ORIENTAL COLLEGE (AUTONOMOUS), TAKYEL, IMPHAL
DEPARTMENT OF CHEMISTRY

B.Sc. Chemistry (Honours)
Four-Year Undergraduate Programme
(Eight - Semester Course)

TEACHING PLANS
for B.Sc. with Chemistry under LOCF
(Effective from Academic Year 2022-23)

Program Learning Outcomes

The student graduating with the Degree B. Sc. (Honours) Chemistry should be able to acquire

- **Core competency:** Students will acquire core competency in the subject Chemistry and in allied subject areas.

(i) Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.

(ii) Students will be able to use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.

(iii) The students will be able to understand the characterization of materials.

(iv) Students will be able to understand the basic principle of equipments, instruments used in the chemistry laboratory.

(v) Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry.

(vi) ***Disciplinary knowledge and skill***: A graduate student is expected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. Further, the student will be capable of using of advanced instruments and related soft-wares for in-depth characterization of materials/chemical analysis and separation technology.

(vii). ***Skilled communicator***: The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.

(viii). ***Critical thinker and problem solver***: The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.

(ix). ***Sense of inquiry***: It is expected that the course curriculum will develop an inquisitive characteristics among the students through appropriate questions, planning and reporting experimental investigation.

(i) ***Team player***: The course curriculum has been designed to provide opportunity to act as team player by contributing in laboratory, field based situation and industry.

(ii) ***Skilled project manager***: The course curriculum has been designed in such a manner as to enabling a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.

(iii) ***Digitally literate***: The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, and use of chemical simulation software and related computational work.

(iv) ***Ethical awareness/reasoning***: A graduate student requires to understand and develop ethical awareness/reasoning which the course curriculum adequately provide.

(v) ***Lifelong learner***: The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT technique and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity.

Teaching Plans under LOCF/NEP-2020 syllabus

SEMESTER - I (Year: 2022 -23 onwards)

Core Course: **INORGANIC CHEMISTRY- I**

Paper Code: **CHM-HC 501**

No of Hours per Week	Credits	Total No. of Hours	Marks
6	4 (Theory)	60	75 (Theory)
4	2 (Practical)	30	25 (Practical)

Course Objectives:

This course aims at giving students theoretical understanding about the basic constituents of matter – atoms, ions and molecules in terms of their electronic structure and reactivity. Structure and bonding in/of these are to be dealt with basic quantum chemistry treatment. Reactivity of chemical species based on their electron transfer affinity is introduced. Further, periodic classification of elements in the periodic table and changes in properties along the periods and groups to be studied in detail. Accompanying laboratory course is designed for students to have hands-on experience of basic quantitative analytical techniques related to volumetric titrations.

Course Outcomes:

On successful completion, students would have clear understanding of the concepts related to atomic and molecular structure, chemical bonding, periodic properties and redox behaviour of chemical species. Students will also have hands on experience of standard solution preparation in different concentration units and learn volumetric estimation through acid-base and redox reactions.

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment /Evaluation
Unit-1	1	Atomic structure	10	Students would have clear understanding of the concepts related to atomic and molecular structure which is the back bond of all natural science.	Lecture cum smart class and exercise	Quiz/Unit test/Seminar/ Group Discussion /Assignment
Unit-2	1	Periodicity of elements	12	Students would have clear understanding of elements in periodic table; physical and chemical characteristics and periodicity.	Lecture cum smart class and demonstration	

Unit-3	1	Chemical Bonding	13	Students would have clear understanding about Chemical bonding	Lecture cum smart class and demonstration	Quiz/Unit test/Seminar/ Group Discussion /Assignment
Unit-4	1	Oxidation reduction	10	Students will also have hands on experience of preparation of standard solution in different concentration units and learnt volumetric estimation through acid- base and redox reaction. .	Lecture cum smart class and Practical	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Nooks.

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
2. Douglas, B.E. and Mc Daniel, D.H., Concepts and Models of Inorganic Chemistry, 3rd Ed. Wiley India, 2006.
3. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed.,Wiley, 2007.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH,2007.
5. Atkins, P.W. & Paula, J. Physical Chemistry, 11th Ed., Oxford University Press, 2018.
6. Housecroft, C. E. and Sharpe, A. G. Inorganic Chemistry, 5th Ed., Pearson, 2018.
7. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, Literary Licensing, LLC,2012.

Course Teachers:

1. Dr. M. Phalguni Singh
2. Dr. N. Ranita Devi

HoD.....

SEMESTER – I (Year 2022-23 onwards**)**
Core Course: Organic Chemistry-I
Paper Code: CHM-HC 502

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	04 (Theory)	60	75 (Theory)
4	02 (Practical)	30	25 (Practical)

Course Objectives:

1)Basic of organic molecules, structure, bonding, reactivity and reaction mechanism

2) Stereochemistry of organic molecules- conformation and configuration, asymmetric molecules

3) Aromatic compounds and aromaticity, mechanism of aromatic reactions

4) Understanding hybridization and geometry of atoms, identifying chiral centers

5) Reactivity, stability of organic molecules, structure, stereochemistry

6) Electrophiles, nucleophiles, free radicals, electronegativity, resonance and intermediates along the reaction pathways

7) Mechanism of organic reactions, substitution vs elimination

Course Outcomes:

Upon completion of this course the students will be able to

1) Design and synthesis of Organic molecules

2) Structure identification through IR, NMR and Mass spectroscopic data

3) Lab/Instrumentation techniques used for analyzing reaction mechanisms

4) Advanced soft-wares / Models used for predicting stereochemistry / study of energy minimization of organic molecules

UNIT-1 : - BASICS OF ORGANIC CHEMISTRY

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Basics of Organic Chemistry (1)	1	Classification, nomenclature and hybridization of organic Compounds	3	The students will be exposed to the naming of organic compounds, hybridization	Lecture/ Discussion/ PPT/Practical	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Electronic Displacement	3	The students will understand the process of electronic movement and their applications	Lecture/ Discussion/ PPT	
	3	Types of organic reaction and their mechanism	3	The students get exposed to the different organic reactions and their mechanism	Lecture/ Discussion/ PPT	
	4	Electrophiles, nucleophiles, homolytic and heterolytic fission, types of reaction intermediate and their stabilities	3	The students will get knowledge about the breakdown of covalent bond and species of electron rich and deficient and reaction intermediate	Lecture/ Discussion/ PPT	

UNIT-2 :- STEREOCHEMISTRY

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Stereochemistry (2)	1	Different projection formulae and their inter conversion	3	The students will be exposed to the different Fischer, Newmann and sawhorse model formulae	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Geometrical isomerism	3	The students will understand the process of different types of isomerism, their applications	Lecture/ Discussion/ PPT	
	3	Optical isomerism	3	The students will understand chirality, enantiomers absolute and relative configuration	Lecture/ Discussion/ PPT	

UNIT-3 :- CHEMISTRY OF ALIPHATIC HYDROCARBON

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Chemistry of Aliphatic Hydrocarbon (3)	1	Chemistry of alkanes	3	The students will be exposed to the preparation of alkanes, reactions	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Chemistry of alkene	3	The students will understand the process of preparation, reactions of alkenes and their name reactions	Lecture/ Discussion/ PPT	
	3	Alkynes	3	The students get exposed to the different reactions of alkyne ,their acidity and type	Lecture/ Discussion/ PPT	
	4	Cycloalkanes and Conformation	6	The students will get knowledge about the Baeyer strain theory for stability of cycloalkane, energy diagram of cyclhexane	Lecture/ Discussion/ PPT	

UNIT-4 AROMATIC HYDROCARBON

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Aromatic Hydrocarbon (4)	1	Aromaticity	3	The students will be exposed to the characteristics of aromatic compounds	Lecture/ Discussion/ PPT/ Practical	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Electrophilic substitution reaction in benzene and mechanism	3	The students will understand the electrophilic reactions on benzene	Lecture/ Discussion/ PPT/Practical	
	3	Directing effects of group on benzene	3	The students will understand the ortho /para directing group and meta directing group	Lecture/ Discussion/ PPT	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Books:

1. Morrison, R.N and Boyd, R.N Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education)
2. Finar,I.L Organic Chemistry (Volume 1) , Dorling Kindersley (India) Pvt. Ltd.(Pearson Education)
3. Nasipuri, D Stereochemistry of Organic Compounds ,Wiley London 1994
4.Kalsi, P.S Stereochemistry Conformation and Mechanism, New Age International ,2005
5.Sykes, P.A guidebook to the mechanism in Organic Chemistry, Pearson Education
6.Loudon, G M, Organic Chemistry, Oxford

Course Teachers:

1. Dr. K. Inaomacha Singh
2. N. Surjit Singh

HoD.....

SEMESTER - I (Year 2022-23 onwards**)**
Skill Enhancement Course: Basic Analytical Chemistry
Paper Code: CHM-SE 501

No. of Hours per Week	Credits	Total No. of Hours	Marks
4	3 (Theory)	45	75 (Theory)
2	1 (Practical)	15	25 (Practical)

Course Objectives:

1. To familiarize students with different micro and semi micro analytical techniques.
2. To help develop the ability to use modern instrumental methods for chemical analysis of food, soil, air and water.

Course Outcomes:

Upon completion of this course the students will be able to

1. explain the basic principles of chemical analysis, design/implement micro scale and semi micro experiments.
2. use modern instrumental methods for chemical analysis of food, soil, air and water and record, interpret and analyze data following scientific methodology.

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Introduction	1	Introduction to Analytical Chemistry	5	The students will be able to understand the concept of sampling, importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
Analysis of soil	1	Composition of soil, Concept of pH and pH measurement of soil sample	5	The students will learn determination of pH of soil samples, estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.	Lecture/ Discussion/ PPT/ Practical	
Analysis of water	1	Sources responsible for contaminating water, water sampling methods, water purification methods.	4	The students will get to know the determination of pH of a water sample, Determination of dissolved oxygen (DO) of a water sample.	Lecture/ Discussion/ PPT/ Practical	
Analysis of food products	1	Idea about food processing and food preservations and adulteration.	4	Students will learn identification of adulterants in some common food items like coffee powder, chilli powder, turmeric powder, coriander powder and pulses, etc.	Lecture/ Discussion/ PPT/Practical	

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Chromatography	1	General introduction on principles of chromatography, paper chromatography, TLC etc.	4	Students will learn the paper chromatographic separation of mixture of metal ion ($Fe^{3+}$and Al^{3+}), compare paint samples by TLC method.	Lecture/ Discussion/ PPT/ Practical	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
Ion-exchange	1	Ion-exchange chromatography	4	The students will learn the basics of ion exchange chromatography, exchange capacity of ion exchanger	Lecture/ Discussion/ PPT/	
Analysis of cosmetics	1	Major and minor constituents of cosmetics and their functions	4	The students will get to learn the analysis of deodorants and antiperspirants, determination of constituents of talcum powder	Lecture/ Discussion/ PPT	

N.B: The contact hours for tutorial classes will be 15 hours.

Reference Books:

1. Willard, H.H. *Instrumental Methods of Analysis*, CBS Publishers.
2. Skoog & Lerry. *Instrumental Methods of Analysis*, Saunders College Publications, NewYork.
3. Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6th Ed.*, Saunders College Publishing, Fort Worth(1992).
4. Dean, J.A. *Analytical Chemistry Notebook*, McGraw Hill.
5. Day, R.A. & Underwood, A.L. *Quantitative Analysis*, Prentice Hall of India.
6. Freifelder, D. Physical Biochemistry *2nd Ed.*, W.H. Freeman and Co., N.Y.USA(1982).
7. Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y. USA.16(1977).
8. Vogel, A.I. *Vogel's Qualitative Inorganic Analysis 7th Ed.*, Prentice Hall.
9. Vogel, A.I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Prentice Hall.
10. Robinson, J.W. *Undergraduate Instrumental Analysis 5th Ed.*, Marcel Dekker, Inc., New York (1995).

Course Teacher: **(i) Dr. O. Gobin Singh**
(ii) Dr. K. Inaomacha Singh
(iii) Dr. K. Gayatri Sharma **HoD**: ……..

SEMESTER-II (Year 2022-23 onwards**)**

Core Course: **ANALYTICAL CHEMISTRY**

Paper Code: **CHM-HC 503**

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4 (Theory)	60	75 (Theory)
4	2 (Practical)	30	25 (Practical)

Course Objectives:

This is an elective course designed to complement the needs of students who wish to learn more about the qualitative/quantitative characterization and separation techniques. The content of this course aims to cover some of the widely used instrumental techniques for characterization of samples. Experiments included aim at giving students hands on experience using different instrumental techniques and chemical analysis.

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Course Outcomes:

On successful completion students will be have theoretical understanding about choice of various analytical techniques used for qualitative and quantitative characterization of samples. At the same time through the experiments students will gain hands on experience of the discussed techniques. This will enable students to take judicious decisions while analyzing different samples.

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment /Evaluation
Unit-1	1	Qualitative and quantitative aspects of analysis	9	The students will have knowledge of analytical data, errors, accuracy and precision	Lecture cum smart class and exercise	Quiz/Unit test/Seminar/ Group Discussion /Assignment
Unit-2	1	Optical methods of analysis	8	The students will understand about fundamental laws of spectroscopy, U.V, IR and Flame atomic absorption and emission Spectroscopy	Lecture cum smart class and Practical	
Unit-3	1	Thermal methods of analysis	12	The students will understand about the theory of TG, Instrumentation and techniques of quantitative estimation of Ca and Mg	Lecture cum smart class and Practical	

Unit-4	1	Electro-analytical methods	8	The students will have knowledge of electro-analytical methods namely pH metric, Potentiometric and conductometric tritrations and techniques for determination of pKa values	Lecture cum smart class and Practical	
Unit-5	1	Separation techniques	8	The students will have knowledge of different solvent extraction techniques and its mechanisms, Classification of different chromatography techniques and its working principles	Lecture cum smart class and Practical	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Nooks.

1. Mendham, J. et al.: Vogel's Text Book of Quantitative Chemical Analysis ; 6th Ed. Pearson Education, 2009.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. CBS Publishers & Distributors, 2004.
3. Christian, Gary D: Analytical Chemistry, 6th Ed. Wiley India (P) Ltd., 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, 4th Ed. W. H. Freeman, 2008.
5. Khopkar, S.M.: Basic Concepts of Analytical Chemistry, 3rd Ed. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, 6th Ed. Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. and Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.1979
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* VanNostrand, New York, 1974.

Course Teachers:

1. Dr. K. Inaomacha Singh
2. Dr. N. Ranita Devi
3. Dr. M. Phalguni Singh

HoD.....

SEMESTER - II (Year 2022-23 onwards**)**
Core Course: Physical Chemistry I
Paper Code: CHM-HC 504

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	**4 (Theory)**	**60**	**75 (Theory)**
4	**2 (Practical)**	**30**	**25 (Practical)**

Course Objectives:

1. To introduce the students with various states of matter.
2. To acquaint the students the physical properties of each state of matter and laws related to describe the states.
3. To introduce the students with the elementary ideas of symmetry, symmetry elements and symmetry operations.
4. To make students understand the idea of electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria.

Course Outcomes:

Upon completion of this course the students will be able to

1. get acquainted with the states of matter, their properties and laws applicable to theses systems.
2. learn the elementary ideas of symmetry, symmetry elements and symmetry operations.
3. understand the basic ideas of electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria and apply to various processes encountered in our daily life.

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Gaseous state: Unit-1	1	Kinetic molecular model of a gas, postulates and derivation of the kinetic gas equation	6	The students will be able to understands the collision frequency; collision diameter; mean free path and viscosity of gases, relation between mean free path and coefficient of viscosity	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Behaviour of real gases, Deviations from ideal gas behaviour	6	The students will have an idea of compressibility factor, , causes of deviation from ideal behaviour. Van der Waals equation of state, virial equation of state.	Lecture/ Discussion/ PPT	
Liquid State: Unit -2	1	Qualitative treatment of the structure of the liquid state; physical properties of liquids and their determination. Effect of addition of various solutes on surface tension and viscosity.	6	The students will get the knowledge of the physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of temperature and addition of various solutes on surface tension and viscosity.	Lecture/ Discussion/ PPT/ Practical	

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Solid State : Unit -3	1	Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, Bragg's law, Analysis of powder diffraction patterns	10	Students will learn the solid state, law of constancy of interfacial angles, rational indices, Miller indices,; X-ray diffraction	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
Molecular and Crystal Symmetry : Unit -4	1	Elementary ideas of symmetry, symmetry elements and symmetry operations	4	Students will learn the elementary ideas of symmetry, symmetry elements and symmetry operations	Lecture/ Discussion/ PPT	
Ionic Equilibria :Unit -5	1	Strong, moderate and weak electrolytes. Buffer solutions	7	The students will learn the degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, derivation of Henderson equation, buffer capacity, buffer action and applications of buffers in analytical chemistry and biochemical processes	Lecture/ Discussion/ PPT/ Practical	
	2	Solubility and solubility product of sparingly soluble salts, qualitative treatment of acid – base titration curves. Theory of acid–base indicators	6	Students will learn applications of solubility product principle. Qualitative treatment of acid – base titration curves, selection of indicators and their limitations	Lecture/ Discussion/ PPT/ Practical	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Books:

1. Atkins, P.W. & Paula, J. deAtkin's Physical Chemistry Ed., Oxford University Press (2006).
2. Ball, D.W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G.W. Physical Chemistry 4th Ed. Narosa(2004).
4. Mortimer, R.G. Physical Chemistry 3rd Ed. Elsevier: NOIDA,UP(2009).
5. Puri, B. R.; Sharma, L.R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co. (2017)
6. Kapoor, K.L. A Text book of Physical Chemistry (Volume1) McGraw Hill Education; Sixth edition (2019)

Course Teacher: **(i) M. Lokendro Singh**
(ii) Dr. Oinam Gobin Singh
(iii) Dr. K. Gayatri Sharma **HoD**: ……..

SEMESTER – II (Year 2022-23 onwards**)**
Skill Enhancement Course: Pesticide Chemistry
Paper Code: CHM-SE 502

No. of Hours per Week	Credits	Total No. of Hours	Marks
4	3 (Theory)	45	75 (Theory)
2	1 (Practical)	15	25 (Practical)

Course Objective*: This is a brief and introductory course on pesticides, through which the students will be introduced to various classes of pesticides, their synthesis, applications and possible hazards of their uses.*

Course Learning Outcome*: Students will be able to explain or describe and critically examine different types of pesticides, their activity/toxicity and their applications and the need for the search of an alternative based on natural products.*

PESTICIDES

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
PESTICIDES	1	Definition, classification and synthesis of different pesticides	10	The students will get able to know about the different types of pesticides	Lecture , discussion and practical	Quiz/Class test/Seminar/Assignment
	2	Benefits and adverse effects of pesticides	6	The students will get able to know about the uses and harmful effects of pesticides	Lecture , discussion	
	3	Mode of action, toxicity and methods of pesticides residue analysis	6	The students will get able to know about the toxicity of pesticides	Lecture , discussion	
	4	Synthesis and technical manufacture and uses of pesticides	8	The students will get able to know about the synthesis of pesticides	Lecture , discussion and practical	

N.B. The contact hours for tutorial classes will be 15 hours.

Recommended Book:

1. R. Cremlyn: Pesticides, Preparation and Mode of Action, John Wiley & Sons, New York, 1978
2. RP Bateman, Pesticide Applications, AAB Press, 2004
3. Principles of Pesticide chemistry: S K Handa, Ed. by Agrobios (India), 2008
4. Pesticide Science & Biotechnology: R Greenhalgh and T R Robers, IUPAC, Blackwell Scientific Publications, 1987
5. The Chemical Process Industries: D N Shreve
6. Pesticide Chemistry : G Matolesy, M. Nadasy, V. Andriska, Elsevier Sc. Publisher, USA, 1988.

Course Teachers:

1. Dr Inaomacha Singh
2. N. Surjit Singh

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SEMESTER – III (Year 2023-24 onwards**)**
Core Course: Green Chemistry
Paper Code: CHM-HC 601

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	04 (Theory)	60	75 (Theory)
4	02 (Practical)	30	25 (Practical)

Course Objectives:

1. Green chemistry and its principles.
2. Green synthesis and reactions.
3. Green chemistry for sustainable solutions.
4. Understanding principles of green chemistry.
5. Understanding design of chemical reactions/chemical synthesis using green chemistry principles.
6. Atom economy and design of chemical reactions using the principle.
7. Understanding the use of green chemistry principle and processes in laboratory reactions.

Course Learning Outcomes:

1. Use of green chemistry in designing new laboratory experiments.
2. Use of principle of atom economy and design experiments using the principle.
3. Use of green chemistry in combinatorial chemistry and biomimetic catalyst.

UNIT -1 :- Introduction to Green Chemistry:

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Introduction to Green Chemistry	1	Definition, need, goals of green chemistry	4	The students will be able to know about the importance of green chemistry	Lecture , discussion and practical	Quiz/Class test/Seminar/Assignment

UNIT -2 :- Principles of Green Chemistry and Designing a Chemical synthesis

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Principles of Green Chemistry and Designing a Chemical synthesis	1	Twelve principles of Green Chemistry	4	The students will be able to know about the principles of green chemistry	Lecture , discussion	Quiz/Class test/Seminar/Assignment
	2	Designing a Green Synthesis	4	The students will understand the design of green reactions	Lecture , discussion	
	3	Green solvents, solvent less processes, immobilized solvents and ionic liquids; energy requirements for reactions	4	The students will be able to know about the uses of green solvents in reactions	Lecture , discussion	
	4	Strengthening/ development of analytical techniques	3	The students will be able to know how to prevent and minimize the generation of hazardous substances in chemical processes.	Lecture , discussion and practical	

UNIT- 3 :- Examples of Green Synthesis/ Reactions

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Examples of Green Synthesis/ Reactions	1	. Green Synthesis	4	The students will be able to know about the synthesis of many organic compounds by green methods	Lecture , discussion	Quiz/Class test/Seminar/Assignment
	2	Microwave assisted reactions	6	The students will understand the synthesis of compounds by Microwave assisted reactions	Lecture , discussion and practical	
	3	Selective methylation of active methylene group using dimethylcarbonate: Solid-state polymerization of amorphous polymers using diphenylcarbonate	4	The students will be able to know about the Selective methylation reactions	Lecture , discussion	
	4	Free Radical Bromination; Role of Tellurium in organic syntheses; Biocatalysis in organic syntheses.	4	The students will be able to know Biocatalysis in organic synthesis.	Lecture , discussion	

UNIT -4 :- Future Trends in Green Chemistry:

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Future Trends in Green Chemistry	1	Oxidation reagents and catalysts	4	The students will be able to know about the use of oxidative reagents and catalysts	Lecture , discussion and practical	Quiz/Class test/Seminar/Assignment
	2	Green chemistry in sustainable development	4	The students will be able to know about the development in Green chemistry	Lecture, discussion	

N.B. The contact hours for tutorial classes will be 15 hours.

Recommended Books:

1. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998).
3. A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
4. M.C. Cann& M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
5. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

Course Teachers:

1. Dr. K. Inaomacha Singh
2. N. Surjit Singh

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SEMESTER -III (Year 2023-24 onwards**)**
Core Course: **INORGANIC CHEMISTRY**-II
Paper Code: **CHM-HC 602**

No. of Hours per Week	Credits	Total No. Of Hours	Marks
6	4 (Theory)	60	75 (Theory)
4	2 (Practical)	30	25 (Practical)

Course Objectives:

This course starts with the basic principles of metallurgy so as to acquaint the students with the application of the redox chemistry they have learnt in the earlier course on inorganic chemistry. Concepts of protonic and non-protonic acids and bases are introduced for students to appreciate different types of chemical reactions. Periodic behaviour of s and p block elements related to their electronic structure and their reactivity is included to acquaint students with the principles governing their reactivity. This course further intend to apprise students about the variety of compounds of the main group elements including oxides, hydrides, nitrides, inter halogens, noble gases and inorganic polymers. As part of the accompanying lab course, experiments involving iodo- and iodi-metric titrations are included for the students to explore other varieties of redox titration. Preparation of simple inorganic compounds is introduced to give hands-on experience of inorganic synthesis.

Course Outcomes:

On successful completion of this course students would be able to apply theoretical principles of redox chemistry in the understanding of metallurgical processes. Students will be able to identify the variety of s and p block compounds and comprehend their preparation, structure, bonding, properties and uses. Experiments in this course will boost their quantitative estimation skills and introduce the students to preparative methods in inorganic chemistry.

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment /Evaluation
Unit-1	1	General Principles of Metallurgy	8	On successful completion of this course students would be able to apply Theoretical principles of redox chemistry in the understanding of metallurgical processes.	Lecture cum smart class and exercise	Quiz/Unit test/Seminar/ Group Discussion /Assignment
Unit-2	1	Acids and Bases	8	Students will have the knowledge of Bronsted-Lowry concept of acid-base reactions, Lewis acid-base concept, Hard and Soft Acids and Base (HSAB), application of HSAB principles.	Lecture cum smart class and Practical	
Unit-3	1	Chemistry of *s* and *p* Block Elements	14	Students will be able to identify the variety of s and p block compounds and comprehend their preparation, structure, bonding, properties and uses.	Lecture cum smart class and practical	
Unit-4	1	Noble Gases	8	Students would have clear knowledge about the specific properties of Noble gas elements	Lecture cum smart class and demonstration	
Unit-5	1	Inorganic Polymers	7	Students will learn the chemistry of inorganic polymers. They also learn the brief introduction of preparation, structure and properties of some industrially important and technologically promising polymers.	Lecture cum smart class and demonstration	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Nooks.

1. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
2. Douglas, B.E. and Mc Daniel, D.H., Concepts and Models of Inorganic Chemistry, 3rd Ed. Wiley India, 2006.
3. Greenwood, N.N. & Earnshaw, A., Chemistry of the Elements, 2nd Ed., Elsevier India,2010.
4. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed.,Wiley, 2007.
5. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH,2007.
6. Miessler, G. L. &Tarr, D. A., Inorganic Chemistry 4th Ed., Pearson, 2010.
7. Weller, M., Armstrong, F., Rourke, J. & Overton, T., Inorganic Chemistry 6th Ed.2015.

Course Teachers:

1. Dr. M. Phalguni Singh
2. Dr. N. Ranita Devi **HoD** .....

SEMESTER - III (Year 2023-24 onwards**)**

Core Course**: Physical Chemistry II**

Paper Code: **CHM-HC 603**

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	**4 (Theory)**	**60**	**75 (Theory)**
4	**2 (Practical)**	**30**	**25 (Practical)**

Course Objectives:

1. To introduce the students with Laws of thermodynamics.
2. To give the students the concept of system, variables, heat and work.
3. To make students understand the concept of partial molar quantities and its attributes.
4. To make students understand the theories/thermodynamics of dilute solutions and colligative properties.

Course Outcomes:

Upon completion of this course the students will be able to

1. use thermochemical equations for calculation of energy and related terms.
2. use of thermodynamics in explaining chemical behavior of solute/solvent and reactions.
3. correlate the concepts of thermodynamics to our daily life.

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Chemical Thermodynamics: Unit-1	1	Intensive and extensive variables; state and path functions; isolated, closed and open systems, Zeroth law and First law of thermodynamics.	8	The students will be able to understands the concept of heat, *q*, work, *w*, internal energy, *U*, enthalpy, *H*, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Thermochemistry	6	The students will gain some idea of heats of reactions and its applications	Lecture/ Discussion/ PPT/ Practical	
	3	Second and third law of thermodynamics and free energy functions	8	The students will learn the concept of entropy, thermodynamic scale of temperature, concept of residual entropy, calculation of absolute entropy of molecules. Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.	Lecture/ Discussion/ PPT	

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Systems of Variable Composition:: Unit -2	1	Partialmolar quantities, Gibbs-Duhem equation,	7	Students will learn the dependence of thermodynamic parameters on composition, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
Chemical Equilibrium : Unit -3	1	Criteria of thermodynamic equilibrium, Equilibrium constants and their quantitative dependence on temperature, pressure and concentration	8	Students will learn the elementary ideas of chemical equilibrium in ideal gases, concept of fugacity, Le Chatelier principle	Lecture/ Discussion/ PPT	
Solutions and Colligative Properties: Unit -4	1	Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation of the four colligative properties using chemical potential	8	The students will be able to learn the Raoult's and Henery's Laws and their applications, thermodynamic derivation of the four colligative properties	Lecture/ Discussion/ PPT/ Practical	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Books:

1. Peter, A. & Paula, J.de. *Physical Chemistry 9th Ed.* ,Oxford University Press (2011).
2. Castellan, G.W. *Physical Chemistry 4th Ed.,* Narosa (2004).
3. Levine, I .N. *Physical Chemistry* 6th Ed., Tata McGraw Hill (2010).
4. Kapoor, K. L. *A Textbook of Physical Chemistry (Volume 2)* McGraw Hill Education; Sixth edition (2019)

Course Teacher: **(i) Th. Heramani Singh**
(ii) Dr. O. Gobin Singh **HoD**: ……..

SEMESTER - IV (Year 2023-24 onwards**)**

Core Course**: Molecular Spectroscopy & Photochemistry**

Paper Code: **CHM-HC 604**

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	**4 (Theory)**	**60**	**75 (Theory)**
4	**2 (Practical)**	**30**	**25 (Practical)**

Course Objectives:

1. To provide the knowledge of the interaction of electromagnetic radiation with molecules.
2. To provide the basic principles of spectroscopy.
3. To make students understand the Franck-Condon Principles and electronic transitions.
4. To make students understand the Photochemical reactions.

Course Outcomes:

Upon completion of this course the students will be able to

1. determine the bond length of diatomic and linear triatomic molecules.
2. learn the concept of vibration-rotation spectroscopy: diatomic vibratiing rotator, P, Q, R branches..
3. learn the Quantitative treatment of Rotational Raman effect, electronic spectra and photochemistry (Lambert-Beer law and its applications).

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Unit-1 : Interaction of electromagnetic radiation with molecules and various types of spectra	1	Born-Oppenheimer approximation, Rotational spectroscopy	8	The students will be able to understand the concept of selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Vibrational spectroscopy	10	The students will gain the idea of classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissoctiation energies, diatomic vibrating rotator, P, Q, R barnches.	Lecture/ Discussion/ PPT	

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Raman Spectroscopy, Electronic spectroscopy: Unit-2	1	Raman Spectroscopy	6	Students will learn the quantitative treatment of Rotational Raman effect; Effect of Vibrational Raman spectra. stokes and anti stokes lines, their intensity difference, rule of mutual exclusion.	Lecture/ Discussion/ PPT	Quiz/Class test / Seminar/ Group Discussion/ Q & A Session/ Assignment
	2	Electronic Spectroscopy	4	Students will learn the concepts of Franck-Condon principles, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre dissociation.	Lecture/ Discussion/ PPT	
Photphysicsl and photochemical processes: Unit-3	1	Laws of photochemistry & Kinetics of photochemical reactions, energy transfer of photochemical reactions, electronic spectra	17	The students will learn the laws of photochemistry, quantum yield, laws of photochemical equivalence, quantum efficiency, kinetics of photochemical reactions ($H_2+Br_2 = 2HBr$, $2HI=H_2+I_2$), Lambert-Beer law and its applications.	Lecture/ Discussion/ PPT/ Practical	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Books:

1. Laideler K.J. and Meiser J.M. *Physical Chemistry 3rd Ed.* ,International (1999).
2. Levine, I .N. *Physical Chemistry* 6th Ed., Tata McGraw Hill (2010).
3. Rohatgi-Mukherjee K. K. *Fundamentals of Photochemistry*, New Age (revised second edition).
4. Kapoor, K. L. *A Textbook of Physical Chemistry (Volume 4)* McGraw Hill Education; Sixth edition (2019)
5. Banwell, C. N. & McCash, E.M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tat McGraw Hill, New Delhi (2006).

Course Teacher: **(i) Th. Heramani Singh**
(ii) Dr. O. Gobin Singh **HoD**: ……..

SEMESTER-IV (Year: 2023-24 onwards)

Core Course: **INORGANIC CHEMISTRY-III**

Paper Code: **CHM-HC 605**

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4 (Theory)	60	75 (Theory)
4	2 (Practical)	30	25 (Practical)

Course Objectives:

This course introduces students to coordination chemistry. Various aspects like nomenclature, structure, bonding, variety and reactivity of the coordination compounds are included for the students to appreciate. Bioinorganic chemistry is included in this course to acquaint students on the useful and harmful aspects of metals in biological systems. Through the accompanying lab course, experiments related to gravimetric analysis, synthesis of coordination compounds and separation of metal ions using chromatography is included. This will broaden the experimental skills of the students where students will learn about various aspects of experiment design depending upon the requirements like synthesis, estimation or separation.

Course Outcomes:

On successful completion, students will be able name coordination compounds according to IUPAC, explain bonding in this class of compounds, understand their various properties in terms of CFSE and predict reactivity. Students will be able to appreciate the general trends in the properties of transition elements in the periodic table and identify differences among the rows. Through the experiments students not only will be able to prepare, estimate or separate metal complexes/compounds but also will be able to design experiments independently which they should be able to apply if and when required.

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment /Evaluation
Unit-1	1	Coordination Chemistry	10	On successful completion, students will be able to name coordination compounds according to IUPAC, explain bonding in this class of compounds, understand their various properties in terms of CFSE and predict reactivity.	Lecture cum smart class and exercise	

Unit-2	1	Transition Elements	14	Students will be able to appreciate the general trends in the properties of transition elements in the periodic table and identify differences among the rows.	Lecture cum smart class and demonstration	Quiz/Unit test/Seminar/ Group Discussion /Assignment
Unit-3	1	Lanthanoids and Actinoids	12	Students will understand elements' periodic in table; physical and chemical characteristics and periodicity of lanthanoids and Actinoids.	Lecture cum smart class and demonstration	
Unit-4	1	Bioinorganic Chemistry	9	Students will have ideas on the useful and harmful aspects of metals in biological systems.	Lecture cum smart class and demonstration	

N.B. The contact hours for tutorial classes will be 15 hours.

Reference Nooks.

1. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed.,Wiley, 2007.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed., Pearson Education India, 2006.
3. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry, Panima Publishing Company, 1994.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH,2007.
5. Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley &Sons, NY, 1967.
6. Greenwood, N.N. & Earnshaw, A., Chemistry of the Elements, 2nd Ed., Elsevier India,2010.

Course Teachers:

1. Dr. M. Phalguni Singh
2. Dr. N. Ranita Devi

HoD.....

SEMESTER-IV (Year 2023-24 onwards)

Core Course : Organic Chemistry- II

Paper Code : CHM-HC 606

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4 (Theory)	60	75 (Theory)
4	2 (Practical)	30	25 (Practical)

Course Objectives:

1. Familiarization about classes of organic compounds and their methods of preparation.
2. Basic uses of reaction mechanisms.
3. Name reactions, uses of various reagents and the mechanism of their action.
4. Preparation and uses of various classes of organic compounds.
5. Organometallic compounds and their uses.
6. Organic chemistry reactions and reaction mechanisms.
7. Use of reagents in various organic transformation reactions

Course Learning Outcomes:

1. Elucidating reaction mechanisms for organic reactions.
2. Organometallic compounds and their uses.
3. Use of active methylene groups inorganic mechanism and preparation of new organic compounds.

UNIT-1 : **CHEMISTRY OF HALOGENATED HYDROCARBONS**

Unit	**Section**	**Topic**	**Lecture hours**	**Learning outcome**	**Pedagogy**	**Assessment/ Evaluation**
Chemistry of halogenated hydrocarbons (1)	1	Alkyl halide (preparation, reactions and their mechanism)	3	The Students will be able to know about the preparation and reaction mechanism of alkyl halide	Lecture, discussion and practical	Quiz/Class test/Seminar/Assignment
	2	Aryl halide (preparation, reactions and their mechanism)	**3**	The Students will be able to know about the preparation and reaction mechanism of aryl halide	Lecture and discussion	
	3	Organo metallic compounds	**3**	The Students get exposed to the preparation of organometallic compounds of Mg and Li and their applications	Lecture, discussion and practical	

UNIT-2 :- ALCOHOLS, PHENOLS, ETHERS AND EPOXIDES

Unit	**Section**	**Topic**	**Lecture hours**	**Learning outcome**	**Pedagogy**	**Assessment / Evaluation**
Alcohols, Phenols, Ethers and Epoxides (2)	1	Alcohols (preparation, reactions and their mechanism, types)	3	The Students will be able to know about the preparation and reaction mechanism of alcohol	Lecture and discussion	Quiz/Class test/Seminar/Assignment
	2	Phenol (preparation, reactions and their mechanism)	**4**	The Students will be able to know about the preparation and reaction mechanism and name reactions of phenol	Lecture, discussion and practical	
	3	Ethers and Epoxides	**3**	The Students get exposed to the preparation of ether and epoxide and their reactions	Lecture and discussion	

UNIT-3 :- CARBONYL COMPOUNDS

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Carbonyl Compounds (3)	1	Aldehydes and Ketones (preparation, name reactions and their mechanisms)	5	The Students will understand the preparation of carbonyl compound and their name reactions and mechanism	Lecture , discussion and practical	Quiz/Class test/Seminar/Assignment
	2	Unsaturated carbonyl compounds	**2**	The Students will be able to know about the preparation and reaction unsaturated carbonyl compounds	Lecture and discussion	
	3	Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	**3**	The Students get exposed to the preparation and application of diethyl malonate and ethyl acetoacetate	Lecture and discussion	

UNIT-4 :- CARBOXYLIC ACIDS AND THEIR DERIVATIVES

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessmen/ Evaluation
Carboxylic acids and their derivatives (4)	1	Preparation, physical properties and reactions of monocarboxylic acids	4	The Students will understand the preparation of carboxylic acid and their name reactions and mechanism	Lecture , discussion and practical	Quiz/Class test/Seminar/Assignment
	2	Dicarboxylic acids, hydroxy acids and unsaturated acids	**3**	The Students will be able to know about the preparation and reaction of unsaturated, hydroxy and di carboxylic acid	Lecture and discussion	
	3	Specific Name reactions of carboxylic acid	**3**	The Students get exposed to different name reactions of carboxylic acids	Lecture and discussion	

UNIT-5 :- Sulphur containing compounds

Unit	Section	Topic	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
Sulphur containing compounds (5)	1	Preparation of thiol, sulphonic acid and thioether	3	The Students will understand the preparation of sulphur containing compounds	Lecture , discussion and practical	Quiz/Class test/Seminar/Assignment
	2	Chemical reactions of thiol, sulphonic acid and thioether	**3**	The Students will be able to know about the reaction of sulphur containing compounds	Lecture, discussion and practical	

N.B.: The contact hours for tutorial classes will be 15 hours.

Recommended Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
4. Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry*, Second edition, Oxford University Press, 2012.
5. Keeler, J., Wothers, P. *Chemical Structure and Reactivity – An Integrated approach*, Oxford University Press.
6. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
7. Carey, F. A.; Sundberg, R. J. *Advanced Organic Chemistry: Reactions and Synthesis (Part B),* Springers.

Course Teachers:

1. *Dr K. Inaomacha Singh*
2. *N. Surjit Singh*

HOD. .....