley-vch.de/books/sample/352730715X_c01.pdf
3. https://ccsuniversity.ac.in/bridge-library/pdf/L-3%20Synthesis%20of%20Nanostructured%20Materials%20Prof%20BPS.pdf
4. https://cdn.intechopen.com/pdfs/57226.pdf
5. https://www.sciencedirect.com/science/article/pii/S1878535217300990

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	9	3	3	9	**39**
CO2	9	3	9	9	3	9	9	**51**
CO3	9	3	9	9	3	9	9	**51**
CO4	9	3	9	9	3	9	9	**51**
CO5	9	3	9	9	3	9	9	**51**
Total	**45**	**15**	**39**	**45**	**15**	**39**	**45**	**243**

Low-1 Medium-3 High-9

Disciple Specific Elective III (B) – Polymer Chemistry

(For Students Admitted from 2022-23)

Semester: VI **Hours/Week: 4**
Subject Code: IBCHE6B **Credit: 4**

Course Objectives:

1. To widen knowledge about principle, type, constituents, synthesis and uses of polymer, rubber, plastics and resins
2. To acquire knowledge on basic principle, composition and applications of conducting and biodegradable polymer

Unit I **(12 hours)**

Introduction to Polymers: Definition and Basic Terminology-Monomers, Polymers, Plastics, Elastomers, Fibres, and Resins. Classification of Polymers– Classification Based on Composition-Homo and Co-Polymers, Classification Based on Physical Properties-Thermoplastic and Thermosetting, Difference Between Thermoplastic and Thermosetting Polymers, Classification Based on Reaction Mode of Polymerization, Addition and Condensation Polymers, Difference between Addition and Condensation Polymers. Molecular Weight of Polymers-Number Average Method, Weight Average Method, Glass Transition Temperature and Characteristics of Polymers.

Unit II **(12 hours)**

Mechanism of Polymers and Rubber: Addition Polymerisation-Mechanism of Free Radical Addition Polymerisation, Ionic Polymerisation, Anionic Polymerisation, and Cationic polymerization, Co-Polymerisation, Coordination polymerization, Ziegler Natta Catalysis and Mechanism. Rubber-Natural and Synthetic Rubbers, Isoprene Rule, Preparation and Uses of Butyl Rubber, Buna-S, Buna-N, Neoprene, Thiocol, Polyurethane, and Silicon rubbers, Compounding of Rubber-Reclaim Rubber, Spongy Rubber, and Foam Rubber, Vulcanization process.

Unit III **(12 hours)**

Polymer Additives and Polymer Processing: Polymer Additives-Definition and Examples-Fillers, Reinforcements, Antioxidants, and Thermal Stabilizers, UV Stabilizers and Absorbers, Fire Retardants, Colorants and Curing agents. Polymer Processing-Bulk Polymerisation, Solution Polymerisation, Suspension Polymerisation and Emulsion Polymerisation.

Unit IV **(12 hours)**

Manufacture and Application of Selected Industrial Polymer: Plastics and Resins-Definition, Thermoplastics and Thermosetting Resins, Constituents of Plastics, Fillers, Dye, Pigment, Plasticizers, Lubricants and Catalysts. Preparation and Uses of Polyethylene, PTFE, PVC, PVA, Polypropylene and Polystyrene, Polyamides. Preparation and Uses of Nylon-6 and Nylon-6, 6, Polyesters, Terylene and Viscose Rayon.

Unit V **(12 hours)**

Conducting Polymers and Biodegradable Polymers: Introduction, Conductivity, Reason for Conductivity, Uses of Conducting Polymers, Process of Doping, Potential Application of Conductivity Polymers, Uses of Conducting Polymers. Biodegradable Polymers, Composition of Biodegradable Plastics, Starch-Based Plastics, Bacteria Based Plastics and Soy-Based Plastics, Application of Biodegradable Polymers on Various Fields.

Course Outcomes:

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

CO1: Define the basic principle of polymers in rubber, plastics, and resins and understand classification based on structure

CO2: Apply the basic knowledge on polymerization to understand the mechanism of formation

CO3: Categorize the plastics and resin based on polymer additives

CO4: Compare the polymer process with properties of polymer obtained

CO 5: Instigate the composition and applications of conducting and biodegradable polymer

Text Books:

1. G.S. Misra, *Introductory Polymer Chemistry*, New Age International (P) Limited Publishers, New Delhi, 2008.
2. Jayadev Sreedhar, N.V. Viswanathan and V.R. Gowariker, *Polymer Science*, New age International Publishers, New Delhi, 2020.

Reference Books:

1. Premamoy Ghosh, *Polymer Science, and Technology of Plastics and Rubbers*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2017.
2. Alka L Gupta, *Polymer Chemistry*, Anu Books, 2019.
3. Joel R. Fried, *Polymer Science & Technology*, Pearson Education, Inc., India, 2014.

Journals:

1. European Polymer Journal
2. Reactive & Functional Polymers
3. Polymer Chemistry

E-Resources:

1. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjvyK2Xo5TxAhVL8HMBHW1DDRMQFnoECBcQAA&url=https%3A%2F%2Fwww.slideshare.net%2Fweldea3%2Fchapter-1-introduction-to-polymers&usg=AOvVaw3N06ZhLnci_yVGlDM8fF1z
2. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiY082h_pPxAhVp4zgGHSxsBwIQFnoECAIQAA&url=https%3A%2F%2Fwww.elsevier.com%2Fbooks%2Fcoordination-polymerization%2Fchien%2F978-0-12-172450-4&usg=AOvVaw2k5UQBVeekm8133AB9i3tg
3. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjy0eiU_5PxAhUzzTgGHXZzA8sQFnoECAUQAA&url=https%3A%2F%2Fwww.springer.com%2Fgp%2Fbook%2F9780306418075&usg=AOvVaw2KvbfUPMySOc60tP5Mn9xt

4. https://pubs.acs.org/doi/10.1021/acs.est.1c00976
5. https://www.hardiepolymers.com/knowledge/polymer-manufacturing-processes/

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	3	3	3	3	27
CO2	9	3	9	3	3	9	9	45
CO3	9	3	9	3	3	9	9	45
CO4	9	3	9	3	3	9	9	45
CO5	9	3	9	9	3	9	9	51
Total	45	15	39	21	15	39	39	213

Low-1 Medium-3 High-9

Skill Enhancement Course –VI- Industrial Chemistry Practicals

(For Students Admitted from 2022-23)

Semester: VI **Hours/Week: 2**
Subject Code: IBCHS65P **Credit: 2**

Course Objectives:

1. Be acquainted with current development in the field of Industrial Chemistry
2. To acquire knowledge of analysis-water samples, essential oils, food samples, soap, cement, pigment, adulterants, natural colouring and flavouring agent (flowers and fruits)

List of Experiments **(30 hours)**

A Practical Course on the preparation of the following Industrial Products in the Cottage Industry level

1. Determination of Alkalinity in Water Samples
2. Separation of Essential Oils by Soxhlet Extractor
3. Testing of Turmeric Powder, Milk, and Mustard Oil for Adulterants
4. Estimation of Glucose in Food Samples
5. Extraction of Natural coloring and flavoring Agents from Flowers and Fruits
6. Estimation of Available Oxygen in Hydrogen Peroxide
7. Preparation of Soap
8. Analysis of Cement
9. Preparation of Pigment (zinc oxide)
10. Estimation of Amino acid (Alanine)

At the end of the semester, a practical examination for two hours will be conducted for 50 marks.

Course Outcomes:

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

CO1: List the types of alkalinity in water samples, and demonstrate separation of essential oils, and testing of adulterants

CO2: Identify extractable coloring and flavoring agents from flowers and fruits

CO3: Compare the estimation of hydrogen peroxide and amino acid

CO4: Deduce the amount of glucose in food samples
CO5: Adapt the novelty in soap preparation by changing additives

Text Book:

1. O.P. Vermani, *Applied Chemistry: Theory and Practice*, New Age International Private Limited, 2017.

Reference Books:

1. John Kenkel, *Chemistry An Industry-Based Laboratory*, Taylor & Francis Publisher, 2020
2. Ranjan Kumar Mohapatra, *Engineering Chemistry with Laboratory Experiments*, PHI Learning, 2015.
3. Manoj Kumar Solanki, *Engineering Chemistry Laboratory Manual*, Edu creation Publishing, 2019.

Journals:

1. Journal of the Society of Chemical Industry
2. International Journal of Industrial Chemistry
3. Journal of Chemical Education

E-Resources:

1. https://images.app.goo.gl/n6FkKJZJwN1QumnT9
2. https://images.app.goo.gl/5GM819F1YZXXhBkW8
3. https://images.app.goo.gl/zxCvxZEqBWU8tkDh9
4. https://gmcsurat.edu.in/lib/exe/fetch.php?media=biochemistry:g-_group_various_method_of_glucose_estimation_gtt_and_carbohydrate_chemistry.pdf
5. https://web.iitd.ac.in/~arunku/files/CEL212_2012/CEL%20212%20Lab%202%20Alkalinity%20and%20Acidity.pdf

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	9	3	9	9	**51**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**21**	**15**	**45**	**45**	**231**

Low-1 Medium-3 High-9

Extra Credit-V - Industrial Training Report

(For Students Admitted from 2022-23)

Semester: VI
Subject Code:IBCHX6 **Credit: 2**

Course Objectives:

1. To learn principles and procedures employed in industrial training
2. To develop practical skills and application of various industry

The students should undergo industrial training in any of chemical, textile, or pharmaceutical industry for ten days. They have to prepare the report with the guidance of the course teacher. Necessary documents and the evidence to be enclosed in the report.

Evaluation Scheme: 75 marks will be given for the documentation of the report and 15 marks for the presentation and 10 marks for the viva voce.

Course Outcomes:

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

CO1: Recall the principles and understand the procedures employed in industrial training of various industries

CO2: Build the practices and skills used in industry for applying in research projects

CO3: Assume the skills required in chemistry graduates such as the proper handling of machine

CO4: Evaluate the application of major concepts utilized in various industry

CO5: Formulate new solutions for technical problems that are observed in the industry

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	9	9	3	9	9	9	**57**
CO3	9	9	9	3	9	9	9	**57**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	9	3	9	9	**51**
Total	**45**	**27**	**45**	**21**	**27**	**45**	**45**	**255**

Low-1 Medium-3 High-9

Ability Enhancement Compulsory Course For B. Sc Home Science: Basic Chemistry

(For Students Admitted from 2022-23)

Semester: I **Hours/Week: 5**

Subject Code:IBNDA13 **Credit: 4**

Course Objectives:

1. To acquire basics on oil, fats, vitamins and food additives.
2. To widen knowledge about Lubricants, Dyes, Fertilizer, Insecticides, Herbicides, fungicides.

Unit I **(15 hours)**

Oils, Fats and Food Additives: Oils and Fats-Classification of Oils, Fat Splitting, Distillation of Completely Miscible and Non-Miscible Oils, Hydrogenation of Oils, Rancidity, Saponification Value, Iodine number, Acid Value. Soap and Synthetic Detergent-Preparation of Soap and Detergent, Different types of Soap and their Composition, Surfactants (LAS, ABS, LABS), Detergent binders and builders. Food Additives-A general study of Food Flavours, Colours and Preservatives, Artificial Sweeteners.

Unit II **(15 hours)**

Water, Ozone, and H_2O_2: Water-Types of Water, Types of Hardness, Removal of Hardness by Reverse Osmosis and Ion Exchange Method, Estimation of Hardness by EDTA Method, Degrees of Hardness. Ozone-Manufacture, Composition, Structure and Properties & Uses.
H_2O_2-Manufacture, Structure, Uses of Hydrogen Peroxide and Estimation of Hydrogen Peroxide by Permanganometry.

Unit III **(15 hours)**

Fertilizer, Insecticides, Herbicides and Fungicides: : Introduction, Requisites of a Good Fertilizer and Classification of Fertilizer, Nitrogen Fertilizers-Ammonium Sulphate, Calcium Ammonium Nitrate, Calcium Cyanamide and Urea; Phosphate Fertilizers and Phosphate slag; Potash Fertilizers: Potassium Chloride, Potassium Sulphate and Potassium Nitrate, Effects of Fertilizers. Classification of Insecticides, Fungicides, Herbicides as Organic and Inorganic-General Methods of Application and Toxicity. Safety Measures when using Pesticides Insecticides-Plant Products - Nicotine, Pyrethrin, Inorganic pesticides-Borates and Organic pesticides-D.D.T. and BHC Fungicide-Sulphur Compounds, Copper Compounds, Bordeaux Mixture Herbicides-Acaricides-Rodenticides. Attractants-Repellents. Preservation of seeds.

Unit IV **(15 hours)**

Carbohydrates, Vitamins, and Dyes: Carbohydrates-Classification and Examples of Carbohydrates, Structure of Glucose, Fructose, Sucrose (Structure only). Vitamins-Definition, Classification, Sources, Deficiency Diseases of Vitamins. Dyes-Definition, Theory of Colour and Constitution, Classification of Dyes, Preparation of Methyl Orange, Congo Red and Malachite Green, Crystal Violet, Phenolphthalein, Fluorescein, Eosin, and Indigo.

Unit V **(15 hours)**

Lubricants, Cement, and Corrosion: Lubricants-Classification of Lubricants, Lubricating Oils (Conducting and Non-Conducting) Solid and Semisolid Lubricants, Synthetic Lubricants
Glass-Glassy State and its Properties, Classification (Silicate and Non-Silicate Glasses), Manufacture and Processing of Glass. Cement-Classification of *cement*, ingredients and their role, Manufacture of cement and the setting process, quick-setting cement.
Corrosion and Passivity-Rusting of Iron, Preventive Methods from Rusting, Cathodic Protection, Galvanization, Use of Inhibitors.

Course Outcomes:

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

CO1: Recall the structure of vitamines, carbohydrates, dyes and understand the reason for colours observed in dyes
CO2: Appreciate the quality of oil, fat based saponification, acid values and iodine number
CO3: Analyse the water resources to find suitable softening technique
CO4: Compare natural source for vitamins, carbohydrates and dye materials
CO5: Formulate the novel lubricants for special requirement, and mechanism behind rusting of Iron material

Text Books:

1. T. Coultate, *Food Chemistry*, C Publishing House, New Delhi, 2015.
2. B.K. Sharma, *Industrial Chemistry*, Krishna Prakashan media Pvt Ltd. Publishing, Uttar Pradesh, 2016.

Reference Books:

1. Shashi Chawla, *A Text Book of Engineering Chemistry*, Dhanpat Rai & Co. (P) Limited, 2017.
2. Arun Bahl, B.S. Bahl, *Textbook of Organic Chemistry,* Sultan Chand & Sons, Company Ltd, 2019.
3. Sathya Prakash, G.D. Tuli, S.K. Basu, & R.D. Madan, *Advanced Inorganic Chemistry***,** Sultan Chand & Sons Company Ltd, 2016.

Journals:

1. Lubrication Science
2. International Journal of Fuels and Lubricants
3. Nutrition Journal

E-Resources:

1. https://www.sciencedirect.com/science/article/pii/B9780123815040000135?via%3Dihub
2. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjF5N2cg5TxAhU1zzgGHVDeCTIQFnoECBAQAA&url=http%3A%2F%2Fwww.dmce.ac.in%2Fnewdmcewebsite%2Fothers%2Fresource%2FHumanities%2FAPLLIED%2520CHEMISTRY%25201.pdf&usg=AOvVaw1RnGsVIE-pz39bbhR03IPT.
3. https://library.e.abb.com/public/34d5b70e18f7d6c8c1257be500438ac3/Oil%20and%20gas%20production%20handbook%20ed3x0_web.pdf
4. https://www.tandfonline.com/doi/full/10.1080/19440049.2015.1069407
5. https://pubs.acs.org/doi/10.1021/es00104a009

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	3	3	3	1	3	9	3	**25**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**39**	**15**	**39**	**13**	**15**	**45**	**39**	**205**

Low-1 Medium-3 High-9

Open Elective Course Offered for Students Other than B. Sc. Chemistry

(For Students Admitted from 2022-23)

Semester	Subject Code	Subject Title	Hours/week	Credit	ESE	Total
III	IBOE3CH	Chemistry in Every Day Life	2	2	50	50
IV	IBOE4CH	Chemistry in the Service of Mankind	2	2	50	50

Chemistry in Everyday Life

(For Students Admitted from 2022-23)

Semester: III **Hours/Week: 2**
Subject Code:IBOE3CH **Credit: 2**

Course objectives:

1. To understand ill effects of cosmetics, fertilizers and importance of protective coatings
2. To gain knowledge about Indian medicine from plants, drugs and pharmaceuticals

Unit I **(6 hours)**

Cosmetics and Perfumes: A general study including preparation and uses of the following: Hair dye, Hair spray, Shampoo, Suntan lotions, Face powder, Lipsticks, Talcum powder, Nail enamel, creams (Cold, Vanishing, and Shaving creams), antiperspirants, and artificial flavours, essential oils and their importance in cosmetic industries concerning Eugenol, Geraniol, Sandalwood oil, Eucalyptus, Rose Oil, Jasmone, Civetone, Muscone.

Unit II **(6 hours)**

Basic Concepts of Surface Coatings: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings; paints and pigments-formulation, composition and related properties, oil paint, vehicle, modified oils, toners, and lakes pigments, fillers, thinners, enamels, emulsifying agents. special paints (heat retardant, fire retardant, eco-friendly paint, plastic paint), dyes, wax polishing, water and oil paints, additives, metallic coatings (electrolytic and electroless).

Unit III **(6 hours)**

Fertilizer Industry: Introduction, requisites of a good fertilizer and classification of fertilizer, nitrogen fertilizers-calcium cyanamide and urea. Phosphate fertilizers-super phosphate of lime, and phosphate slag. Potash fertilizers: potassium chloride, potassium sulphate and potassium nitrate, effects of fertilizers.

Unit IV **(6 hours)**

Drugs and Pharmaceuticals: Definition and application of the representative drugs of the following classes-analgesics agents, antipyretic agents, anti-inflammatory agents (aspirin, paracetamol, ibuprofen). antibiotics (chloramphenicol). Antibacterial and antifungal agents (sulphonamides, sulphacetamide). Antiviral agents (acyclovir), central nervous system agents (phenobarbital, diazepam), cardiovascular (glyceryl trinitrate), antilaprosy (dapsone), hiv-aids related drugs (azt- zidovudine).

Unit V **(6 hours)**

Indian Medicinal Plants: First aid and safety: indian medicinal plants-palak, vallarai, kizhanelli, thumbai, hibiscus, adadodai, thoothuvalai, nochi, thulasi, aloe vera, neem and omavalli-chemical constituents and medicinal uses (structures are not required).

First aid and safety-treatment of shock, hemorrhage, cuts, and wounds. burns-classification and first aid. Asbestos, lead paints, cement, welding fumes and gases-hazard alert and precautions for safety.

Course Outcomes:

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

CO1: Find the safe cosmetics products by relating to essential oil used
CO2: Apply the basics to appreciate the protective coatings used in everyday life
CO3: Analyse the chemical composition to know environmental hazards of pesticides
CO4: Assess the representative drugs that are used for different diseases
CO5: Adapt safety measure for first aid in any accidents and suggest Indian phytochemical drugs

Text Books:

1. Andrew Edward Parnell, *Applied Chemistry*, Maxwell Press, 2021.
2. White H L**,** *Introduction To Industrial Chemistry*, John Wiley Publishers, 2015.

Reference Books:

1. Rasheeduz Zafar, *Medicinal Plants of India*, CBs Publishers and Distributors, New Delhi, 2019.
2. P.C. Jain, and Monica Jain, *Engineering Chemistry*, Dhanpat Rai Publishing Company Ltd., New Delhi, 15th Edition, 2010.
3. Jayashree Ghosh, *Fundamental Concepts of Applied Chemistry*, S. Chand and Company Limited, New Delhi, 2006.

Journals:

1. Flavour and Fragrance Journal
2. Surface and Coatings Technology
3. Indian Journal of Medical Sciences

E-Resources:

1. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjTjO7FipTxAhXP7nMBHYryDKMQFnoECBAQAA&url=https%3A%2F%2Fwww.slideshare.net%2Fprashantlpingale%2Fintroduction-to-cosmetics-138603089&usg=AOvVaw2U9Reh5S6d1kHXEeZWGWXm
2. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjH2qv7mJTxAhXh63MBHV3oC0QQFnoECA8QAA&url=https%3A%2F%2Fwww.slideshare.net%2Fahmadkhan_99%2Fsurface-treatment-an-overview-12339427&usg=AOvVaw22RnPUXgHbnWQs4qOqwe8i
3. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiB1u7SnJTxAhV57XMBHYbwDRQ4ChAWegQIAxAA&url=https%3A%2F%2Fwww.eia.gov%2Fenergyexplained%2Foil-and-petroleum-products%2F&usg=AOvVaw3hhhszgaZ-IkQLLHv6gWtH
4. https://www.nhp.gov.in/NHPfiles/Final_e-book.pdf
5. https://www.nhp.gov.in/drugs-and-pharmaceuticals_pg#:~:text=The%20terms%20drug%2C%20medicine%20and,active%20ingredient%20(combination%20product).

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	9	3	3	9	9	**45**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	9	3	9	9	**51**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**45**	**21**	**15**	**45**	**45**	**231**

Low-1 Medium-3 High-9

Chemistry in the Service of Mankind

(For Students Admitted from 2022-23)

Semester: IV **Hours/Week: 2**
Subject Code: IBOE4CH **Credit: 2**

Course objectives:

1. To understand basic concepts of food nutrition, diseases and treatment methods
2. To gain knowledge about commercial polymer, soaps, detergents and green chemistry

Unit I **(6 hours)**

Food and Nutrition: Food and nutrition-carbohydrates, proteins, fats, minerals and vitamins, definitions, sources, and their physiological importance - balanced diet; adulterants in milk, ghee, oil, coffee powder, tea, asafoetida, chilli powder, pulses and turmeric powder-identification, colour chemicals used in food-soft drinks and its health hazards. Food preservatives-definition, examples, advantage, and disadvantage of preservation and green fertilizers.

Unit II **(6 hours)**

Chemistry of Important Commercial Polymers: Definition, classification of polymers, polyethylene, pvc, polyamides, polyesters, bakelite, phenolic resins, epoxy resins and their applications (preparation is not required). Natural rubber, synthetic rubbers, vulcanization-definition and its applications. silicon rubber, biomedical polymer-contact lens, dental polymers and artificial heart.

Unit III **(6 hours)**

Soaps, Detergents and Green Chemistry: Manufacture of soaps, formulation of toilet soaps, different ingredients used-soft soaps, shaving soaps and creams; anionic detergents-manufacture and applications. Cationic detergents-manufacture and applications. Introduction to green chemistry -need for green chemistry, goals of green chemistry, limitations/obstacles in the pursuit of the goals of green chemistry.

Unit IV **(6 hours)**

Diseases and Treatment-I: Common diseases, causes, and treatment of some common diseases-insect borne diseases, air borne diseases, water borne diseases, digestive disorders, respiratory disorder, nervous disorder, and other diseases, important indian medicinal plants and their uses-cardiovascular drugs, anti-hypertensive drugs, anti-anginal drugs, sulpha drugs.

Unit V **(6 hours)**

Diseases and Treatment-II: Cancer-Causes, Spread and Treatment, dosage and effects of Chlorambusil, Methotrexate (preparation and structure elucidation is not required). Diabetes-control, dosage, and uses of Barbiturates, Hydantoin, and Succinimides (preparation and structure elucidation is not required). Antibiotics-classification, properties and uses of Penicillin, Streptomycin, Erythromycin, Tetracycline and antihistamine (preparation and structure elucidation is not required).

Course Outcomes:

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

CO1: Recall the importance of polymer in biomedical field and understand the nutritional value of food products

CO2: Choose appropriate food preservatives

CO3: Compare and find the correct soap formulation for soaps, detergent manufacturing based on purpose

CO4: Evaluate the disease nature and its treatment procedures with knowledge acquired

CO5: Propose the remedies for common disease based on plant products

Text Books:

1. John M. Deman, *Principles of Food Chemistry*, Springer International Publishing AG, New Delhi, 3th Edition, 2018.
2. Jeyashree Gosh, *Text Book of Pharmaceutical Chemistry*, S. Chand and company, New Delhi, September 2017.

Reference Books:

1. G.R. Chatwal, *Pharmaceutical Chemistry -Inorganic* 5th Edition, Himalaya Publishing House, New Delhi, 2018.
2. R.S. Khandpur, *Handbook of Biomedical Instrumentation* 3rd Edition, Tata McGraw – Hill Publishing Company, New Delhi 2014 .
3. Leslie Cromewell, F.J. Weilbell, and E.A. Pfeiffer, *Biomedical Instrumentation and Measurements*, Prentice Hall of India, New Delh 2014.

Journals:

1. Journal of Surfactants and Detergents
2. Journal of Food Chemistry and Nutrition
3. Infectious Diseases in Clinical Practice

E- Resources:

1. https://www.ebooksread.com/dl2.shtml?id=209403&ext=pdf_external&f=chemistryinservi00findrich&a_id=35451
2. https://www.forgottenbooks.com/en/books/ChemistryintheServiceofMan_10007755
3. Books%2FME%2FIntroduction%2520to%2520Polymer%2520Science%2520and%2520Technology.pdf&usg=AOvVaw27kEhfpq-ZS5ViV_Lxfdju
4. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj8p-CntJvxAhXDX30KHRyWAYUQFnoECA0QAA&url=http%3A%2F%2Fwww.healthycleaning101.org%2Finformation_about_soaps_and_detergents%2F&usg=AOvVaw357YZ9Nzkup82jQm4UJCu_
5. https://web.njit.edu/~mitra/green_chemistry/EXP_4.htm

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	3	3	3	9	9	**39**
CO2	9	3	9	3	3	9	9	**45**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	3	9	9	**45**
CO5	9	3	9	3	3	9	9	**45**
Total	**45**	**15**	**39**	**15**	**15**	**45**	**45**	**219**

Low-1 Medium-3 High-9

CERTIFICATE COURSES

PREAMBLE

Water and waste water treatment

- ❖ Course title - Waste water treatment was replaced with Water and waste water treatment methods
- ❖ Course was completely revamped.

Dairy Chemistry

- ❖ Course content was modified in Unit V

CERTIFICATE COURSE ON WATER AND WASTE WATER TREATMENT

(For Students Admitted from 2022-23)

S. No	Subject Code	Subject	Total contact Hours	credits	ESE	Total
1.	ICWT1	Water and Waste Water Treatment	30	2	100	100
2.	ICWT2P	Water and Waste Water Treatment Practicals	50	2	100	100
Total			80	4	200	200

Water and Waste Water Treatment

(For Students Admitted from 2022-23)

Subject Code: ICWT1 **Hours/Week: 2**
Credit: 2

Course Objectives

1. To acquire knowledge on water resources and conservation methods
2. To understand the chemistry behind treatment methods for industrial effluent and potable water

Unit I **(6 hours)**

Introduction to water: Sources of water, types of impurities in water, hardness of water, methods of hardness determination, disadvantages of hard water and water quality Indices. boiler troubles, water softening methods.

Unit II **(6 hours)**

Potable water treatment: Steps involved in the treatment of potable water, sterilization of potable water by Chlorination and Ozonisation, purification of water by reverse osmosis process. potable water standards.

Unit III **(6 hours)**

Waste water treatment: Screening, Grit removal, Filtration - removal of coarse particles - sedimentation, sedimentation with coagulation; aeration, nutrient removal in activates sludge, attached growth, Trickling filter, Rotating biological contactors, treatment with activated carbon. wastewater effluent standards.

Unit IV **(6 hours)**

Water Analysis: Colour, turbidity, odour, free CO_2, free chlorine, chlorine demand, ammonia, sulphate, chloride, alkalinity, acidity, suspended solids, dissolved solids, pH, dissolved dxygen, BOD and COD.

Unit V **(6 hours)**

Water management and conservation: Water resources and planning, water policy, Indian scene, main aspects of water management and water conservation resource management.

Course Outcomes:

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

CO 1: Define and relate the soft water and hard water
CO 2: Apply the methods for collection and analysis of water samples
CO 3: Compare the purification methods of domestic and the sewage water
CO 4: Justify the choice of treatment method for boiler feed water
CO 5: Propose the solution for the various boiler troubles

Text Books:

1. A. Ravikrishnan, *Engineering Chemistry*, Sir Krishna Hitech Publishing Company Pvt. Ltd., Chennai, 2021.
2. B.K. Sharma, *Industrial Chemistry-I*, Anu Books, New Delhi, 2020.

Reference books:

1. Monika Jain and P. C. Jain, *Engineering Chemistry*, Dhanpat Rai Publishing Company Ltd., New Delhi, 2019.
2. S.S. Dara and S.S. Umare, *A Text Book of Engineering Chemistry*, S. Chand & Company Ltd., New Delhi, 2013.
3 O.P. Palanna, *Engineering Chemistry*, McGraw Hill Education, 2017.

Journals

1. Water Economics and Policy
2. Sustainable Environment Research
3. Journal of Water Chemistry and Technology

E- Resources:

1. https://www.ebooknetworking.net/ebooks/engineering-chemistry-2-by-ravikrishnan.html
2. http://www.sasurieengg.com/e-course-material/I-year-E-course-material-II-sem/3.CY6251%20-%20Engineering%20Chemistry%20-%20II.pdf
3. https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.scribd.com/document/23180395/Engineering-Chemistry-Unit-I-Water Treatment&ved=2ahUKEwjmsZuL_5vxAhWVfn0KHR3GCmIQFjAKegQIDhAC&usg=AOvVaw1r7KpVE_GGutWTtkWsL4XJ
4. https://www.watconman.org/introduction/
5. https://www.cdc.gov/healthywater/drinking/public/water_treatment.html

Course	Programme Outcomes

Outcomes								
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	3	1	9	3	9	9	3	**34**
CO2	9	3	9	3	9	9	1	**43**
CO3	9	3	9	1	9	3	9	**43**
CO4	3	3	9	3	9	9	3	**39**
CO5	9	3	1	3	9	1	3	**29**
Total	**33**	**13**	**37**	**13**	**45**	**31**	**19**	**188**

Low-1 Medium-3 High-9

Water and Waste Water Treatment Practicals

(For Students Admitted from 2022-23**)**

Subject Code: ICWT2P **Hours/Week: 2**

Credit: 2

Course Objectives

1. To build practical skills to analyse water samples

2. To understand instrumental errors and precisions

List of Experiments for water samples analysis **(50 hours)**

1. Determination of Acidity.
2. Determination of Alkalinity.
3. Determination of Chloride.
4. Determination of Total Hardness.
5. Determination of Salinity.
6. Determination of Chemical Oxygen Demand.
7. Determination of Biological Oxygen Demand.
8. Determination of Total Dissolved Solids.
9. Determination of Mixed Liquid Suspended Solids.
10. Determination of Dissolved Oxygen.

Course Outcomes:

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

CO1: Recall the methods of waste water treatment and demonstrate the current development in the field

CO2: Apply the practical skill for purification of water

CO3: Analyze the water and waste water samples for acidity, alkalinity, pH, chloride, sulphate, salinity, calcium, COD, BOD, TDS, MLSS and dissolved oxygen

CO4: Compare the various industrial processes of water

CO5: Adapt the better treatment methods for unknown water samples

Textbook

1. V. Veeraiyan and L. Devaraj Stephen, *Engineering Chemistry Laboratory*, VRB Publishers Pvt. Ltd., Chennai, 2017.

Reference Books:

1. A.R. Kulandaivelu, V. Venkateswaran and R. Veeraswamy, *Basic Principles of Practical Chemistry*, Sultan Chand and Sons, New Delhi, 2017.
2. Manoj Kumar Solanki, *Engineering Chemistry Laboratory Manual*, Edu creation Publishing, 2019.

Journals:

1. Environmental Science: Water Research & Technology
2. Water
3. Journal of Water Process Engineering

E- Resource:

1. https://drive.google.com/file/d/1_AWwqxmCesBZ3WgH8LCBR1r2P60u_sEg/view?usp=sharing
2. https://publishing.energyinst.org/topics/fuel-quality-and-control/ip-test-methods/ip-1
3. https://www.canterbury.ac.nz/media/documents/science-outreach/chloride_volhard.pdf
4. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/755569/COD-215nov.pdf
5. http://www.water-chemistry.in/2008/10/determination-of-mixed-liquor-suspended-solids/

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	9	9	9	9	9	**63**
CO2	9	9	9	3	9	9	9	**60**
CO3	9	3	9	3	9	3	3	**42**
CO4	9	9	3	3	9	3	3	**39**
CO5	9	9	3	9	9	3	3	**45**
Total	**45**	**42**	**33**	**27**	**45**	**27**	**27**	**249**

Low-1 Medium-3 High-9

CERTIFICATE COURSE ON DAIRY CHEMISTRY

(For students admitted from 2022-23**)**

S. No.	Subject Code	Subject	Total Contact Hours	Credits	ESE	Total
1.	ICDC1	Dairy Chemistry	30	2	100	100
2.	ICDC2P	Dairy Chemistry Practicals	50	2	100	100
Total			80	4	200	200

Dairy Chemistry

(For Students Admitted from 2022-23**)**

Subject Code: ICDC1 **Hours/Week: 2**

Credit: 2

Course Objectives

1. To acquire knowledge on milk, milk proteins and milk lipids
2. To understand physico – chemical changes and effects of various milk constituents of the milk products

Unit I (**6 hours)**

Milk: General composition of milk, factors affecting the composition of milk, physico-chemical change taking place in milk due to processing parameters, boiling pasteurization, sterilization and homogenization.

Unit II **(6 hours)**

Milk proteins and Milk lipids: Physical properties of milk proteins, reaction of milk proteins with formaldehyde and ninhydrin. milk carbohydrate - lactose, estimation of lactose in milk. milk vitamins - water soluble vitamins, effect of heat and light on vitamins, composition and classification of milk lipids.

Unit III **(6 hours)**

Creams: Definition, composition, chemistry of creaming process - gravitational and centrifugal methods of separation of cream, factors influencing cream separation (mention the factors only). Butter: definition, composition, manufacture, acidity, salt and moisture content.

Unit IV **(6 hours)**

Milk powder: Definition, principles of drying process-spraying, manufacture of milk powder by spray drying process, quality control of milk powder. ice cream: definition, ingredients, types, percentage of composition, manufacture of homemade and commercial ice-cream.

Unit V **(6 hours)**

Milk adulterants: Definition, common types of adulterants in milk (water, neutralizer, starch, formalin, glucose, cane sugar, and urea) and Ill effects of adulterants.

Course Outcomes:

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

CO1: Understand and recall the basic principles and properties of milk
CO2: Select the correct process in milk powder production
CO3: Analyze the chemical composition of creams, butter, milk powder and ice cream
CO4: Determine the adulterant in milk and milk products
CO5: Formulate the innovative dairy products

Text Book:

1. P.F. Fox and P. L. H. McSweeney, Diary Chemistry and Biochemistry, Springer, 2015.

Reference Books:

1. P. L. H. Mc. Sweeney, Advanced Diary Chemistry Proteins Applied Aspects, Springer, 2016.
2. Y. H. Hui, Dairy Science and Technology Hand Book, Wiley-VCH, 2014.

Journals:

1. The Journal of Diary Chemistry
2. International Diary Chemistry
3. Journal of Diary Research

E-Resources:

1. http://www.agrimoon.com/wp-content/uploads/CHEMISTRY-OF-MILK.pdf
2. https://dairyprocessinghandbook.tetrapak.com/chapter/milk-and-whey-powder
3. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=6170

4. https://www.frontiersin.org/articles/10.3389/fped.2018.00313/full
5. https://vikaspedia.in/health/health-campaigns/beware-of-adulteration/adulteration-in-milk-and-milk-products

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	3	1	3	1	1	3	**21**
CO2	9	3	9	3	9	3	3	**39**
CO3	9	3	9	3	3	9	9	**45**
CO4	9	3	9	3	9	9	3	**45**
CO5	9	9	3	9	9	3	3	**45**
Total	**45**	**21**	**31**	**21**	**31**	**25**	**21**	**195**

Low-1 Medium-3 High-9

Dairy Chemistry Practicals

(For students admitted from 2022-23**)**

Subject Code: ICDC2P **Hours/Week: 2**
Credit: 2

Course Objectives

1. To acquaint with techniques associate with dairy quality assessment
2. To understand the chemistry behind treatment methods for dairy products analysis

List of Experiments **(50 hours)**

1. Determination of boiling point and freezing point in various milk.
2. Determination of Total Solid (TS) and Solid Not Fat (SNF) by Lactometer and Gravimetric method.
3. Determination of fat in milk and selected dairy products.
4. Determination of viscosity in various milk samples.
5. Detection and quantification of starch in milk.
6. Determination of pH in various milk samples.
7. Detection of cellulose in milk sample.
8. Chemical analysis of butter milk.
9. Detection of adulterants and preservatives in milk.
10. Detection of ammonium sulphate in milk.
11. Isolation of lactose from milk.
12. Isolation of casein from milk.
13. Manufacture of homemade and commercial ice cream.
14. Detect the quality and adulterants in ghee.
15. Preparation of dairy products (milk powder and milk khoa).

Course Outcomes:

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

CO1: Understand the current development in the field of dairy chemistry and illustrate the various industrial processes of milk

CO2: Apply the determination of viscosity and pH of milk

CO3: Isolate the lactose and casein from milk

CO4: Explain the various analysis for checking quality of milk
CO5: Develop the eco-viable process for home- made and commercial ice cream, ghee, creams, butter, milk powder, palkova.etc

Reference Books:

1. Jagdish Prasad, Dairy Products Manufacturing Technology, Kalyani Publishers, 2020.
2. Richmond Henry Droop, Dairy Chemistry a Practical Handbook for Dairy Chemists and others having Control of Dairies, Nabu Press, 2010.
3. K. P. S. Sangwan, Technology of Dairy Plant Operation, 2008.

Journals:

1. The Journal of Diary Chemistry
2. International Diary Chemistry
3. Journal of Diary Research

E- Resource:

1. https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/MILK_AND_MILK_PRODUCTS.pdf
2. http://allpedia.dkart.in/health/adulterants-in-the-foods/4866-detection-of-cellulose-in-milk.html#:~:text=Cellulose%20in%20milk%20gives%20blue,until%20iodine%20begins%20to%20precipitate.
3. http://www.madehow.com/Volume-3/Ice-Cream.html
4. https://patents.google.com/patent/CN105410885A/en#:~:text=The%20method%20comprises%20steps%20as,first%20permeate%20after%20the%20whey
5. https://vlab.amrita.edu/?sub=3&brch=63&sim=1091&cnt=1

Course Outcomes	Programme Outcomes							
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**Total**
CO1	9	9	3	9	3	3	3	**39**
CO2	9	3	9	1	9	9	3	**43**
CO3	9	3	9	3	9	3	3	**39**
CO4	9	3	3	3	3	3	3	**27**
CO5	9	3	9	3	9	3	9	**45**
Total	**45**	**21**	**33**	**19**	**33**	**21**	**21**	**193**

Low-1 Medium-3 High-9

CERTIFICATE PROGRAMME ON AROMATHERAPY AND COSMETICS

(Six months programme)
(For Students Admitted from 2022-23)

Programme Outcome (PO)

PO-1	Enable students to select the most appropriate treatment methods for each client and perform treatments safely, effectively and holistically.
PO-2	To blend the knowledge of Phytochemistry and botany in identifying plant based medications.

PO-3	Give appropriate aftercare advice and offer support to patient through the use of aromatherapy preparations (lotions, oils, creams or blends of essences).
PO-4	Identify the most suitable range of aromatherapy treatments for each individual client based on detailed case notes.
PO-5	To make the student aware of the range of employment opportunities within aromatherapy practice.

PREAMBLE

This course aims at helping the students to understand the basic concepts of Aromatherapy and Cosmetics. Aromatic art of blending essential oil, their Chemistry that helps to solve both physical and psychological issues and to become a successful entrepreneur.

S. No	Subject Code	Subject	Total contact Hours	credits	ESE	Total
1.	ICAT1	Aromatherapy and Cosmetics	60	2	100	100
2.	ICAT2P	Preparative Lab for Cosmetics and Personal Care Products	120	2	100	100
Total			180	4	200	200

Aromatherapy and Cosmetics

(For students admitted from 2022-23)

Hours/Week: 3

Subject Code: ICAT1 **Credits: 2**

Course Objectives

1. To help the students in understanding the key concepts of aromatherapy and cosmetics
2. To acquire complete knowledge and experience of aromatherapy in health care such as skin care, hair care, body massage and reflexology

Unit-I Basic Anatomy and Physiology (12 hours)

Cells - types-structure and functions-aroma dermatology and safety issues. Skin diseases, infections, and pigmentation, skin allergies –types, signs and symptoms. Inflammatory disorders-skin care, nails, hair and sebaceous glands. Structure and functions - skeletal – muscular-cardiovascular-nervous-digestive-lymphatic and integumentary system.

Unit-II Introduction to Aromatherapy and Cosmetics (12 hours)

Theory of aromatherapy-history and formulation of plants and their essences. A holistic approach to aromatherapy. Principle-botanical & chemical properties of herbal plants. Chemistry of essential oils/aroma chemicals/cosmetics.

Introduction to cosmetic products- various cosmetics in everyday life-cleanser, moisturizers, toners, exfoliators, herbal hair oils, creams, gel, lotions, shampoos, face washes, face packs. Preservatives, antioxidants, fragrances, thickeners, functional materials, active ingredients and miscellaneous ingredients.

Unit-III Preparation and Uses of Cosmetics (12 hours)

Cosmetic products-physical & chemical properties-function and use of the various raw materials used in cosmetics-personal care products for both genders with an emphasis on ingredient selection, product design, formulation development, product testing, packaging and regulatory requirements. Therapeutic properties of essences and safety considerations.

Unit-IV Production Process of Cosmetic Products (12 hours)

Introduction to soap-different types of natural soap-cold process (coconut oil, aloe vera, seaweed and almond oil soap)-melt and pour process (papaya, charcoal, sandal, turmeric & carrot soap). cosmetic products-raw materials, carrier media-plant oils, cream and gels-methods of preparation of carrier oils including their chemical composition, source and storage requirements. blending essences-detailed study-reasons for selecting specific essences, selection of appropriate carrier mediums, techniques for blending, percentage calculation for dilution-an outline of the range of current uses of essences in professional and home treatments. Value added products of 15-25 essential oils. Herbal oil using Hibiscus

Unit-V Entrepreneurship & Skill Development in Aromatherapy (12 hours)

Introduction to women entrepreneurship-supportive measures for women's economic activities-Entrepreneurship- direct and indirect funding support-sources of new business ideas-generating new innovative ideas-creative problem solving-innovation-protecting the ideas and other legal issues for the Entrepreneur.

Course Outcomes (CO):

After successful completion of this course, students will be able to

CO1: Understand the basic concepts of Anatomy and Physiology
CO2: Examine the therapeutic usage of essential oil in health
CO3: Prepare the daily used cosmetics and learn its applications
CO4: Study the different types of soaps and its preparatory methods
CO5: Apply the knowledge of entrepreneurship & skill development in aromatherapy

Text Books:

1. Lorraine Nordmann, "*Professional Beauty Therapy: Level 3*", Cengage Learning EMEA, 5th edition, 2016.
2. Blossom Kochhar, "*Health and Beauty through Aromatherapy*" UBS Publishers, 2015.

Reference Books:

1. Julia Lawless, "*Encyclopedia of essential oils: The complete guide for use of Aromaticoils"*, Red Wheel, Weiser; 1st Edition, 2013.
2. Dr. Eric Zielinski, "*The Healing Power of Essential Oils: Soothe Inflammation, BoostMood, Prevent Autoimmunity, and Feel Great in Every Way"*, Harmony, 1st Edition (2018).

Journals:

1. ACS Omega
2. Journal of Agricultural and Food Chemistry
3. ACS Sustainable Chemistry and Engineering

E-Resources:

1. https://www.pdfdrive.com/essentials-of-anatomy-and-physiology-e25774384.html
2. https://www.pdfdrive.com/in-focus-essential-oils-aromatherapy-your-personal-guide-includes-an-18x24-inch-wall-chart-e195268361.html
3. https://www.pdfdrive.com/essential-oils-challenge-a-beginners-guide-to-the-phenomenal-powers-of-essential-oils-essential-oil-recipes-for-aromatherapy-stress-relief-and-anti-aging-bonus-essential-oils-guide-weight-loss-e194991966.html
4. https://www.global-cosmetics.com/cosmetic-manufacture-infrastructure/production-process/
5. https://www.pure-chemical.com/blog/commonly-used-chemicals-in-cosmetics/

Pedagogy: ICT enabled Teaching learning evaluation-Lecturing, discussions, seminar and power point presentations.

Course Outcomes	Programme Outcomes					
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**Total**
CO1	3	3	9	3	9	**27**
CO2	9	3	9	3	9	**33**
CO3	9	3	9	1	9	**31**
CO4	3	3	9	3	9	**27**
CO5	9	3	1	3	9	**25**
Total	**33**	**15**	**37**	**13**	**45**	**143**

Low-1 Medium-3 High-9

Preparative Lab for Cosmetics and Personal Care Products

(For students admitted from 2022-23)

Hours/Week: 6

Subject Code: ICAT2P **Credit: 2**

Course Objectives

1. To strengthen the students to get practical experience on aromatherapy-using oil for skin care, hair care, full body massage and reflexology
2. It enables the students to apply the beauty treatment confidently and helps to improve the particular functioning of systems through body massage

List of Experiments: **(120 hours)**

1. Preparation of various types of hair growth oil.
2. Preparation of hair cream, hair pack, hair gel and hair lotion (mix and match).
3. Preparation of glow gel, anti-acne cream, anti-aging cream and pigmentation gel.
4. Preparation of various types of serum for hair and face.
5. Preparation of various types of face washes-lemon, neem and chemical face wash.
6. Preparation of cold process soap-coconut oil soap, almond oil soap.
7. Preparation of melt and pour soap-papaya soap, charcoal soap, carrot soap.
8. Preparation of chemical soap.
9. Preparation of shikakai paste, bath powder and hair wash powder.
10. Preparation of various types of face packs, scrubs, massage cream and lotions.
11. Various methods of massage-face massage-body massage-foot massage.

12. Aroma facial recipe (for massage only).

Course Outcomes

After successful completion of this course, students will be able to

CO1: Study the pressure points in the body

CO2: Demonstrate the methods to prepare aroma oil to control hair fall and to treat skin and hair related problems

CO3: Preparation of aroma oil for head, hand, foot, face and body massage

CO4: Classify the essential oil and carrier oil

CO5: Understand the preparatory methods and application of cosmetics

Text Books:

1. Valerie Ann Worwood, *Aromatherapy in Everyday life*, V&S Publishers, 5th Edition 1991.
2. Marta Tuchowska, *Aromatherapy and Essential Oils for Beginners: Discover the Phenomenal Powers of Essential Oils to Relax, Revitalize, and Revolutionize Your Health, Create Space Independent* Publishing Platform, 2nd Edition (December 17, 2015).

Reference Books:

1. Amanda Gail Aaron, "*The complete guide to natural soap making",* Althea Pr, 2019.
2. Ace McCloud, "*Massage therapy: Trigger point therapy: Acupressure therapy: Learn the best techniques for optimum pain relief and relaxation",* Pro Mastery Publishing, 2017.

Journals:

1. Environmental Science and Technology
2. Journal of Industrial and Engineering Chemistry
3. Journal of Natural Products

E-Resources:

1. https://www.pdfdrive.com/essential-oils-aromatherapy-an-introductory-guide-more-than-300- recipes-for-health-home-and-beauty-e182244462.html
2. https://www.pdfdrive.com/365-days-of-diy-skin-care-hacks-essential-oils-natural- soaps-homemade-face-masks-diy-natural-beauty-recipes-e199756635.html
3. https://www.pdfdrive.com/the-complete-guide-to-creating-oils-soaps-creams-and-herbal- gels- for-your-mind-and-body-101-natural-body-care-recipes-e199756901.html
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Course Outcomes	Programme Outcomes					
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**Total**
CO1	3	3	9	3	9	**27**

CO2	9	3	9	3	9	**33**
CO3	9	3	9	3	9	**33**
CO4	3	3	9	3	9	**27**
CO5	9	3	3	3	9	**27**
Total	**33**	**15**	**39**	**15**	**45**	**147**

Low-1 **Medium-3** **High-9**