

ST. JOSEPH'S UNIVERSITY

BENGALURU-27



DEPARTMENT OF BIOCHEMISTRY

**SYLLABUS FOR UNDERGRADUATE PROGRAMME
(NEP)**

For Batch 2022-2025

FOREWORD

Board of Studies

The Biochemistry syllabus for the batch 2022-2025 has been approved by the board of studies meeting held on 17th December 2022.

The members of the board are:

1. Prof. V. R. Devaraj, Professor of Biochemistry, Bangalore City University.
2. Prof. Sarada Subramanian, Professor of Neurochemistry, National Institute of Mental Health and Neurosciences (NIMHANS) Bangalore
3. Mr. Anup Chandra Kant Production controller and quality control analyst, India Fine Chemicals
4. Prof. Mohanadas, Professor of Biochemistry, Department of Biochemistry, St. Joseph's University, Bangalore
5. Prof. Sandra Misquith, Professor of Biochemistry, Department of Biochemistry, St. Joseph's University Bangalore.
6. Dr. Shraddha K. N. Asst. Professor of Biochemistry, Department of Biochemistry, St. Joseph's University Bangalore.
7. Dr. Daniel Andrew Gideon, Asst. Professor of Biochemistry, Department of Biochemistry, St. Joseph's University, Bangalore.

Advisory Board Members:

The department would also like to place on record that the syllabus was designed keeping in mind the wide scope of the subject, the job potential and the future of the students who graduate in the subject. After consultation of several syllabi and obtaining the opinion of several prominent people in the field the syllabus was designed.

The members of the department would like to acknowledge all those who have greatly contributed to the framing of the syllabus. These include:

1. Prof. Jenny Loertscher, Prof. of Biochemistry, University of Seattle, USA
2. Prof. Drubojoythi Chatterjee Professor of Biochemistry, Vice Chancellor Amity University Kolkata.
3. Prof. Siddhartha Sarma, Chairman, Molecular Biophysics Unit, Indian Institute of Science, Bangalore
4. Prof. D. N. Rao. Hon. Professor of Biochemistry, IISc, Convenor, Talent Development Centre, The Advisor, Challakere campus
5. Prof. Harpreet Singh, Director of Physiology, Ohio State University, USA.
6. Prof. Devaraj, Chairman and Professor of Biochemistry, BCU
7. Prof. Sarada Subramanian, Professor of Neurochemistry, NIMHANS
8. Dr. Vishnu Janardhan Scientist II Protein Biology, Thermo Fisher Scientific
9. Mr. Anup Chandra Kant, Production controller and quality control analyst, India Fine Chemicals

Part A			
1	Title of the Academic Program	BSc Biochemistry, Botany and Zoology	
2	Program Code	SJC BSc Biochemistry honours (To be given by Examination Section)	
3	Name of the College	St. Joseph's University	
4	Objective of the College	<ol style="list-style-type: none"> 1. Academic Excellence 2. Character Formation 3. Social Concern 	
5	Vision of the College	"Striving for a just, secular, democratic and economically sound society, which cares for the poor, the oppressed and the marginalized"	
6	Mission of the College	M1	St. Joseph's College (Autonomous) seeks to form men and women who will be agents of change, committed to the creation of a society that is just, secular and democratic.
		M2	The education offered is oriented towards enabling students to strive for both academic and human excellence.
		M3	The college pursues academic excellence by providing a learning environment that constantly challenges the students and supports the ethical pursuit of intellectual curiosity and ceaseless enquiry.
		M4	Human excellence is promoted through courses and activities that help students achieve personal integrity and conscientise them to the injustice prevalent in society.
7	Name of the Degree	Bachelor of Science (B.Sc.,)	
8	Name of the Department offering the program	Biochemistry	
9	Vision of the Department offering the Program	"The Department intends to arouse in students an interest in the world of sciences. To get a better understanding of how living things exist. To appreciate the reactions that take place in the living system. To correlate the laws of nature and the physical laws that blend together in all life forms"	
10	Mission of the Department offering the Program	<ul style="list-style-type: none"> ● The Department of Biochemistry aims at developing the young mind to question, to seek and to understand how living things function. ● The department also looks at developing students into the realms of analytical thinking and self-reliance. ● At the end of the course, students have developed skills to handle the subject as part of academics or industry. 	
11	Duration of the Program	3 years (Six semesters)	
12	Total No. of Credits	36	
13	Program Educational Objectives (PEOs)	PEO 1	
		PEO2	
		PEO 3	
<p>Programme Educational Objectives: PEOs are statements that describe Institution's Mission aligned with the programme (To be Prepared in consultation with other departments (Languages and Optional subjects) 2-5 PEOs can be written.</p> <ul style="list-style-type: none"> • Guidelines for the PEOs <ul style="list-style-type: none"> – PEOs should be consistent with the mission of the Institution 			

- The number of PEOs should be manageable
- PEOs should be achievable by the program
- PEOs should be specific to the program and not too broad

14	Graduation Attributes	The Following graduate attributes reflect the particular quality and feature or characteristics of an individual, that are expected to be acquired by a graduate through studies at St. Joseph's College. <ul style="list-style-type: none"> ● Disciplinary knowledge ● Communication Skills ● Critical thinking ● Problem solving ● Analytical reasoning ● Research-related skills ● Cooperation/Team work ● Reflective thinking ● Information/digital literacy ● Self-directed learning and Lifelong learner ● Multicultural competence ● Moral and ethical awareness/reasoning ● Leadership readiness/qualities ● International Outlook 	
15	Program Outcomes (POs)	PO1	
		PO2	
		PO3	
		PO4	

Programme Outcomes: POs are statements that describe what the students graduating from any of the educational Programmes should be able to do (To be Prepared in consultation with other departments (Languages and Optional subjects. 4-10 POs can be written

- **Guidelines for the POs**

- Program outcomes basically describe **knowledge, skills and behavior** of students as they progress through the program as well as by the time of graduation.
- POs should not be too broad
- They must be aligned with the **Graduation Attributes**

16	Program Specific Outcomes (PSOs)	PSO1	
		PSO2	Students will be introduced to organic chemistry, they will also learn some aspects of physical chemistry. These will act as foundation to understanding how the biological processes function. In practical classes they will develop skills in determining several parameters in physical chemistry that have a direct implication in the living system. RBPT component will also be introduced to augment skills already developed in the first semester.
		PSO3	In this semester students will be exposed to fundamental concepts in inorganic chemistry, environmental chemistry and organic chemistry which will help in developing skills in addressing how life evolved and how the inorganic world is closely entwined with the natural world.
		PSO4	Students will develop a theoretical understanding of analytical techniques that will permit them to study the biological system and the processes therein. In the practical component they will have hands on experience of how to handle instruments and analyze data.
		PSO5	Students will be introduced to biomolecules and how they function. They will be able to correlate all the chemistry they learnt in the first four semesters and understand how beautifully the animate

		world obeys all the natural, chemical and physical laws. They will learn to isolate, identify and assay the biomolecules. They will also develop skills in conducting independent research as part of an on-going project work.
	PSO6	From an understanding of biomolecules the focus shifts to an understanding of the processes involved in the biological system from reactions occurring at the cell surface to the degradation of molecules and their synthesis. Modern techniques in molecular and cellular chemistry will be developed and understood.
<p>Programme Specific Outcomes: PSOs are statements that describe what the graduates of a specific educational Programme should be able to do.</p> <p>These statements are to be written by individual departments offering optional programmes. In addition Language departments also to write general statements for BA, BSc and Commerce Programs. For the Microbiology optional for MCB/MCZ PSOs have been shown as examples. 4-10 PSOs can be written</p> <ul style="list-style-type: none"> • Guidelines for the PSOs <ul style="list-style-type: none"> – Program Specific outcomes basically describe knowledge and skills of students as they progress through the program as well as by the time of graduation. – POs should not be too broad - They must be aligned with the Graduation Attributes 		

Part B

B.Sc. BBZ Curriculum

Courses and course completion requirements	No. of credits
General English	12
Second language: Introductory Kannada/Kannada/ Hindi/ Sanskrit/ Tamil/ Additional English/French/German.	12
Biochemistry	42
Botany	
Zoology	
Open elective courses (non-professional)	
Foundation courses	
Term paper	
Soft skills (IGNITORS)	
Human resource development (HRD)/Theology	
Outreach activity	
Extra and Co-curricular activities	5

SUMMARY OF CREDITS IN BIOCHEMISTRY

DEPARTMENT OF BIOCHEMISTRY (UG) (2021-2024)								
Semester 1	Code Number	Title	No. of Hours of Instructions	Number of Hours of teaching per week	Number of credits	Continuous Internal Assessment (CIA) Marks	End Semester Marks	Total marks
Theory	BCH-121	Inorganic and Physical Chemistry	60	04	04	40	60	100
Practical	BCH-1P1	Stoichiometry and Volumetric Analysis	44	4	02	35	15	50
Total Number of credits:			06					
Semester 2	Code Number	Title	No. of Hours of Instructions	Number of teaching h /week	Number of credits	Continuous Internal Assessment (CIA) Marks	End Semester Marks	Total marks
Theory	BCH-221	Physical and Organic Chemistry	60	04	04	40	60	100
Practical	BCH-2P1	Physical Chemistry for biologists	44	4	02	35	15	50
Total Number of credits:			06					
Semester 3	Code Number	Title	No. of Hours of Instructions	Number of teaching h /week	Number of credits	Continuous Internal Assessment (CIA) Marks	End Semester Marks	Total marks
Theory	BCH-322	Inorganic and organic chemistry	60	04	04	40	60	100
Practical	BCH-3P1	Organic synthesis, purification and characterisation	33 +11	03 + 1	02	35	15	50
Total Number of credits:			06					
Semester 4	Code Number	Title	No. of Hours of Instructions	Number of teaching h /week	Number of credits	Continuous Internal Assessment (CIA) Marks	End Semester Marks	Total marks
Theory	BCH-422	Biomolecules and Analytical techniques in Biochemistry - 1	60	04	04	40	60	100
Practical	BCH-4P1	Separation, isolation and characterization of biomolecules	33 + 11	03 + 1	02	35	15	50
Total Number of credits:			06					

Semester 5	Code Number	Title	No. of Hours of Instructions	Number of teaching h/week	Number of credits	Continuous Internal Assessment (CIA) Marks	End Semester Marks	Total marks
Theory	BCH-5122	Biomolecules - 2	45	03	03	40	60	100
Practical	BCH-5P1	Enzymology and nucleic acid chemistry	44	04	02	35	15	50
Theory	BCH-5222	Analytical techniques in Biochemistry -2	45	03	03	40	60	100
Practical	BCH-5P2	Project work –I*	44		02	-	-	-
Total Number of credits:					10			
Semester 6	Code Number	Title	No. of Hours of Instructions	Number of teaching h/week	Number of credits	Continuous Internal Assessment (CIA) Marks	End Semester Marks	Total marks
Theory	BCH-6122	Metabolism	45	03	03	40	60	100
Practical	BCH-6P1	Estimation of food quality and identification of adulterants	33 + 11	03 +1	02	35	15	50
Theory	BCH-6222	Recent developments in the field of Biochemistry	45	03	03	40	60	100
Practical	BCH-6P2	Project work – II + Project - I	44		02	0	50 +50	100
Total Number of credits:					10			

CORE COURSES (CC)	
Course Title	Code Number
Inorganic and Physical Chemistry	BCH-121
Physical and Organic Chemistry	BCH-221
Inorganic and Organic Chemistry	BCH-322
Biomolecules and analytical techniques in Biochemistry - 1	BCH-422
Introduction to Forensic Biochemistry using case studies	BCHOE-1
We are what we eat	BCHOE - 2
Biomolecules - 2	BCH-5122
Analytical techniques in Biochemistry - 2	BCH-5222
Bioenergetics, biological oxidation, metabolism and diseases of metabolism	BCH-6121
Recent developments in the field of Biochemistry	BCH-6221
Volumetric Analysis	BCH-1P1
Physical chemistry practical	BCH-2P1
Organic synthesis, separation, purification and identification of groups	BCH-3P1
Separation, isolation and characterization of biomolecules	BCH-4P1
Estimation of food quality and identification of adulterants	BCH-5P1
Project Work - I	-
Enzymology and nucleic acid chemistry	BCH – 6P1
Project Work -II	BCH – 6P2

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)	
Course Title	Code Number

GENERIC ELECTIVE COURSES (GSE)[For Physical Sciences, Arts and Commerce UG Students]	
Course Title	Code Number
Introduction to Forensic Science	BCHOE-1
We are what we eat	BCHOE - 2

SKILL ENHANCEMENT COURSE (SEC) – Any practical oriented and software based courses offered by departments to be listed below	
Course Title	Code Number

VALUE ADDED COURSES (VAC) Certificate courses that add value to the core papers can be listed	
Course Title	Code Number

Online courses offered or recommended by the department to be listed	
Course Title	Code Number
Principles of Biochemistry	EDX course (Harvard University)
Learning how to learn	Coursera
Introduction to statistics	Coursera (Stanford university)
Introduction to mathematical thinking	Coursera (Stanford university)
Introduction to ordinary differential equations	Coursera (KAIST)

Course Outcomes and Course Content

Semester	I
Paper Code	BCH 121
Paper Title	Inorganic and Physical Chemistry
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objectives of the paper:

This paper introduces the students to basic concepts in inorganic and physical chemistry required to understand chemistry. It acts as a bridge course to what they have already studied at the high school level and complements it with additional concepts. They will be able to apply it to the chemistry occurring within the living system. They should be able to create experiments both theoretically and experimentally to illustrate their understanding of the concepts.

Course Content:

Atomic structure: In this unit students will study the fundamentals of atomic structure that will help them conceptualize how an atom appears.

Electromagnetic radiation – (wave length, frequency, velocity, wave number) electromagnetic spectrum, Nature of wave particle.

Quantum numbers & their significance (Principal quantum number, Azimuthal quantum number(1), Magnetic quantum number (m) and Spin quantum number (s)

Shapes of Atomic orbitals – s, p and d orbitals.

Pauli Exclusion Principle, Aufbau Principle, Hund's rule of maximum multiplicity -cause of stability of half-filled and completely filled energy levels.

Electronic configuration of elements up to At No.54, (n+1) rule, $2n^2$, order of energy levels to be followed)

Oxidation numbers – concept, difference between valency and oxidation number, and computation.

Calculation of equivalent weights of oxidising and reducing agents. (Self-study)

10 h

Chemical bonding: Students will be able to not only conceptualise how molecules are formed from atoms but be able to create models of any molecule real or imaginary by knowing and understanding the forces that hold atoms together.

Ionic bond -factors favouring formation – lattice energy – energetics of Ionic bond formation (NaCl as example). Born – Haber cycle – for NaCl. Calculation of lattice energy; Characteristics of ionic compounds (self-study). Covalent bond- definition, pictorial representation of covalent bond formation in

H₂, HCl, NH₃, CO₂ and N₂. Valence bond theory – postulates, Sigma and pi bonds Hybridization of orbitals and directoral characteristics –sp,sp², sp³(egs- methane, ethene and acetylene) Resonance forms of H₂ and Benzene. VSPER theory-Shapes of H₂O, NH₃, H₃O⁺, SF₄,ClF₃ and ICl-

Molecular Orbital Theory – postulates, atomic orbitals and molecular orbitals; conditions for the formation of molecular orbitals. LCAO – Bonding and antibonding molecular orbitals; comparison between bonding and antibonding molecular orbitals. Shapes of molecular orbitals (by s-s, s-p, p-p overlap) – pictures to be given. Molecular orbital diagrams for the formation of H₂, He and O₂. Polarisation concept, Fajan's rule, bond length, bond angle and bond energy, dipole moment. Coordinate bond – Donor, acceptor, representation of the formation of co-ordinate bond in H₃O⁺, NH₄⁺. Chelates – ligands, chelates in biological systems (mention chlorophyll, vitamin B₁₂, haeme, catalase as examples) Hydrogen bond – inter and intramolecular hydrogen bond- anomalous properties of HF, H₂O, NH₃ and nitro phenols; Van der Waals forces – definition. Concept of hydrophobic interactions.

15 h

Liquids: As the living system is mainly composed of water, students require to possess a thorough understanding of liquids and their properties to correlate it with the functioning of living organisms. This unit seeks to give them a fundamental understanding of liquids.

Properties of liquids –vapour pressure, viscosity and surface tension. Relationship between vapour pressure and boiling point, freezing point-heat of fusion.

Viscosity-Definition, units, experimental determination using Ostwalds viscometer. Viscosity and shape/size of molecules.

Surface tension:- Definition, units, experimental determination using stalagmometer. Surfactants – effect of surfactants on surface tension.

Viscosity and Surface tension in everyday life (self-study).

6h

Solutions and Colligative properties: Most living tissues like blood tears, etc are solutions, an understanding of solutions and their properties are required to understand the living system.

Concentration units – molarity, molality, normality, mole fraction – simple problems (self study).

Types of solutions – homogenous and heterogeneous, factors influencing solubility– nature of solvent, solute, temperature, pressure and practice size. Solubility curves– plots showing solubility of sodium chloride, potassium nitrate, lead nitrate and sodium sulphate against temperature. Henry's law – statement, Applications. Colligative properties– Definition, Relative lowering of vapour pressure. Raoult's law of relative lowering of vapour pressure, Osmosis- preparation of copper ferrocyanide semi permeable membrane,

Osmotic pressure – measurement by Berkley – Hartley method. Theory of dilute solutions – Laws of osmotic pressure - Van't Hoff Boyle's law, Van't Hoff Charles' law and Avogadro's law. Hypo-, hyper- and isotonic solutions. Donnan membrane equilibrium and its applications. Elevation in boiling point, ebullioscopic constant. Depression in freezing point, cryoscopic constant. Limitations of colligative properties. Abnormal molecular weights and the van't Hoff factor – degree of association, Degree of dissociation

Simple problems related to the above topics (self-study)

9h

Acids, Bases and Buffers: To understand how the pH is maintained in the living system a basic knowledge of acids, bases and buffers is essential. In this unit students will be exposed to these fundamentals that will help them analyse and appreciate the need to maintain pH in the living system.

Modern concepts of acids and bases - Arrhenius, Lowry - Bronsted and Lewis concepts. Limitations of each concept.

Strong and weak acids - ionisation constant K_a and pK_a of weak acids, comparison of acid strength on this basis,

Ionic product of water, common ion effect, solubility product and ionic product of sparingly soluble salts and conditions for precipitation. and in qualitative analysis –in prediction of selective precipitation of second and forth group basic radicals, precipitation of third group basic radicals.

Hydrolysis of salts– pH of salt solutions. Hydrogen ion concentration- pH, pH of some biological fluids and its importance (self-study).

Buffers-definition, types, buffer action and buffer capacity. pH of buffers-Henderson– Hasselbalch equation-derivation, preparation of buffers, problems. Biological buffers (self-study)

10 h

Electrochemistry: Most reactions occurring in the living system are redox reactions. The basics of electrochemistry will act as the foundation for understanding these reactions.

Strong and weak electrolytes – definition and examples (self-study).

Activity and activity coefficient – concepts. Activity and mean activity of the electrolyte. Mean ionic activity. Ionic strength- classification of electrolytes as 1:1, 2:2, 2:1 electrolytes with examples.

Electrochemical cells: conventions of representing galvanic cells, half-cell reactions and cell reaction;

Reversible electrodes and cells – definition. Types - Cation reversible electrode, anion reversible electrode, redox electrode. (Examples and electrode reactions to be given)

Single electrode potential – Nernst equation, Factors affecting single electrode potential.

Standard Electrode Potential (definition). Reference electrodes – primary reference (Standard hydrogen electrode), secondary reference electrodes (calomel, quinhydrone and glass electrodes).

Electrochemical series- to predict the ease of oxidation, displacement reaction to calculate standard emf of cell; Ion selective electrodes- concept, types and applications.

10 h

References

1. General Chemistry: The essential concepts by Raymond Chang and Jason Overby 6th Edition (Indian). Publishers: University Science Books
2. Physical Chemistry for biosciences 11th edition by Raymond Chang Publishers: University Science Books
3. Physical chemistry for biologists by Peter Atkins and Julio de Paula, 2nd Edition Publishers: W. H Freeman & Co.
4. Principles of Inorganic Chemistry by Puri, Sharma and Kalia Publishers : Vishal Publishers
5. Principles of Physical Chemistry by Puri, Sharma and Pathania Publishers : Vishal Publishers

BLUEPRINT

Code number: **BCH 121**

Title of the paper: **Inorganic and Physical Chemistry**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Atomic Structure	10	14
Chemical Bonding	15	20
Liquids	6	8
Solutions and Colligative properties	9	12
Acids bases and Buffers	10	14
Electrochemistry	10	14
TOTAL	60	82
Maximum marks for the paper (Excluding bonus question)= 60		

Practical I

BCH 1P₁ – Volumetric analysis

(11 sessions 3h/week + 1 h/week self-study)

Course Objectives: At the end of this course students should be able to have developed the right techniques required to carry out volumetric analysis. They should be able to design new experiments and understand how to represent the results they obtain. Importantly they would have acquired team spirit and the ability to work in groups.

Course Content:

Errors & Standard Deviation: Exponential notation – expression of a large number in an exponential form; purposes, positive and negative powers of 10.

Graphical representation of data – Types of graphs, Advantages of showing data in graphical form.

Calibration of glass ware; Introduction to Volumetric Analysis-Estimation of NaOH using Std. HCl

Introduction to RBPT

Estimation of HCl using Std. Na₂CO₃

Redox Titration KMnO₄ with Oxalic acid

Define RBPT problem

Complexometric titration: Estimation of Zn²⁺ using EDTA

Preparation of RBPT CHARTS.

Presentation of the charts by each group.

Discussion of materials required.

Preparation of solutions

Standardize / check solutions

Do the main experiments individually

- 1) Preparation of poster
- 2) Presentation of results through posters

Repetition

Viva

Course Outcomes: At the end of the course, the student should

CO1	Knowledge	Have developed a good knowledge of basic inorganic and physical chemistry.
CO1	Understand	Have developed a very good understanding of the concepts in basic inorganic and physical chemistry.
CO1	Apply	Be able to apply their knowledge and understanding by working out problems and becoming self-sufficient in the application of the concepts.
CO1	Analyze	Be able to work out problems and analyse results with aplomb.
CO1	Evaluate	Be able to critically evaluate what they have studied and extend their knowledge to related issues
CO1	Create	Be able to work in teams to design experiments that would illustrate the concepts they have studied

Semester	II
Paper Code	BCH 221
Paper Title	Physical and Organic Chemistry
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objectives of the paper:

In this paper students learn basic concepts in physical chemistry required to understand biological world. They will appreciate the fact that all physical and chemical properties of molecules are the same whether it is in the test tube or in the living cell. They will be introduced to organic chemistry and the fundamental concepts that are applicable both *in vitro* and *in vivo*

Biochemical Thermodynamics: Students will be able to understand the basics of the flow of heat and how it is crucial for the survival of living things.

Self-study: System, surrounding, work and heat- Exothermic and Endothermic reactions. Work done in reversible isothermal expansion- state function and path function-first law of thermodynamics. Entropy- Gibbs free energy-spontaneity of a physical and chemical process.

Energy conversion in living organisms- metabolism and catabolism- Internal energy and enthalpy- measurement of heat-heat capacity- temperature variation of enthalpy.

Enthalpy of phase transition-differential scanning calorimeter for the determination of phase transitions of biological macromolecules

Calculation of ΔH^0 of a reaction using bond enthalpies -enthalpy of combustion-biofuels-enthalpy of formation-Isothermal Titration Calorimetry (ITC) in drug design.

Entropy- the direction of spontaneous change-Second law of thermodynamics-Entropy change accompanying heating and phase transition -problems-entropy change on surroundings

Gibbs energy and spontaneity -structure of proteins and biological membranes-hydrophobic interaction- thermodynamic factors that contribute to the spontaneous assembly of biological macromolecules

Gibbs energy change and equilibrium constant (mathematical relation and numericals)

Assignment Topic: Thermodynamics of nitrogen fixation

6 h

Chemical Equilibrium: In this unit students will be able to learn and appreciate chemical reactions and the laws that dictate whether a reaction can occur or not. They will be able to comprehend the various parameters that govern a reaction.

Self study: Reversible reactions with examples. Law of mass action, Chemical equilibrium – definition and characteristics. Homogeneous and heterogeneous systems with examples. Le Chatelier’s principle.

Variation of $\Delta_r G$ with composition in a reaction- Mathematical relation between free energy change and equilibrium constant-numericals-Thermodynamic criteria for spontaneity

Binding of oxygen at hemoglobin and myoglobin- standard reaction Gibbs energy- Calculation of standard Gibbs energy of reaction from standard Gibbs energy of reaction-numericals

Standard Gibbs energies of formation of compounds and their thermodynamic stability endergonic compounds-Effect of catalyst and temperature on equilibrium constant-thermodynamic and biological standard state.

Assignment Topic: ATP and its role in biosynthesis

3 h

The Kinetics of Life Processes: Students will be able to understand how reactions proceed and how this understanding leads to proposing mechanisms by which reactions take place.

Differential rate law-rate law and rate constant -reaction order-determination of rate law (isolation method).

Integrated rate law- first order (no derivation) - half-life period-numericals on half-life period

Pharmacokinetic analysis- rate constant for second order reaction- determination of rate constant by graphical method.

The temperature dependence of reaction rates- The Arrhenius equation-Determination of Arrhenius parameters-numericals

Assignment Topic: Enzyme mechanisms

6 h

Phase rule: This unit strives to illustrate how phases coexist. This will help students to appreciate the coexistence of polar and non-polar substances that go to making up the living system

Definitions of Phase & Components, Criterion of phase equilibrium, Gibb's phase rule (no derivation) .

Application of phase rule to one component system –water system, Two component system-water-potassium iodide (freezing mixtures). Solutions of liquids in liquids– ideal solutions and Raoult's and Henry's law. Non-ideal solutions-vapour pressure-composition and temperature-composition curves of

ideal and non-ideal solutions- azeotropes –HCl - H₂O and water-ethanol system. Distillation of solutions-Lever rule. Partial miscibility of liquids (Water – Phenol). Critical Solution Temperature (lower and upper). Effect of impurity on CST. Immiscibility of liquids. Principle of steam distillation. Nernst distribution law- statement, deviations from distribution law due to association and dissociation of the solute in one of the solvents. Applications of distribution law– solvent extraction.

10 h

Colloids

Types of colloidal systems, electrical properties of colloids. Emulsions and emulsifiers; Gels; *Applications of emulsions in lipid chemistry (self-study).*

2 h

Introduction to Organic Chemistry: Students will be introduced to the compounds of carbon that occur naturally. They will correlate what they have studied in earlier units of both first and second semester with the study of carbon compounds.

Structural formulas: dash, condensed and bond-line formulas.

Resonance theory, curved arrows in resonance structures, rules for writing resonance structures, resonance contribution.

Physical properties and molecular structures of organic compounds, ionic compounds: ion – ion forces, intermolecular forces (van der Waals forces), boiling points, solubilities.

Use of curved arrows in illustrating reactions,

Heterolysis of bonds: carbocations and carbanions, electrophiles and nucleophiles,

Strengths of Bronsted-Lowry acids and bases; the acidity constant K_a ; acidity and pK_a ; predicting the strength of bases,

Relationship between structure and acidity. Effect of hybridization, inductive effect and delocalization on acidity:

carboxylic acids versus alcohols.

Comparisons of conjugate acid–base strengths based on inductive effects of other functional groups.

Effect of Solvents on acidity.

Organic compounds as bases

Self-study: Functional groups: alkyl halides, alcohols, phenols, ethers, amines, aldehydes and ketones, carboxylic acids, esters, amides and nitriles, end chapter problems.

7 h

Alkanes: Students will obtain a general idea of the simplest of hydrocarbons that form an important structural backbone for all other carbon compounds. They will appreciate the correlation between structure and the properties of molecules.

IUPAC nomenclature of alkanes; branched alkanes; cycloalkanes. alkyl halides, alcohols, alkenes, cycloalkenes and alkynes

Physical properties of alkanes;

Conformations- Newman projection and sawhorse formula.

Conformational analysis of ethane; butane.

Relative stabilities of cycloalkanes-ring strain. Conformations of cyclohexane. Axial and equatorial bonds of cyclohexane. Monosubstituted cyclohexane

8h

Stereochemistry: Students will understand how molecules are oriented in space. They will learn that biomolecules are stereospecific and how one stereoisomer differs from the other.

Enantiomers and chiral molecules; molecules with one chiral centre;

Test for chirality: plane of symmetry;

Naming enantiomers in the R, S- system. D,L system of nomenclature.

Optical activity. Molecules with more than one chiral centre. Fischer projection formula.

Separation of enantiomers, resolution.

Significance of Chirality in biological system.

8 h

Alkyl Halides: In this unit students will be introduced to reaction mechanisms. They will get a fundamental understanding of how reactions take place. They will be able to later correlate these fundamentals with reactions that occur in the living system.

Alkyl halides nomenclature (revise); Nucleophilic substitution reaction, Kinetics of SN_2 reaction, mechanism and stereochemistry of SN_2 reaction. Kinetics of SN_1 reaction, mechanism and stereochemistry of SN_1 reaction. Carbocations structure and stability. Racemisation. Factors affecting SN_1 and SN_2 reactions. Elimination reactions of alkyl halides. The E_2 and E_1 reaction mechanisms. Substitution versus elimination.

10 h

References

1. Organic Chemistry by T. W. Graham Solomons et al 11th edition. Publishers:Wiley Student Edition
2. Organic Chemistry by Paula Bruice 6th edition Publishers: Pearson
3. Organic Chemistry by Morrison and Boyd 7th edition Publishers: Prentice Hall
4. Principles of Physical Chemistry by Puri, Sharma and Pathania Publishers : Vishal Publishers
5. Physical Chemistry for biosciences by Raymond Chang 11th edition Publishers: University Science Books
6. Physical chemistry for biologists by Peter Atkins and Julio de Paula, 2nd Edition Publishers: W. H Freeman & Co.

BLUEPRINTCode number: **BCH 221**Title of the paper: **Physical and Organic Chemistry**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Biochemical thermodynamics	6	8
Chemical Equilibrium	3	4
Kinetics of life processes	6	8
Phase rule	10	14
Colloids	2	3
Introduction to Organic chemistry	7	10
Alkanes	8	10
Stereochemistry	8	11
Alkyl halides	10	14
TOTAL	60	82
Maximum marks for the paper (Excluding bonus question)= 60		

Practical II

BCH 2P₁ – Physical Chemistry Practical

(11 sessions 3h/week + 1h/week self-study)

Course Objectives:

This course aims to make students learn how various physical parameters can be determined. By the end of this course students should be able to critically analyse and execute experimental techniques on all the theoretical concepts they have imbibed in the theory papers of the first two semesters. They would have learnt to survey literature and work as a team to ask questions and find solutions to the same using the experimental techniques they have learnt.

Course Content:

1. Determination of density and viscosity of a given liquid using Ostwald's viscometer.
2. Determination of percentage composition of a binary mixture by viscosity method.
3. Determination of density and surface tension of a given liquid using a stalagmometer.
4. Determination of standard electrode potential.
5. Potentiometric estimation of FAS
6. Determination of pK_a of a weak acid
7. Molar conductance of electrolytes.
8. Enthalpy of fuels
9. Any other suitable experiment.
10. RBPT
11. Viva

Course Outcomes: At the end of the course, the student should

CO2	Knowledge	Have developed both a theoretical and an experimental knowledge of physical chemistry. They would have learnt the fundamentals of organic chemistry.
CO2	Understand	Have developed a very good understanding of the concepts in physical and organic chemistry.
CO2	Apply	Be able to apply their knowledge and understanding by working out problems and becoming self-sufficient in the application of the concepts.
CO2	Analyze	Be able to work out mechanisms of reactions and analyse results..
CO2	Evaluate	Be able to critically evaluate what they have studied and assess to what extent they are capable of independent research.
CO2	Create	Be able to work in teams to design experiments that would illustrate the concepts they have studied.

Semester	III
Paper Code	BCH 322
Paper Title	Inorganic and Organic Chemistry
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objectives of the paper: In this section students will be exposed to the role of metals not only in the living system but also the harmful effects of the environment on the living system. They will learn about the various families of carbon compounds. They will understand how the functional groups in a molecule dictate their properties and thereby their functions.

Course Content:

Chemistry of coordination compounds:

This unit focusses on the properties of metal ions especially transition elements. The multiple stable oxidation states, the spin states etc of these metal ions and how they form coordinate bonds is the main thrust of this unit. This will help understand their role in the biological system.

Basic definitions: Coordinate bond, coordination complex, central metal atom/ion, oxidation number, ligands, donor atom, coordination number. -Classification of ligands with example. Isomerism in coordination complexes - Magnetism and colour in coordination complexes - shape of d subshell - crystal field theory - octahedral - tetrahedral and square planar complexes - calculation of crystal field splitting energy - spectrochemical series - high spin and low spin complexes.

Role of iron in myoglobin, haemoglobin and cytochromes; Copper in haemocyanin, Magnesium in chlorophyll, Cobalt in vitamin B-12 and Molybdenum in nitrogenase; Metalloenzymes: examples of metals as coenzymes and the role they play with special reference to carbonic anhydrase and carboxypeptidase A.

12 h

Alkenes and Alkynes: Students will learn the stereochemistry of the unsaturated carbon bonds and understand the various reactions these unsaturated hydrocarbons can undergo.

Alkenes and alkynes nomenclature. E, Z system of designating alkene, diastereomers; relative stabilities of alkenes; Electrophilic addition of HX to alkenes: mechanism; Markovnikov's rule.

Acid catalysed hydration of alkenes; Oxidative cleavage of alkenes.

1,3-butadiene; stability of conjugated dienes; 1,4 addition, kinetic vs thermodynamic control. Diels Alder reaction. Acidity of terminal alkynes and their utility as nucleophiles in C-C bond formation.

10 h

Alcohols, ethers and epoxides: Students will learn the reactions of oxygen bonded in different ways to the carbon atom and how this influences the type of reaction the molecule undergoes.

Nomenclature; Classification-examples of monohydric, dihydric and trihydric alcohols. Alcohols as acids; Reactions of alcohols with HX; PBr_3 ; SOCl_2 . Intermolecular dehydration of alcohols; The Williamson ether synthesis. Ether cleavage using strong acids. Synthesis of epoxides (mechanism excluded); Reactions of epoxides: acid and base catalysed ring opening of unsymmetrical epoxides, regioselectivity – examples

4 h

Organometallic compounds: In this unit students will learn the versatility of organometallic compounds and the rich contribution they have made in the synthesis of organic compounds.

Preparation of organolithium and organomagnesium compounds. The Grignard reaction. Reactions of organolithium and organomagnesium compounds with compounds containing acidic hydrogen; epoxides. Alcohols from Grignard reagents.

3 h

Aromatic hydrocarbons: Aromatic hydrocarbons and heterocyclic molecules abound in nature. This unit sets the foundation to our understanding of biomolecules that possess these features.

Modern theories of the structure of benzene. Huckel rule; aromatic, antiaromatic and nonaromatic species in benzenoid and heterocyclic systems (5 and 6 membered rings with examples from biological systems). General mechanism of electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel-Crafts acylation and alkylation). Influence of substituents (alkyl; -OH, halogen and nitro) on the reactivity of the ring and the orientation of the incoming electrophile. Acidity of phenols. Kolbe reaction and Reimer Tiemann reaction

10 h

Aldehydes and ketones: The polarity of the carbonyl compounds plays a crucial role in intermediary metabolism, hence a preliminary understanding of these compounds and the manner in which they react will help students understand important biochemical reactions at a later stage.

Synthesis of aldehydes by the oxidation of primary alcohols and by the reduction of acyl chloride, esters and nitriles.

Synthesis of ketones by ozonolysis, oxidation of secondary alcohols, Friedel Craft's reaction and using Grignard reagent.

Nucleophilic addition to carbonyl compounds: mechanism of addition using strong nucleophiles and acid catalyzed nucleophilic addition. Relative reactivity of aldehydes and ketones.

Addition of alcohols - hemiacetals and acetals, mechanism of acid-catalysed acetal formation.

Addition of amines (primary and secondary amines, hydrazine and hydroxylamine).

Addition of HCN - mechanism. Wittig reaction (no mechanism, few examples).

Oxidation of aldehydes and ketones; acidity of α -hydrogen, enolate ion.

Keto enol tautomerism; Base-catalysed aldol reaction, dehydration of aldol product (mechanism of both), crossed aldol reactions.

Claisen-Schmidt reaction (mechanism excluded). Addition to α , β -unsaturated aldehydes and ketones (mechanism excluded). Michael addition (mechanism excluded)

10 h

Carboxylic acids: Organic acids play a pivotal role in the living system existing as anions at neutral pH and thereby forming salts of the acids with the abundant Na⁺, K⁺ and most especially Ca²⁺ ions, which are soluble in an aqueous environment. Hence this unit will help set the foundation to understanding the important contribution of organic acids in the living system.

Preparation of carboxylic acids by the oxidation of aldehydes and primary alcohols; hydrolysis of cyanohydrins, nitriles; and by carbonation of Grignard reagents.

Nucleophilic substitution at the carboxylic carbon - general mechanism.

Relative reactivity of acid derivatives.

β- dicarbonyl compounds: acidity, Claisen condensation with mechanism, crossed Claisen condensation.

Acetoacetic ester synthesis – alkylation and acylation. Malonic ester synthesis – alkylation.

7 h

Amines: The most important class of biomolecules are proteins which in turn are made of amino acids, there are also a large group of physiologically important amines that have far reaching effects. Hence it is important to understand these properties of these molecules for a better understanding of their role in the biological system.

Basicity of amines, comparison of basicity of 1^o, 2^o and 3^o amines in vapour and solution phase, basicity of arylamines.

Preparation of amines by alkylation of ammonia; Gabriel synthesis; reductive amination; reduction of nitro compounds, nitriles, oximes and amides; Hofmann's rearrangement.

Action of nitrous acid on 1^o, 2^o and 3^o amines. Replacement reactions and coupling reactions of arenediazonium salts. Hofmann elimination.

4 h

References

1. Organic Chemistry by T. W. Graham Solomons et al 11th edition. Publishers: Wiley Student Edition
2. Organic Chemistry by Paula Bruice 6th edition Publishers: Pearson
3. Organic Chemistry by Morrison and Boyd 7th edition Publishers: Prentice Hall
4. Environmental Chemistry by A. K. De 8th Edition Publishers: New Age International (P) Limited.
5. Concise inorganic Chemistry by J. D. Lee 5th Edition Publishers: Oxford Publications

BLUEPRINT

Code number: **BCH 322**

Title of the paper: **Inorganic and Organic Chemistry**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Chemistry of coordination compounds	12	16
Alkenes and Alkynes	10	14
Alcohols, ethers and epoxides	4	5
Aldehydes and ketones	10	14
Organometallic compounds	3	4
Aromatic hydrocarbons	10	14
Carboxylic acids	7	10
Amines	4	5
TOTAL	60	82
Maximum marks for the paper (Excluding bonus question)= 60		

Practical III

BCH 3P₁ – Organic synthesis, purification and characterization

(11 sessions 3h/week + 1 h/ week self-study)

Course objectives:

Develop skills to prepare useful organic compounds in the laboratory.

Analyse common organic reagents and compounds based on their properties.

Apply the properties of functional groups of organic compounds to carry out selective organic reactions.

Verify reactivity of organic functional groups.

Course content:

- Purification and separation of organic compounds
- Recrystallisation and melting point/boiling point determination of organic compounds
- Preparation, recrystallisation and characterization of acetanilide from aniline
- Preparation, recrystallisation and characterization of tribromophenol from phenol
- Preparation, recrystallisation and characterization of benzoic acid from methyl benzoate
- Preparation, recrystallisation and characterization of benzoic acid from benzaldehyde.
- Preparation and characterization of methylacetate from methanol and acetic acid.
- Extraction of caffeine from tea leaves
- Purification by sublimation of caffeine.
- Characterisation of functional groups in reactants and products of all the above synthesized organic molecules.
- Viva

Note: Students will do a complete qualitative organic analysis of reactants and products, after they have synthesized the molecules. The reactions have been chosen such that either the reactants or the products belong to one of the organic groups based on solubility. They will determine the m.p/b.p of the reactants and products and also carry out the organic reactions that will help them classify the molecules according to their groups.

Course Outcomes: At the end of the course, the student should

CO3	Knowledge	Have developed both a theoretical and an experimental knowledge of organic chemistry. They would have learnt about the role of metals in the biological system. They would gain knowledge about the toxic effects of heavy metals and organic compounds to the living system.
CO3	Understand	Have developed a very good understanding of the way molecules are synthesized and purified chemistry.
CO3	Apply	Be able to apply their knowledge and understanding to developing better methods for synthesis and purification of organic compounds.
CO3	Analyze	Be able to work out mechanisms of reactions and analyse results.
CO3	Evaluate	Be able to critically evaluate the quality of the products prepared and correlate it with the theoretical aspects of the subject they have studied.
CO3	Create	Be able to develop strategies for the synthesis of new compounds and for the analysis of molecules in the environment.

Semester	IV
Paper Code	BCH 422
Paper Title	Biomolecules and analytical techniques in biochemistry - 1
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objectives of the paper:

This paper aims to introduce students to elements, molecules and macromolecules that make up the living system. They will also be exposed to basic analytical techniques which will help them in future to analyse structure function relationships of molecules.

Course Content:

Introduction to biochemistry:

Understanding how life evolved: - insights from the big bang theory to life on earth in order to create scientific interest amongst students in life processes. Special focus on the scientists who have contributed to our understanding.

1h

Fundamental properties of elements, their role in formation of biomolecules and in chemical reactions within living organisms.

2h

Unique property of water as a universal solvent and its importance in biological system.

1h

Biomolecules: To understand the structure and properties of:

Carbohydrates: - anomeric carbon atom, with an example of triose, pentose and hexose sugar. Structure of glucose, fructose, galactose, amino sugars and acid sugars, Classification of polysaccharides (based on composition and function)– homopolysaccharides (starch, glycogen, cellulose, chitin) heteropolysaccharides (hyaluronic acid, chondroitin sulphate and heparin). Partial structures and hydrolysis products. Biological role. Glycoproteins and glycolipids and their importance in biological systems.

7 h

Proteins: - Amino acids – classification and structure based on nature of R group at pH 6.5. Biological role. Properties -reactions of amino group and carboxylic group. Isoelectric pH (pI) and concept of zwitterion, determination of pI for different types of amino acids.

Peptides – understanding the peptide bond, examples of naming peptides. Self-study Function of some biologically important peptides – insulin, vasopressin, bradykinin, and some antibiotics.

Proteins – classification based on (i) structure – fibrous, globular and transmembrane (ii) composition – simple and conjugate proteins (iii) function with appropriate examples. Structural analysis of proteins –

primary –importance of knowing the amino acid sequence, a discussion of the types of bonds seen in the construction of the primary structure; secondary – peptide bond and the formation of hydrogen bonds leading to ordered regular structures like α -helix and β -pleated sheets ((schematic diagram)). How these two types of secondary structure differ from each other. Tertiary structure – brief discussion of the intermolecular forces due to the presence of the side chain of amino acids. Quaternary structure – types of forces existing between different monomeric units in a quaternary structure Understanding protein architecture using haemoglobin as example.

8h

Lipids: - Classification and general role in biological systems. Fatty acids – structure of C16 (palmitic acid) and C18 (stearic acid) saturated fatty acids and C18 (oleic, linoleic and linolenic acids) and C24 (arachidonic acid) unsaturated fatty acids. Triglycerides – structure of simple and mixed; Structure and function of cholesterol. Reactions of triglycerides: - saponification number and iodine number. Rancidity – causes and prevention.

4h

Solids and X-ray crystallography:

In this unit students will learn about crystalline solids and how their structure can be determined using x-ray crystallography.

Types-Crystalline and Amorphous. Size and Shapes (self-study).

Definition of Space Lattice and Unit cell.

Symmetry elements in crystals.

Laws of Crystallography, Weiss and Miller Indices with simple numericals.

Seven Crystal systems: - names and dimensions.

Defects in crystalline solids – Schotky & Frenkel defects.

Study of crystal structures of NaCl and KCl using X-ray diffraction. Advantages and disadvantages of studying the structure of biomolecules by X-ray crystallography.

10 h

Photochemistry:

Many biomolecules are inherently chemiluminescent. To exploit this fact and develop techniques around it to study biomolecules and processes within a cell a basic understanding of the principles of photochemistry are imparted in this unit.

Fundamental laws relating to photochemistry. Chemiluminescence; Bioluminescence; Photocatalysis and photochemical reactions.

3 h

Spectroscopy – Theoretical aspects:

Ever since the discovery of the hydrogen spectrum the different wavelengths of light have been exploited to study molecular structure. This unit gives the student the fundamentals behind the use of electromagnetic radiation in studying molecular structure.

Electromagnetic radiation (EMR) - Characteristics – Frequency, wavelength and wave number and mathematical expressions connecting them. Types of Spectra: (Atomic and molecular). Absorption and

emission spectra: continuous, band and line. Regions of electromagnetic spectrum.

3 h

UV spectroscopy:

Types of electronic transitions in organic molecules, meaning of λ_{\max} , ϵ and A , observed transitions in a typical UV-vis spectrum, effect of conjugation on λ_{\max} .

Spectrophotometry including ELISA and their applications in biological investigations / experiments.

4h

Infrared (IR) spectroscopy:

Infrared (IR) spectroscopy as an instrumental method for detecting functional groups,

Interpreting IR spectra, IR spectra of hydrocarbons and some functional groups containing heteroatoms.

Raman effect and its applications to be done in brief.

4 h

NMR spectroscopy:

Nuclear spin, origin of the signal; chemical shift, shielding and deshielding of protons, equivalent and non-equivalent protons; integration of signal areas; signal splitting; spin-spin coupling (effect of coupling constant excluded). Interpretation of NMR spectra. Proton NMR and rate processes. Problems combining UV, IR and NMR techniques.

8 h

Mass Spectrometry:

Basic principles of mass spectrometry and tandem mass spectrometry –soft ionization techniques – applications of MALDI and SELDI for understanding biomolecules.

Self Study: Analysis of different types of spectra and identification of simple compounds.

5 h

References:

1. Introduction to Spectroscopy Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan 5th Edition Publishers: Cengage learning.
2. An Introduction to X-ray crystallography M Woolfson 2nd Edition Publishers: Cambridge University Press
3. Organic Chemistry by T. W. Graham Solomons et al 11th edition. Publishers: Wiley Student Edition
4. Organic Chemistry by Paula Bruice 6th edition Publishers: Pearson
5. Organic Chemistry by Morrison and Boyd 7th edition Publishers: Prentice Hall
6. Biochemistry R. Garrett and C. Grisham 6th Edition Publishers: Brooks/Cole
7. Lehninger Principles of Biochemistry D.Nelson and M. Cox 8th edition Publishers: Macmillan and Co.
8. Fundamentals of Biochemistry: Life at the Molecular Level, Donald Voet, Judith G. Voet, Charlotte W. Pratt 5th Edition Publishers: Wiley

BLUEPRINT

Code number: **BCH 422**

Title of the paper: **Biomolecules and Analytical techniques in Biochemistry - 1**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Introduction to biochemistry	4	5
Carbohydrates	7	10
Proteins	8	11
Lipids	4	5
Solids and X-ray crystallography	10	14
Photochemistry	3	5
Spectroscopy – theoretical aspects	3	4
UV Spectroscopy	4	5
IR spectroscopy	4	5
NMR Spectroscopy	8	11
Mass spectrometry	5	7
TOTAL	60	82
Maximum marks for the paper (Excluding bonus question)= 60		

Practical IV

BCH 4P₁ – Separation, isolation and characterization of biomolecules
(11 sessions 3h/week +1h/week self-study)

Course objectives:

Students will be introduced to the 30 basic molecules that constitute life.

The students will obtain hands-on training in basic separation techniques in biochemistry like electrophoresis, chromatography, etc.

Gain expertise in the isolation and characterization of various biomolecules

Course content:

- Brief introduction to biomolecules – their structure and properties
- Separation of plant pigments using paper chromatography.
- Separation of plant pigments by column chromatography using silica gel-G.
- TLC of amino acids.
- SDS-PAGE
- Identification of functional groups by qualitative tests of biomolecules

- Identification of functional groups by IR spectroscopy
- Determination of amount of reducing sugar by DNS method
- Estimation of amino acids by Cd-Ninhydrin method
- Estimation of RNA by orcinol method
- Estimation of DNA by diphenylamine method
- Viva

Course Outcomes: At the end of the course, the student should

CO4	Knowledge	Have developed both a theoretical and an experimental knowledge of analytical chemistry.
CO4	Understand	Have developed a very good understanding of techniques used to determine the structure of molecules.
CO4	Apply	Be able to understand how to read spectral data and understand electron density maps .
CO4	Analyze	Be able to analyse spectral data and assign spectral lines to structural features of a molecule.
CO4	Evaluate	Be able to critically evaluate the molecule under investigation and decide if it has been purified from the quality of the .spectral analysis
CO4	Create	Be able to develop strategies for studying and understanding the structure of molecules and extend it to biomolecules.

**The Proposed question paper pattern for the
End Semester Examinations (Theory) for the batches starting from 2022-23
Department of Biochemistry - DISCIPLINE CORE**

Time : 2 hrs

Maximum marks 60

Part A: 1 mark questions (11 out of 13)

Part B 2 mark questions (8 out of 10)

Part C: 3 mark questions (6 out of 8)

Part D: 5 mark questions (analytical/thinking type) [3 out of 5]

**The Proposed question paper pattern for the
Mid Semester Test (Theory) for the batches starting from 2022-23
Department of Biochemistry - DISCIPLINE CORE**

Time : 60 MINUTES

Maximum marks 25

Part A: 1 mark questions (5 out of 7)

Part B 2 mark questions (3 out of 5)

Part C: 3 mark questions (3 out of 5)

Part D: 5 mark questions (analytical/thinking type) [1 out of 2]

**The Proposed question paper pattern for the
End Semester Examinations for the batches starting from 2022-23
Department of Biochemistry - OPEN ELECTIVE**

Time : 90 MINUTES

Maximum marks 50

Short answer (1 or 2 marks)

Part A: 1 mark questions: 20 out of 22 questions

Part B: 2 mark questions: 15 out of 17 questions

Total marks: 50 (with choice) 56 (without choice)

**The Proposed question paper pattern for the
Mid Semester Test for the batches starting from 2022-23
Department of Biochemistry - OPEN ELECTIVE**

Time : 30 MINUTES

Maximum marks 25

MCQ test

**The Proposed question paper pattern for the
Practical assessment for the batches starting from 2022-23
Department of Biochemistry – DISCIPLINE CORE**

Total number of classes: 12

Practical Internal assessment: 50 marks

Part A: Continuous assessment of each practical class based on skill, reporting of experiment, documenting of results and understanding the experiment (includes calculations etc): 35 marks

Part B: Oral Viva: 15 marks (To be notified and considered as the end semester examination)

Mapping OF Mission statements with Program Educational Objectives

Mission Statements	PEO1	PEO2	PEO3	PEO4	PEO5
M1					
M2					
M3					
M4					

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

Mapping of PEOs with POs

PEOs/POs	PO1	PO2	PO3	PO4	PO5
PEO1					
PEO2					
PEO3					
PEO4					
PEO5					

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

Mapping of PEOs with PSOs

PEOs/POs	PSO1	PSO2	PSO3	PSO4	PSO5
PEO1					
PEO2					
PEO3					
PEO4					
PEO5					

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

Mapping of Course Outcomes to Program Outcomes

PEOs/POs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1					
CO2					
CO3					
CO4					
CO5					
CO6					

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

NOTE : Mapping of Course Outcomes to Program Learning Outcomes is written after every course