ST. JOSEPH'S UNIVERSITY

BENGALURU-27

DEPARTMENT OF BIOCHEMISTRY

SYLLABUS FOR UNDERGRADUATE PROGRAMME
(SEP)
The syllabus for semesters 1 to 4 have been passed in the BoS meeting. Syllabus for other semesters are provisional and require BoS approval in the near future

For Batch 2024-2027

FOREWORD

Board of Studies

The I and II semester biochemistry syllabus for the batch **2024-2027** under the SEP was **approved** by the board of studies at the BOS meeting held on 27th July 2024. Syllabus of semesters III and IV were approved on the BOS meeting held on 7th Feb 2025. The subsequent semesters will be deliberated and approved in subsequent meetings.

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.
8. Dr. Sangita Das, 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 many 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. Drubojyothi 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

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Part A			
1	Title of the Academic Program	BSc Biochemistry, Zoology, Biology, Microbiology, Biotechnology.	
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	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	● 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	

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.

- **Guidelines for the PEOs**
  - 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. • **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.

Programme Specific Outcomes: PSOs are statements that describe what the graduates of a specific educational Programme should be able to do.

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

- **Guidelines for the PSOs**
  - 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. Biochemistry Curriculum

Courses and course completion requirements	No. of credits
General English	
Second language: Introductory Kannada/Kannada/ Hindi/ Sanskrit/ Tamil/ Additional English/French/German.	
Biochemistry	
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	

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-124	Introduction to biochemistry - 1	45	03	03	40	60	100
Practical	BCH-1P1	Stoichiometry and Volumetric Analysis	44	4	02	50	nil	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-224	Introduction to biochemistry - 2	45	03	03	40	60	100
Practical	BCH-2P1	Physical Chemistry for biologists	44	4	02	50	nil	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-325	Introduction to biochemistry - 3	45	03	03	40	60	100
Practical	BCH-3P1	Organic synthesis, purification and characterisation	44	04	02	50	nil	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-425	Introduction to biochemistry - 4	45	03	03	40	60	100
Practical	BCH-4P1	Separation, isolation and characterization of biomolecules	44	04	02	50	nil	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-5126	Enzymology, membrane and nucleic acid chemistry	45	03	03	40	60	100
Practical	BCH-5P1	Enzymology and nucleic acid chemistry	44	04	02	50	nil	50
Theory	BCH-5226	Analytical techniques in Biochemistry	45	03	03	40	60	100
Practical	BCH-5P2	Project work –I*	44	04	02	50	-	50*
Theory	BCH -5326	Spectroscopy; spectrometry Hormones and neurotransmitters	45	03	03	40	60	100
Practical	BCH-5P3	Separation techniques and estimation of food quality	44	04	02	50	nil	50
Total Number of credits:					08			
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-6126	Bioenergetics and biological oxidation	45	03	03	40	60	100
Practical	BCH-6P1	Bioenergetics and biological oxidation	44	03	02	50	nil	50
Theory	BCH-6226	Metabolism	45	03	03	40	60	100
Practical	BCH-6P2	Project work – II*	44	03	02	50		50*
Theory	BCH-6326	Recent developments in the field of Biochemistry	45	03	03	40	60	100
Practical	BCH-6P3	Practical bioinformatics	44	03	02	50		50*
Total Number of credits:					15			

CORE COURSES (CC)	
Course Title	Code Number
Introduction to biochemistry - 1	BCH-124
Introduction to biochemistry - 2	BCH-224
Introduction to biochemistry - 3	BCH-325
Introduction to biochemistry - 4	BCH-425
Enzymology, membrane and nucleic acid chemistry	BCH-5126
Analytical techniques in Biochemistry	BCH-5226
Spectroscopy, spectrometry; Hormones and neurotransmitters	BCH-5326
Bioenergetics and biological oxidation,	BCH-6126
Metabolism	BCH6226

Recent developments in the field of Biochemistry	BCH-6326
Stoichiometry and Volumetric Analysis	BCH-1P1
Physical chemistry for biologists	BCH-2P1
Organic synthesis, separation, purification and identification of groups	BCH-3P1
Separation, isolation and characterization of biomolecules	BCH-4P1
Enzymology and nucleic acid chemistry	BCH-5P1
Project Work – I	BCH-5P2
Separation techniques and estimation of food quality	BCH-5P3
Bioenergetics and biological oxidation	BCH – 6P1
Project Work –II	BCH – 6P2
Practical bioinformatics	BCH – 6P3

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 - 1	BCHOE-1
We are what we eat	BCHOE - 2
Drugs, toxins and poisons – uses and abuses	BCHOE -3
Introduction to Forensic Science - 2	BCHOE-4

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 124**
Paper Title	**Introduction to biochemistry - 1**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper:

This paper introduces the students to basic concepts in inorganic and physical chemistry required to understand biochemistry. 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:

UNIT 1: Atomic structure, periodic table and an introduction to biochemistry (6h): In this unit students will study the fundamentals of atomic structure that will help them conceptualize how an atom appears. They will understand why nature chose elements to carry out functions by understanding the position of the elements in the

periodic table. They will learn how these elements combine to form molecules, macromolecules and supramolecular structures that lead to life on earth.

Atomic structure: Electromagnetic radiation – (wavelength, 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);problems on quantum numbers; shapes of atomic orbital – s, p and d orbital, (self-study –worksheet and problem sheet will be given to students).

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+l) rule, $2n^2$, order of energy levels to be followed). **2 h**
Periodic table: Introduction to periodic table and placement of elements. Trends (row and group) in periodicity – ionization energy, electron affinity and electronegativity. **1 h**

Ionisation energy, electron affinity and electronegativity. **1 h**
Introduction to biochemistry: Evolution of life on earth – physical evolution – brief mention of big bang theory – conversion of energy into matter (from star to planets – no details). Chemical evolution – formation of molecules, macromolecules and supramolecular structures.
Biological evolution – concept of abiogenesis.
Introduction to the atomic clock for a better understanding and summation of evolution.
Fundamental properties of elements involved in the living system (CHONPSX), group I and II elements of the periodic table and the transition elements, why they were chosen for the formation of biomolecules – 30 small molecules that make up life. Brief glimpse of the role of biomolecules in the living system. **3 h**
Assignment: Comment on the cosmic calendar in a few brief sentences.

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. **13 h**
Ionic bond –factors favouring formation – lattice energy – energetics of ionic bond formation (example NaCl). Born-Haber cycle – for NaCl. **2 h**
Calculation of lattice energy. Covalent bond – definition, pictorial representation of covalent bond formation in H_2, HCl, NH_3, CO_2 and N_2. **1 h**
Lewis dot structure – calculation of formal charge, Valence bond theory – postulates, sigma and pi bonds. **1 h**
Hybridization of orbitals and directorial characteristics – sp^3, sp^2, sp (eg - alkane, alkene and alkyne). **1 h**
Resonance forms of H_2 and Benzene. VSPER theory-Shapes of H_2O, NH_3, H_3O^+, SF_4,ClF_3 and ICl^- **2 h**
Molecular Orbital Theory (MOT) – 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). Molecular orbital diagrams for the formation of H_2, He and O_2. **3 h**
Polarisation concept, Fajan's rule, bond length, bond angle and bond energy, dipole moment. **1 h**
Van der Waals forces – definition. Hydrogen bond – inter and intramolecular hydrogen bond – comparative properties of HF, H_2O, NH_3 and ortho and para-nitrophenols. **2 h**
Assignment 1: Draw the structures of some simple important biomolecules using (a) VSEPR theory (b) using hybridization theory.
Assignment 2: List the different types of chemical bonds one observes in nature, illustrate with suitable examples.

Liquids, Solutions and Colligative properties: 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. Most living tissues like blood tears, etc are solutions, an understanding of solutions and their properties are required to understand the living system. **12 h**

Properties of liquids – Unique properties of water – consequences of these properties on life on earth. Concept of hydrophobic interactions. vapour pressure, viscosity and surface tension. Definition and how they arise. *Viscosity*

and Surface tension in everyday life (self-study). **1 h**
Relationship between vapour pressure and boiling point, freezing point-heat of fusion.

Solutions and Colligative properties:
Concentration units – molarity, molality, normality, mole fraction – simple problems (self study – problem sheet to be provided).
Types of solutions – homogenous and heterogeneous, factors influencing solubility– nature of solvent, solute, temperature, pressure and particle size. Solubility curves– plots showing solubility of sodium chloride, potassium nitrate, lead nitrate and sodium sulphate against temperature. Application in tissue extraction processes example salting in and salting out of proteins e.g. effect of NaCl or $(NH_4)_2SO_4$. **2 h**
Henry's law – statement, Applications. Colligative properties– Definition, Relative lowering of vapour pressure. Raoults' law of relative lowering of vapour pressure. **1 h**
Theory of dilute solutions – Osmosis, Laws of osmotic pressure - Van't Hoff Boyle's law, Van't Hoff Charles' law and Avogadro's law. Hypo-, hyper- and isotonic solutions (importance of maintaining isotonic solutions in the living system). **2 h**
Elevation in boiling point, ebullioscopic constant. Depression in freezing point, cryoscopic constant. Limitations of colligative properties. **2 h**
Abnormal molecular weights and the van't Hoff factor – degree of association, Degree of dissociation
Simple problems related to the above topics (self-study – problem sheet to be provided) **2 h**

Colloids
Types of colloidal systems, electrical properties of colloids. Emulsions and emulsifiers; Gels; examples of biological colloidal solutions. **2 h**
Assignment 1: List all the different types of colloidal solutions one observes in nature.
Assignment 2: Give the applications of emulsions in lipid chemistry.

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. **6 h**

Modern concepts of acids and bases - Arrhenius, Lowry - Bronsted and Lewis concepts. Limitations of each concept.
Dissociation of acids and bases – K_a and K_b; dissociation of water – K_w. **1 h**
Common ion effect, solubility product and ionic product of sparingly soluble salts and conditions for precipitation. Application in tissue extraction processes example salting in and salting out of proteins **1 h**
Hydrolysis of salts– pH of salt solutions. Hydrogen ion concentration- pH, *pH of some biological fluids and their importance (*self-study*).* **2 h**
Buffers-definition, types, buffer action and buffer capacity. pH of buffers-Henderson– Hasselbalch equation-derivation, preparation of buffers, problems. **2 h**
Assignment: Name at least three biological buffers and give their importance.
Assignment : In a cell a pH gradient exists. Diagrammatically show this gradient and explain how the pH is maintained in this gradient.

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. **8 h**

Structural formulae: dash, condensed and bond-line formulae. Use of curved arrows in illustrating reactions. Resonance theory, curved arrows for movement of electrons, rules for writing resonance structures, resonance contribution. **1 h**
Physical properties and molecular structures of organic compounds, ionic compounds: ion– ion forces, intermolecular forces (van der Waals forces), boiling points, solubilities. **1 h**

Heterolysis of bonds: carbocations and carbanions, electrophiles and nucleophiles. **1 h**
Strengths of Bronsted-Lowry acids and bases; the acidity constant K_a; acidity and pK_a; predicting the strength of bases. **1 h**
Relationship between structure and acidity. Effect of hybridization, inductive effect and delocalization on acidity: carboxylic acids versus alcohols. **1 h**
Comparisons of conjugate acid–base strengths based on inductive effects of other functional groups. **1 h**
Self-study: Self-study: IUPAC nomenclature of some molecules having different functional groups – alkyl halides, alcohols, phenols, ethers, amines, aldehydes and ketones.
Effect of Solvents on acidity.
Organic compounds as bases **1 h**
carboxylic acids, esters, amides and nitriles, end chapter problems from Solomons.
Assignment 1: Name some important acids and bases found in a living cell. Mention at least two roles each plays.
Assignment 2: Look up the following molecules - What are the functional groups present in (a) proteins (b) aldose sugars (c) phosphatidylcholine

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 PeterAtkins 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 124**

Title of the paper: **Introduction to biochemistry - 1**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Atomic Structure; periodic table; introduction to biochemistry	6	11
Chemical Bonding	13	22
Liquids	2	3
Solutions and Colligative properties	8	14

Colloids	2	3
Acids bases and Buffers	6	10
Introduction to organic chemistry	8	14
TOTAL	**45**	**77**
Maximum marks for the paper (Excluding bonus question)= 60		

Practical I

BCH 1P1 – Stoichiometry and 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:

1st week: 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.
2nd week: Introduction to stoichiometry, mole concept, volumetric analysis by problem solving; Calibration of glass ware;
3rd week: Estimation of HCl using Std. Na_2CO_3; Introduction to RBPT
4th week: Redox Titration $KMnO_4$ with Oxalic acid; Define RBPT problem
5th week: Complexometric titration: Estimation of Zn^{2+} using EDTA
6th week: Preparation of RBPT CHARTS. Presentation of charts by each group. Discussion of materials required.
7th week: Preparation of solutions Standardize / check solutions
8th week: Carry out of the main experiments individually

9th week: Preparation of poster Presentation of results through posters
10th week: Class test
11th week: Viva (written and oral)

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 224**
Paper Title	**Introduction to biochemistry – 2**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

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

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. **3 h**

Self-study: Thermodynamic parameters – brief review of enthalpy, entropy and free energy changes. 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 $\triangle_r G$ with composition in a reaction – Mathematical relation between free energy change and equilibrium constant – numericals. Thermodynamic criteria for spontaneity. **1 h**

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. **1 h**

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 **1 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. **6 h**

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. **2 h**

Pharmacokinetic analysis- rate constant for second order reaction- determination of rate constant by graphical method. **2 h**

The temperature dependence of reaction rates – The Arrhenius equation – determination of Arrhenius parameters - numericals. **2 h**

Assignment Topic: Suitable examples of mechanisms of enzyme catalyzed reactions

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 **10 h**

Definitions of phase & components, criterion for phase equilibrium, Gibb's phase rule (no derivation). Application of phase rule to one component system – water system. **2 h**

Two component system – water-potassium iodide (freezing mixtures).
Solutions of liquids in liquids – ideal solutions and Raoult's and Henry's law. **1.5 h**

Non-ideal solutions – vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions – azeotropes – HCl-H_2O and water-ethanol system. **1.5 h**
Distillation of solutions – Lever rule. Partial miscibility of liquids (Water-Phenol). **1 h**
Critical Solution Temperature (lower and upper). Effect of impurity on CST. **2 h**
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. **2 h**
Assignment 1: Explain the significance of phase diagrams in biochemistry.
Assignment 2: Discuss how the phase rule could be applied to study the denaturation of proteins under varying temperature and pH conditions.

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. **8 h**

IUPAC nomenclature of alkanes, branched alkanes, cycloalkanes, alkyl halides, alcohols, alkenes, cycloalkenes and alkynes **1 h**
Physical properties of alkanes; **1 h**
Conformations – Newman projection and sawhorse formula. Conformational analysis of ethane; butane. **3 h**
Relative stabilities of cycloalkanes – ring strain. Conformations of cyclohexane. Stability of conformers. Axial and equatorial bonds of cyclohexane. Monosubstituted cyclohexane – conformers and their relative stability **3h**
Assignment 1: Draw the structures of at least five naturally occurring molecules that have the Howarth ring structure. Name them using IUPAC nomenclature.
Assignment 2: In living cells most molecules are either unsaturated or have functional groups. However fossil fuels are mainly saturated hydrocarbons. How did fossil fuels arise?

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. **8 h**

Enantiomers and chiral molecules; molecules with one chiral center with examples from the living system; **1 h**
Test for chirality: plane of symmetry; **2 h**
Naming enantiomers in the R, S- system. D, L system of nomenclature using glucose and amino acids as examples. **2 h**
Optical activity. Molecules with more than one chiral centre. Fischer projection formula, diastereomers; mesomers. **1 h**
E, Z system of designating alkenes. **1**
Separation of enantiomers (including racemic mixtures), resolution by chiral chromatography, chemical and biochemical methods. **1 h**
Significance of Chirality in biological systems. **1 h**
Assignment 1: Draw the structure of any 5 optically active biomolecules and mark their chiral centers.
Assignment 2: Name a few different molecules (they should be from different classes of biomolecules) possessing unsaturation. Try to give their IUPAC nomenclature.

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. **10 h**

Alkyl halides nomenclature (revise); Nucleophilic substitution reaction. **1 h**
Kinetics of SN_2 reaction, mechanism and stereochemistry of SN_2 reaction. **1 h**
Kinetics of SN_1 reaction, mechanism and stereochemistry of SN_1 reaction. **1 h**
Carbocations structure and stability. Racemisation. **1 h**

Factors affecting SN_1 and SN_2 reactions. **2 h**
Elimination reactions of alkyl halides. **1 h**
The E_2 and E_1 reaction mechanisms. **2 h**
Substitution versus elimination. **1 h**
Assignment 1: Give the mechanism for any one (a) S_N2 (b) E2 reaction taking place in nature
Assignment 2: Draw the structures of at least two different intermediates (carbocations/carbanions) seen in biochemical reactions. Explain how they are stabilized.

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.

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Code number: **BCH 224**

Title of the paper: **Introduction to biochemistry - 2**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Chemical Equilibrium	3	5
Kinetics of life processes	6	10
Phase rule	10	17
Alkanes	8	14
Stereochemistry	8	14
Alkyl halides	10	17
TOTAL	**45**	**77**
Maximum marks for the paper (Excluding bonus question)= 60		

Practical II

BCH 2P1 – Physical chemistry for biologists
(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 imbided 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 density and surface tension of a given liquid using a stalagmometer.
3. Determination of CST of phenol water system.
4. Partition coefficient of butanol in water/acetic acid system.
5. Chemical equilibrium and Le-Chatelier's principle.
6. Determination of molecular mass of a polymer using an Ostwald's viscometer.
7. Determination of percentage composition of a binary mixture by viscosity method.
8. Kinetics of acid catalysed hydrolysis of an ester.
9. Percentage purity of NaCl using CST method.
10. Polarimeter.
11. Any other suitable experiment.
12. Class test and 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 325**
Paper Title	**Introduction to biochemistry - 3**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper: In this section students 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:

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

Relative stabilities of alkenes; Electrophilic addition of HX to alkenes: mechanism; Markovnikov's rule, regioselectivity– examples.
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. **9 h**
Assignment 1: The peptide bond is a partial double bond. What type of reactions do you speculate could occur across this bond?
Assignment 2: How are unsaturated fats converted to saturated fats? Why are these reactions not healthy for a human?

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 Williamsons ether synthesis. Ether cleavage using strong acids. Synthesis of epoxides (mechanism excluded); Reactions of epoxides: acid and base catalysed ring opening of unsymmetrical epoxides. **4 h**
Assignment 1: Name a biomolecule containing (a) a thio ether bond (b) a hydroxyl group (c) An epoxide

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**
Assignment 1: The oceans are rich in halides, these have been incorporated by marine creatures, draw and name the structures of such molecules?
Assignment 2: Describe how nature could have used Grignard's idea to synthesise molecules?

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 Friedel-Crafts alkylation. Influence of substituents on the reactivity of the ring and the orientation of the incoming electrophile. Acidity of phenols. **9 h**

Assignment 1: How does aromaticity influence the role of biological molecules?

Assignment 2: Do anti and non aromatic molecules exist in nature?

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 by 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.

Assignment1: Give examples from biochemical reactions that require conversion to the carbonyl group before further reactions can take place.

Assignment 2: Nucleophilic addition on the carbonyl bond is often seen in the living system - give two reactions that illustrate this. **9 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 Ca^{2+} 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**

Assignment 1: HCN was present in early earths atmosphere – how did it contribute to the generation of long chain carboxylic acids?

Assignment 2: List the small organic acids used as fuels or starting material of other important biomoelcules and mention how the two are related?

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 the properties of these molecules for a better understanding of their role in the biological system.

Basicity of amines, comparison of basicity of 1º, 2º and 3º 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 rearrangement.
Action of nitrous acid on 1º, 2º and 3º amines. Replacement reactions and coupling reactions of arenediazonium salts. Hofmann elimination. **4 h**
Assignment 1: Name some important biological amines and give reactions for their synthesis in nature?
Assignment 2: Transamination and deamination result in the production of important intermediates of the tricarboxylic acid cycle – give examples of such reactions?

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

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Code number: **BCH 325**

Title of the paper: Introduction to biochemistry – 3

Practical III

BCH 3P1 – Organic synthesis, purification and characterisation

(11

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Alkenes and Alkynes	10	17
Alcohols, ethers and epoxides	4	7
Aldehydes and ketones	9	16
Organometallic compounds	3	5
Aromatic hydrocarbons	8	13
Carboxylic acids	7	12
Amines	4	7
TOTAL	**45**	**77**
Maximum marks for the paper (Excluding bonus question) = 60		

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, recrystalisation and characterization of acetanilide from aniline
- Preparation, recrystalisation and characterization of tribromophenol from phenol
- Preparation, recrystalisation and characterization of benzoic acid from methyl benzoate
- Preparation, recrystalisation and characterization of benzoic acid from benzaldehyde.
- Preparation, recrystalisation and characterization of m-nitromethylbenzoate from methylbenzoate.
- 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.
- RBPT
- 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 425 (SEP)**
Paper Title	**Introduction to biochemistry - 4**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper:

This paper aims to introduce students to molecules and macromolecules that make up the living system. They will also study solids and X-ray diffraction crystallography to understand the structure of crystalline solids. This will help them in future to analyse structure function relationships of molecules. Co-ordination chemistry will give them an insight into how metal ions play a role in biological systems.

Course Content:

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 gramicidin.
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 structure – 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 arising 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 an 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**

Chemistry of coordination compounds:

This unit focusses on the properties of metal ions especially transitions 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**

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.

Self-study:Types-crystalline and amorphous. Size and shapes.
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. Jablonski diagram and its significance. **4 h**

References:

1. Introduction to SpectroscopyDonald 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 8thedition 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

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Code number: **BCH 425(SEP)**

Title of the paper: **Introduction to Biochemistry - 4**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Carbohydrates	7	12
Proteins	8	14
Lipids	4	7
Chemistry of coordination compounds	12	21
Solids and X-ray crystallography	10	17
Photochemistry	4	6
TOTAL	**45**	**77**
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
- TLC of amino acids.
- Identification of functional groups by qualitative tests of biomolecules
- Determination of saponification value of oil or fat.
- Determination of iodine value of oil or fat.
- 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
- Preparation of coordination complex
- Any other suitable experiment
- 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.

Semester	V
Paper Code	**BCH 5126**
Paper Title	Enzymology, membrane and nucleic acid chemistry
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper:
This paper introduces students to some more macromolecules that make up the living system. They will appreciate the structure function relationship that exists.

Enzymes
To acquire fundamental knowledge of enzymes and their importance in biological reactions. To understand the ability to differentiate between a chemical catalyst and biocatalyst. Exposure to the concept of activation energy and its importance in biological reactions. Exposure to the nature of non-protein biocatalysts such as ribozymes. Understanding the role of enzymes in clinical diagnosis and industries. To get acquainted with the role of enzymes in diagnosis of various diseases.

Self-study: factors affecting reaction processes, activation energy, role of catalysts, Different biomolecules acting as catalysts – enzymes and ribozymes.

Concept of holoenzymes and requirement of cofactors (metal ions and coenzymes - only names with examples).
Coenzyme functions of B-complex vitamins (niacin, flavin, thiamine, pyridoxal phosphate, pantothenic acid, lipoic acid, cobalamine – no structures only descriptive treatment of the enzymatic reactions they are involved in).
Salient features of active site. Mechanism of enzyme action – lock and key model using carboxypeptidase A and induced fit model using lysozyme as example (only brief qualitative explanation). Specificity of enzymes (with reactions) – broad specificity, absolute specificity (group, bond, stereospecificity- cis/trans and D/L).
Classification and nomenclature (common and systematic names, EC number not required) into 7 main classes with an example of a reaction catalysed by each class of enzymes. **6h**
Enzyme kinetics – effect of substrate concentration (Michaelis-Menten equation to be given- no derivation) Lineweaver-

Burke curve, significance of K_M (affinity), K_{cat} (efficiency) and K_{cat}/K_M (specificity). Effect of pH and temperature on kinetics (explanation of bell shaped curve). Enzyme inhibition – reversible and irreversible inhibitions. Brief mention of mechanism by which reversible inhibition occurs with suitable examples (competitive, non-competitive and uncompetitive inhibitions only). Lineweaver-Burke curves for these inhibitions. Comparison of results obtained using Lineweaver-Burke, Eadie-Hofstee and Hanes-Woolfe plots. Discussion of the advantages and disadvantages of these plots.
Enzyme regulation (concept with suitable example of each type) – selective proteolysis, phosphorylation, adenylation, disulfide bridge formation, allosteric regulation, feedback inhibition.
Isoenzymes as important biochemical markers in health and disease – lactate dehydrogenase, creatine kinase. **8h**

Biomembranes and their characteristic features: 10 h

To understand the importance of lipids as storage molecules and as structural components of biomembranes. To understand composition and structure of biomembranes, transport mechanisms across biological membranes. Exposure to the mechanism of signal transduction by steroid and polypeptide hormones and the role of second messengers in signal transduction.

Concepts of osmosis, simple diffusion, active transport, Donnan-Gibbs equilibrium and their application in the living system.
Lipids as storage and structural components of biomembranes: - Recognize the structures of saturated and unsaturated fatty acids, glycerol, and sphingosine (recap from Unit 1). The role of hydrophilic head and hydrophobic tail groups in lipid function. Lipid rafts and their role in membrane dynamics. The functional importance of saturated versus unsaturated fatty acids. **4h**
Triacylglycerol serves a long-term energy storage role in animal cells. Explanation as to why triaclyglycerols are so energy dense (compare energy per carbon atom of glucose and a fatty acid). The impact of cholesterol and fatty acid saturation on membrane fluidity. **2h**
Protein composition of a membrane supports its function. Distinguish between integral and peripheral membrane proteins. **1h**
Basic elements of cell signaling systems – G-protein coupled receptors and their second messengers, role of calcium in cell signaling, IP_3 pathway. **3h**

Nucleic acids - structure and function:-
In this unit the students will understand the structure of nucleic acids and the various types of nucleic acids along with their role in the biological system

Nucleic acids – nomenclature and structures of sugars, bases, nucleosides and nucleotides, including cyclic nucleotides e.g.: cyclic AMP role in biological system. Polynucleotides - Watson and Crick model of DNA (salient features), DNA polymorphism - mention of A, B and Z-DNA (important differences). Biological importance of DNA. Types of RNA and their biological role. Unusual nucleotides, Wobble hypothesis. Biological role of circular RNA, microRNA, and non-coding RNA. **5 h**

Molecular biology and fundamentals of genetics:
Having understood the structure of nucleic acids they will now be able to understand the way these nucleic acids function in the living system and how this understanding has several applications that help improve the quality of life be it plant, animal or human.

Central dogma of molecular biology, and how it is not rigid. Brief account of enzymatic aspects of prokaryotic DNA replication. Transcription – simple mechanism (details of factors not required). Genetic code (general features only). Translation – amino acid activation, initiation, elongation and termination of protein synthesis (details of factors not required). Transcriptional and translational regulation **5h**

Self-study: Brief historical background of DNA replication-– proof of semi-conservative mode of replication
Viral, bacterial and eukaryotic genome; euchromatin and heterochromatin; banding patterns of chromosomes; centromeres and telomeres.
Analyse coding and non-coding regions of eukaryotic genome and their importance.
E. coli lac operon, PCR, expression vectors and their importance in biotechnology.
To produce insulin using recombinant DNA technology.
Acquaintance with the merits and demerits of transgenic crops. **11h**

References:

1. Biochemistry R. Garrett and C. Grisham 6th Edition Publishers: Brooks/Cole
2. Lehninger Principles of Biochemistry D.Nelson and M. Cox 8thedition Publishers: Macmillan and Co.
3. Fundamentals of Biochemistry: Life at the Molecular Level, Donald Voet, Judith G. Voet, Charlotte W. Pratt 5th Edition Publishers: Wiley
4. Introduction to Nutrition and metabolism D. A. Bender and S. Cunnigham 6th Edition Publishers: CRC Press (Taylor and Francis group)
5. ISE Harper's Illustrated Biochemistry V. Rodwell, D. Bender, et al 31st Edition Publishers: McGraw Hill
6. Biochemistry J. Berg L. Stryer et al 9th edition Publishers: W H Freeman
7. Zubay's principles of Biochemistry, revised and enlarged edition by V. B Rastogi and K. R Aneja 2016 Publishers: Medtech

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Code number: **BCH 5126**

Title of the paper: Enzymology, nucleic acid and membrane chemistry

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Nucleic acids – structure and function	5	9
Molecular biology and fundamentals of genetics	16	27
Biomembranes and their characteristic features	10	17
Enzymes	6	10
Enzyme kinetics	8	14
TOTAL	**45**	**77**
Maximum marks for the paper (Excluding bonus question)= 60		

Practical V

BCH 5P1 – Enzymology and Nucleic acid Chemistry
(11 sessions 3h/week +1h/week self-study)

Course objectives:

- To understand the concepts for preparation of buffers.
- Acquiring training to estimate activity of enzymes.
- To determine pH optimum, K_M and V_{max} of enzymes and to analyse enzyme kinetics.
- To determine optimum temperature for the activity of an enzyme.
- Acquire learning to isolate RNA, DNA, total nucleic acids and total RNA from bacteria, yeast and plant tissues and to check for purity using absorption maxima and agarose gel electrophoresis.

Practical content:

- Preparation of triple buffer system using phosphate and citrate and determination of pH using pH meter.
- Isolation of urease and demonstration of its activity.
- Isolation of acid phosphatase and demonstration of its activity.
- Determination of specific activity of salivary amylase by DNS.
- Effect of temperature on the rate of enzymatic reaction.
- Effect of pH on the rate of enzymatic reaction.
- Influence of substrate concentration on the rate of enzymatic reaction.
- Kinetics of horseradish peroxidase catalyst one electron oxidation.

- Determination of K_M and V_{max} of salivary amylase.
- Isolation of plasmid from bacteria, estimation of purity of isolate by absorption maxima.
- Determination of purity by agarose gel.
- Viva.

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

CO4	Knowledge	Have developed both a theoretical and an experimental knowledge of basic biocemistry chemistry.
CO4	Understand	Have developed a very good understanding of techniques used to estimate not only naturally occurring molecules but also adulterants in food.
CO4	Apply	Be able to apply their knowledge in the understanding of new biomolecules and correlate it with what they already have a knowledge about.
CO4	Analyze	Be able to analyse molecules from unknown sources and designate their characteristic features.
CO4	Evaluate	Be able to critically evaluate the biological sample they are handling be it a protein a carbohydrate or an adulterant. They can assess the nutritional value of foods.
CO4	Create	Be able to create diet charts, design experiments to assess food quality and express their knowledge in useful terms for the lay person.

Semester	V
Paper Code	**BCH 5226**
Paper Title	**Analytical techniques in Biochemistry**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper:

In this paper students will be exposed to various analytical techniques that are used to study biomolecules and biomolecular processes. They will understand the principle and working of various techniques and how they can be best used to study the biological system.

Course Content:

Separation techniques – centrifugation, chromatography and electrophoresis **20 h**

Students will learn about cell theory and techniques for fractionation of sub-cellular organelles. **2h**
Understand the applications of centrifugation and chromatography in biological investigations **5h**
Develop competence in handling various chromatographic techniques and apply them in isolating and characterizing different biomolecules. Advanced chromatographic techniques – HPLC, FPLC, LC-MS and GC-

MS. **5h**
Purify proteins by affinity chromatography using epitope tags such as histidine tag, GST tag, Flag tag. **2h**
Understanding the principles of electrophoresis, and applications of various types of electrophoresis including the blotting techniques. Understanding various techniques used to identify biomolecules after separation, including protein and carbohydrate labelling and staining. **6h**

Radioisotopes, Non-radioisotopes and their applications: 12h

In this unit students will get a basic understanding of what are radio and non-radioisotopes and how they are used in understanding the biological system. They will also gain an insight into the workings of instruments used to measure radioactivity

Introduction to radioisotopes: Characteristics of radioelements – Nucleus – structure, nuclear forces – N/P ratio, mass defect, binding energy; packing fraction, instability of nuclei. **1 h**
Self-study: Radioactivity –Types of radioactive decay, Properties of α, β, γ radiations.
Group displacement law. Decay law - decay constant, Half-life period and average life of a radioactive element. Numericals/problems. **1 h**
Detection of radioactivity – GM counter and scintillation counters (only principle and working) **1 h**
Apply the principles of radiochemistry to analytical determination of biomolecules and life processes. **1 h**
Radio immunoassays and radio labeling studies to understand how molecules interact and how they are distributed within a cell. **2 h**
Radiolabeling studies to understand how metabolic reactions are taking place **2 h**
Safety measures
What are non-radioisotopes? How non-radioisotopes are used in understanding biomolecules and biochemical processes? Examples of specific non-radioisotopes including fluorescent compounds and fluorescent proteins. Advantages and disadvantages of radio and non-radioisotopes. **4 h**

Sequencing techniques for proteins, nucleic acids and carbohydrates: 13 h
In this unit students will be given a comprehensive idea as to how major macromolecules are sequenced and the importance of obtaining this knowledge.

Historical background of reactions used by Sanger and Edman for protein sequencing. **1 h**
Brief explanation of steps involved in sequencing of proteins – separation and determination of number of monomeric units (N and C terminus). **4 h**
Cleavage by current methods used for protein sequencing. **3 h**
DNA sequencing by dideoxynucleotide method. Oligonucleotide synthesis of RNA primers. **3 h**
Modern aspects in carbohydrate sequencing. Problems and challenges. **2 h**

References:

1. Biophysical Chemistry – Principles and Techniques by Upadhaya, Upadhaya and Nath, 2016 Himalaya Publishing House
2. Tools of Biochemistry by T. Cooper Wiley Publishers
3. Principles and techniques in biochemistry and molecular biology by Walker and Wilson 8th edition, Cambridge University Press
4. Biochemical Calculations by I.Segel 2nd edition Wiley Publishers
5. Biochemistry by D. Voet and J. Voet 4th edition Wiley Publishers

BLUEPRINT

Code number: **BCH 5226**

Title of the paper: **Analytical techniques in Biochemistry**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Separation techniques – centrifugation, chromatography and electrophoresis	20	34
Radioisotopes and their applications	12	21
Sequencing techniques for proteins, nucleic acids and carbohydrates	13	22
TOTAL	**45**	**77**
Maximum marks for the paper (Excluding bonus question)= 60		

Note: Units have been further divided into subsections for which hours have been allotted to ensure uniform questions from each subsection within a unit.

Practical VI

BCH 5P2– Project Work – 1

Course Objectives:

Student will learn to do independent research. The training obtained by conducting RBPT experiments in the earlier semesters will help them to design and execute a simple project in their final year.

Course Content:

Review of literature. Writing a proposal. Executing part of the proposal

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

CO4	Knowledge	Have a knowledge of the various techniques that are used to understand the biological system.
CO4	Understand	Have developed a very good understanding of techniques and how to apply them.
CO4	Apply	Be able to apply their knowledge writing a project proposal.

CO4	Analyze	Be able to analyse work already carried out by others and how they can extend it in their understanding of the topic.
CO4	Evaluate	Be able to critically evaluate the type of work already carried out and whether they can extend it to the system they wish to investigate.
CO4	Create	Be able to design experiments, find protocols or ameliorate on existing ones both theoretically and experimentally.

Semester	V
Paper Code	**BCH 5326**
Paper Title	**Spectroscopy; spectrometry; Hormones and neurotransmitters**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper: Students will be introduced to the various spectroscopic techniques used to analyze biomolecules and biomolecular processes.

Spectroscopy and spectrometry **24 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 electromagenetic 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. **4 h**

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. Analysis of different types of spectra and identification of simple compounds, problems to be done as a part of self-study. **5 h**

Hormones and neurotransmitters **21 h**

Hormone biochemistry **6 h.**

This chapter intends to provide a general and basic overview of hormones and how they function.

General features and classes of hormones (classification).

Group I. hormones which bind to intracellular receptors: steroids, thyroid hormone, retinoic acid receptor and vitamin D receptor (nuclear receptor superfamily). Common structural features of nuclear receptors, effect of ligand binding and transactivation. Role of protein-protein interactions – homo and heterodimerization. Example of estrogen receptor to be taken.

Group II. Hormones which bind to cell surface receptors. Ligand-receptor interactions, Hill plot and Scatchard plot. Insulin and catecholamine as classic examples of hormones which involve cell surface receptors.

Neurotransmission and hormones (endocrinology) **10 h**

Neurotransmitters - types and characteristics: a) Small molecules eg. amines (acetylcholine, epinephrine, dopamine and histamine); b) amino acids (glutamate, aspartate, GABA and glycine); c) neuropeptides - eg. leptin and neuropeptide Y and d) nitric oxide (as an example of a gaseous neurotransmitter). **3 h**

Brief overview of hormones and their active groups (which facilitate hormone-receptor interactions). Anatomy of the electrical synapse - neuronal junction and neuromuscular junction. Synthesis of neurotransmitters, storage and release. **3 h**

Stages of action of neurotransmitters. Role of voltage-gated ion channels and ions in the generation of action potential. Role of key enzymes involved in neurochemistry - acetylcholine esterase, monoamine oxidase, phosphodiesterase-4 and nitric oxide synthase. **4 h**

Chemistry of Vision

Chromophore of rhodopsin and retinal. Chemistry of visual excitation, photobleaching and signal transduction of rod cells from light reception to generation of receptor potential (qualitative treatment only). Role of GPCRs and phosphodiesterases. **5 h**

BLUEPRINT

Code number: **BCH 5326**

Title of the paper: **Spectroscopy and spectrometry; hormones and neurotransmitters**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Spectroscopy and spectrometry	24	41
Hormones and neurotransmitters	21	36
TOTAL	**45**	**77**
Maximum marks for the paper (Excluding bonus question)= 60		

Note: Units have been further divided into subsections for which hours have been allotted to ensure uniform questions from each subsection within a unit.

Practical VII

BCH 5P3 – Separation techniques and estimation of food quality
(11 sessions 3h/week +1h/week self-study)

Course objectives:

- Training in the determination of moisture in food.
- To test adulteration in food and determination of minerals, amino acids and sugars in foods.
- To acquire training in various separation techniques.

Practical content

- Determination of
    b. Moisture content of foods
    c. Adulterants in food
    d. Calcium in ragi
    e. Iron in drumsticks.
- Estimation of vitamin-C in lemon and gooseberries.
- Estimation of proteins using biuret method
- Estimation of reducing sugars by Hedgedon and Jensen method.
- Estimation of anti-nutrients in food.
- Separation of plant pigments using paper chromatography.
- Separation of plant pigments by column chromatography using silica gel-G.
- Identification of functional groups by IR spectroscopy
- SDS-PAGE
- Viva

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

CO5	Knowledge	Have a good knowledge of metabolic processes and how they are regulated..
CO5	Understand	Have developed a very good understanding of how all processes are interconnected and deregulation can lead to disease conditions.
CO5	Apply	Be able to apply their knowledge in understanding the nature of metabolic processes and disease conditions.
CO5	Analyze	Be able to analyse case studies and predict what the process is and where it could be going wrong.
CO5	Evaluate	Be able to critically evaluate their analysis.
CO5	Create	Be able to design studies that would bring to the fore the various metabolic processes that occur in the living system and the factors that control them.

Semester	VI
Paper Code	**BCH 6126**
Paper Title	Bioenergetics and biological oxidation

Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper:

In this paper students will be brought face to face with the processes taking place in the living system. They will obtain an understanding of the concepts required to figure out the various thermodynamic parameters that govern the various processes both physical and chemical that are occurring within the cell.

Course Content:

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. **8 h**

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 – anabolism and catabolism, internal energy and enthalpy – measurement of heat capacity – temperature variation of enthalpy. **2 h**

Enthalpy of phase transition – differential scanning calorimeter for the determination of phase transitions of biological macromolecules; Calculation of $\triangle H^0$ of a reaction using bond enthalpies – enthalpy of combustion – biofuels – enthalpy of formation – Isothermal Titration Calorimetry (ITC) in drug design. **2 h**

Entropy – the direction of spontaneous change – second law of thermodynamics – entropy change accompanying heating and phase transition – problems – entropy change on surroundings **1 h**

Gibbs energy and spontaneity – structure of proteins and biological membranes – hydrophobic interactions – thermodynamic factors that contribute to the spontaneous assembly of biological macromolecules. **2 h**

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

Assignment Topic: Thermodynamics of nitrogen fixation **1 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. **12 h**

Self-study: Strong and weak electrolytes – definition and examples.

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

Electrochemical cells: conventions of representing galvanic cells, half-cell reactions and cell reaction; **1 h**

Reversible electrodes and cells – definition. Types – cation reversible electrode, anion reversible electrode, redox electrode (examples and electrode reactions to be given). **1.5 h**

Single electrode potential – Nernst equation, factors affecting single electrode potential. **1.5 h**

Standard electrode potential (definition). Reference electrodes – standard hydrogen electrode, calomel, quinhydrone. **2 h**

Electrochemical series – to predict the ease of oxidation, displacement reaction to calculate standard emf of cell; Ion selective electrodes- concept, types and applications. **2 h**

Bioenergetics and biological oxidation: **12 h**

To learn basic concepts of bioenergetics. Understanding the importance of high energy compounds, electron transport

chain; synthesis of ATP under aerobic and anaerobic conditions. Mechanisms of oxidative phosphorylation and substrate level phosphorylation. To learn the concept and mechanism of ATP synthesis.

Concept of coupling reactions with an example. Structure of ATP, explanation of why it's a high energy molecule based on its structure. Gibb's free energy and its application to biological systems. Hydrolysis of ATP and energetics of the reaction, other high energy compounds. Definition of electron transport chain; components of ETC (no structures) and how they are successively oxidised and reduced, diagrammatic representation of ETC - both from NADH and from reduced substrate via $FADH_2$ (electrode potential values and points at which ATP is produced are to be given). Evidence in favour of the sequence of the electron transport chain. Mechanism of oxidative and substrate level phosphorylation. Significance of P/O ratio. Basic concept of the mechanism by which ATP is synthesized. Photophosphorylation brief overall concept.

Redox Biology **13 h**

To understand the properties of free radicals, reactive oxygen species (ROS) & reactive nitrogen species (RNS) and their physiological and cellular importance.

Oxygen and living system (anaerobes and aerobes), oxygen chemistry and its toxicity – superoxide, singlet oxygen, hydroxyl radical, peroxide and other biologically important non-radicals. **2 h**

Production and sources of reactive oxygen species (ROS) and reactive nitrogen species (RNS) in living system (intrinsic and extrinsic). **1 h**

Pro-oxidants, oxidative stress and its responses. Oxidative damage to biomolecules: Lipid, DNA, and proteins. Methods to detect oxidative damage (brief overview of methods without going into protocols). **4 h**

Antioxidant defences: Non-enzymatic (reduced glutathione, ascorbic acid, vitamin- E. carotenoids. flavonoids, thio-redoxin, etc.) and their mode of action. Enzymatic (super oxide dismutase, catalase, glutathione peroxidase, glutathione reductase, glutathione-S-transferase and peroxidases) – mention only the reactions of these enzymes and diseases linked to enzyme deficiency. Applications of antioxidants. **6 h**

Title of the paper: **Bioenergetics and biological oxidation**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Biochemical thermodynamics	8	14
Electrochemistry	12	21
Bioenergetics and biological oxidation	12	21
Redox Biology	13	21
TOTAL	**45**	**77**
Maximum marks for the paper (Excluding bonus question)= 60		

Note: Units have been further divided into subsections for which hours have been allotted to ensure uniform questions from each subsection within a unit.

Practical VIII

BCH 6P1 – Bioenergetics and Biological oxidation

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

Course objectives:

- To have a hands on experience in determining thermodynamic and electrochemical parameters.
- To use the same with reactions occurring in the living system.
- To understand how free radicals are generated and can be enzymatically and non-enzymatically removed from the living system.

Practical content

1. Determination of standard electrode potential.
2. Potentiometric estimation of FAS
3. Heat of solution and heat of neutralization
4. Molar conductance
5. Molar heat of combustion
6. Effect of detergents on membranes
7. Estimation of cholesterol
8. Scavenging of free radicals by antioxidants (DPPH method)
9. Estimation of hydrogen peroxide using xylenol orange.
10. Any other suitable experiment
11. Class test
12. Viva

Semester	VI
Paper Code	**BCH 6226**
Paper Title	Metabolism
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Metabolism: **27 h**

To understand how biomolecules are utilized and their ultimate fate. To understand the concept of homeostasis and the regulation of metabolic pathways.

Carbohydrate metabolism - Glycolysis and the TCA cycle, gluconeogenesis and the concept of pseudo cycles.

To acquire knowledge related to the role of TCA cycle in central carbon metabolism, importance of anaplerotic reactions and redox balance. **6 h**

Lipid metabolism: β-oxidation of fatty acids and an overall view of the synthesis of cholesterol. **4 h**

Protein and amino acid metabolism: Source and fate of proteins in humans. Production of important molecules from amino acids by transamination, deamination and decarboxylation. **4 h**

Nitrogen metabolism in aquatic and terrestrial animals and the role of kidney in erythropoiesis. Urea cycle **2 h**

Metabolism of purine and pyrimidines – synthesis of UTP (reactions with structures); conversion of UTP to CTP and TTP (no need for structures); synthesis of IMP (reactions with structures); conversion of IMP to AMP and GMP (no need for structures); Formation of uric acid (reactions with structures). **6 h**

Regulation of metabolic processes with examples from above mentioned processes **4 h**

Biochemical nutrition **6 h**

In this unit students will learn the importance of a healthy diet for a healthy life. They will understand the wisdom of choice of foods and their relevance to everyday functioning of the human body. They will understand the biochemistry behind lifestyle diseases and how to avoid them.

The glycemic index, balanced diet, micronutrient deficiencies and its remedies, nutraceuticals and their importance, junk foods and their hazards.

Specialized food for people with special needs - diabetics, pregnancy, inherited genetic disorders.

A brief glimpse at the sleep wake cycle, circadian clock, and exercise. Their role in metabolic regulation.

Metabolic disorders and metabolic markers of disease: **7 h**

To become aware of the variations in the levels of trigycerides and lipoproteins and their relationship with various diseases.

To gain awareness on muscular dystrophies, the role of steroids in muscle building and the use of hormones in cattle and poultry industry.

To learn about the normal constituents of urine, blood and their significance in maintaining good health.

Exposure to the mechanisms of causation of diseases of liver and kidney.

Appreciation of the fact that differences in the properties of metabolic enzymes of host and pathogens can be exploited for the development of new drugs. To gain insights into metabolic engineering for the production of useful biomolecules.

Common types of metabolic disorders.
Lipid profile test – its significance.
Liver and kidney function tests and their significance.
Urine and blood tests and their significance.
Metabolic enzymes. Enzymes unique to microorganisms that can be exploited for drug design.
Note: In each of the above an assessment of the factor being considered should be discussed.

Cancer markers and the mechanism of cancer **5 h**
What is cancer? What triggers abnormal cell division? How does this occur? Drugs and inhibitors and their mode of action to understand how this occurs.

References:

1. Biochemistry R. Garrett and C. Grisham 6th Edition Publishers: Brooks/Cole
2. Lehninger Principles of Biochemistry D.Nelson and M. Cox 8thedition Publishers: Macmillan and Co.
3. Fundamentals of Biochemistry: Life at the Molecular Level,Donald Voet, Judith G. Voet, Charlotte W. Pratt 5th Edition Publishers: Wiley
4. Introduction to Nutrition and metabolism D. A. Bender and S. Cunnigham 6th Edition Publishers: CRC Press (Taylor and Francis group)
5. ISE Harper's Illustrated Biochemistry V. Rodwell, D. Bender, et al 31st Edition Publishers: McGraw Hill
6. Biochemistry J. Berg L. Stryer et al 9th edition Publishers: W H Freeman
7. Textbook of Biochemistry with clinical correlations by T Devlin 7th edition Wiley-Liss

BLUEPRINT

Code number: **BCH 6226**

Title of the paper: **Metabolism**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Metabolism	27	46
Biochemical nutrition	6	10
Metabolic disorders and metabolic markers of disease	7	12
Cancer markers and the mechanism of cancer	5	9

TOTAL	**45**	**77**

Note:

Units have been further divided into subsections for which hours have been allotted to ensure uniform questions from each subsection within a unit.

Practical IX

BCH 6P2– Project Work – 2

Course Objectives:

Student will learn to do independent research. The training obtained by conducting RBPT experiments in the earlier semesters will help them to design and execute a simple project in their final year.

Course Content:

Executing part of the proposal, presentation of work done

Semester	VI
Paper Code	**BCH 6326**
Paper Title	Recent developments in the field of Biochemistry
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives of the paper: This paper focuses on the various recent developments in biochemistry. Once they understand the basics expounded in this paper, students will be able to read scientific literature and understand the same, since a large number of Nobel prizes in chemistry, medicine and physiology have gone to those working in the domain of biochemistry. Students will appreciate the work and the course should motivate them to pursue and excel in the field.

Course Content:

Advanced omics methods: **23 h**

Exposure to the concepts of genomics, proteomics, metabolomics and their importance in human health. Basic definition of other omics methods in multiomics – eg. ionomics, redoxomics, epigenomics and metagenomics.

Genomics types: structural, comparative and functional genomics. Genome: definition, a mention of genome complexity and contents of genomes [eukaryotic, prokaryotic and viral genomes], workflow involved in genome sequencing- whole genome sequencing (WGS) and next generation sequencing (NGS) as examples. Metagenomics as a tool to study microbiomes – eg. gut microbiome and soil microbiome.

Transcriptomics – definition, methods involved in transcriptomics – DNA microarray [mention its use in research, diagnoses, drug designing, profiling studies and epigenetics]. Semiquantitative and quantitative real-time PCR (qRT-PCR) RNAseq – basic workflow and its relevance in drug discovery and medicine. RNAi screening – method and uses. **8 h**

Proteomics: Proteomes. Top-down and bottom-up workflows. Quantitative proteomics. Protein microarrays in protein analyses and diagnoses of various human diseases, Use of single cell proteomics in research. Gel-based proteomics using 2D-GE and DIGE. **8 h**

Metabolomics: brief introduction to metabolic, signaling and gene-regulatory pathways that operate in living systems, and brief mention of use of various chromatographic-mass spectrometric approaches to identify biomolecules (details of techniques already covered in previous papers).

Interactomics: Use of GST pull down assay, yeast two-hybrid assay (Y2H), FRET, phage display, co-immunoprecipitation, chromatin immunoprecipitation (CHIP-seq) and electrophoretic mobility shift assay (EMSA) in interactomics studies. **7 h**

Techniques for identification of biomolecules in tissue samples:
Hybridization techniques- types and applications. Fluorescent In situ Hybridisation (FISH), microarrays, Use of microarrays as tools for identification of normal and abnormal expression of biomolecules. Confocal microscopy and its applications. **3 h**

Mutational Analysis and Gene Editing: **19 h**
Mutation screening technique - single stranded conformation polymorphism (SSCP) analysis and DNA heteroduplex analysis. **2 h**
Site directed mutagenesis, DNA libraries- genomic and cDNA libraries and their uses, oligonucleotide synthesis (phosphoramidite synthesis) and artificial gene synthesis (Gibson assembly), **4 h**
Random mutations and directed evolution: Brief understanding of the methodology and its applications **4 h**
Mutation detection techniques, such as denaturing gradient gel electrophoresis (DGGE), constant denaturing gel electrophoresis (CDGE), temporal temperature gradient gel electrophoresis (TTGE), single-strand conformation polymorphism (SSCP), and protein truncation test (PTT), have assisted researchers with analyzing mutations. More recently, high resolution melt (HRM) analysis has also become a technique of choice for mutation detection. **5 h**
CRISPR/Cas9 technology – Introduction and brief background to the work. A brief working knowledge of the method and its applications. **4 h**

References:

1. Biochemistry R. Garrett and C. Grisham 6th Edition Publishers: Brooks/Cole
2. Lehninger Principles of Biochemistry D.Nelson and M. Cox 8thedition Publishers: Macmillan and Co.
3. Fundamentals of Biochemistry: Life at the Molecular Level, Donald Voet, Judith G. Voet, Charlotte W. Pratt 5th Edition Publishers: Wiley
4. Lewin's Genes XII, by J. Krebs et al 12th edition Publishers; Jones and Barlett
5. Genetics a conceptual approach by B. A Pierce 7th edition Macmillan Press
6. Recent Trends in Molecular Biology and Biotechnology (Volumes 1 & 2) Editor Yogendra Singh 2020, Integrated Publications.
7. Wilson and Walker's Principles and Techniques in Biochemistry and Molecular Biology 9th Edition Edited by: Andreas Hofman and Samuel Clokie, Cambridge University Press
8. CRISPR: Methods and Protocols: 1311 (Methods in Molecular Biology) Hardcover – Illustrated, 2 June 2015 by Magnus Lundgren (Editor), Emmanuelle Charpentier (Editor), Peter C. Fineran (Editor) Publishers: Springer Nature

BLUEPRINT

Code number: **BCH 6326**

Title of the paper: **Recent developments in the field of Biochemistry**

Topic	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Advanced omics methods	23	40
Techniques for identification of biomolecules in tissue samples	3	5
Mutational analysis and gene editing	19	32
TOTAL	**45**	**77**

Note: Units have been further divided into subsections for which hours have been allotted to ensure uniform questions from each subsection within a unit.

Practical X

BCH 6P3 – Practical bioinformatics
(11 sessions 3h/week +1h/week self-study)

Course Objectives: At the end of this course students will have developed practical working knowledge of basic bioinformatics tools used for analysis of biomolecules such as nucleic acids and proteins. These basic skills are absolutely necessary for following published literature and for gaining a deeper understanding on how to apply advancements in computer science and technology to analyze and compare biomolecules, predict their physicochemical properties and lay groundwork for experimental studies. Bioinformatics predictions often pave the way for further experimentation.

Practical content

1. Introduction to genomic databases [NCBI Gene, GenBank, RefSeq], sequence withdrawal from databases, protein sequence databases [UniProt KB / Swiss-PROT]. BRENDA as a tool for enzymology studies.
2. Pair-wise alignment: EMBOSS-Needle and EMBOSS-Water for analysis of %similarity and identity scores. Multiple sequence alignment (MSA): Use of Clustal Omega and JalView to build MSA analysis results. Generation of evolutionary tree/cladogram using Clustal Omega and PHYLIP. BLASTp.
3. Protein Data Bank – downloading pdb files and molecular viewers – ChimeraX, Discovery Studio Viewer and PyMOL.
4. Prediction of secondary structures and protease cleavage sites in proteins, helix interaction tool (HELIX server), prediction of N-terminal transmembrane helices.
5. Predicting physiochemical properties of protein sequence (pI, molecular mass, atomic composition, amino acid composition, solubility and hydropathy index) using bioinformatics tools – Use of ExPASy ProtParam, Multiple Protein Profiler (MPP) and AAProp.
6. Protein-protein interaction databases [STRING, PRIDE]. Construction of protein-protein interactome map. KEGG database – basic usage of KEGG database in metabolomics studies.
7. Primer designing and virtual cloning: generation of restriction maps using online tools or Clone Manager.
8. Prediction of ADME properties of small molecules/drugs using ADMET-SAR, Swiss-ADME and Qik-Prop
8. Protein folding using AlphaFold, SWISS-MODEL and I-TASSER. Analysis of protein folding results – Ramachandran plot analysis using PROCHECK.
9. Use of protein topology prediction – Caver and POCASA.
10. Molecular Docking using AutoDock tools or AutoDock Vina. Docking protocol and post-docking analyses of intermolecular interactions.

11. Protein-protein interaction docking using ClusPro 2.0.

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

CO1	Knowledge	Have developed a working knowledge of basic bioinformatics tools and their applications in research
CO1	Understand	Have developed a deeper understanding of the biochemical principles involved in bioinformatics tools that they have used.
CO1	Apply	Be able to apply these tools rightly and to exploit these resources to plan experiments and understand life processes better.
CO1	Analyze	Be able to analyze information and find meaningful solutions.
CO1	Evaluate	Be able to critically evaluate existing theories, ask the right questions and provide new insights based on structure-function aspects.
CO1	Create	Be able to use these and other tools to create new knowledge and to publish scientific papers.

The Proposed pattern for the End Semester Examinations (Theory) for the batches starting from 2022-23
Department of Biochemistry- SUBJECTIVE ELECTIVE
Time : 90 MINUTES
Maximum marks 60
Part A: 1 mark questions (16 out of 18)
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) [2 out of 3]

The Proposed pattern for the Mid Semester Test (Theory) for the batches starting from 2022-23
Department of Biochemistry - SUBJECTIVE ELECTIVE
Time : 60 MINUTES
Maximum marks 25
Part A: 1 mark questions (10 out of 12)
Part B 2 mark questions (2 out of 3)
Part C: 3 mark questions (2 out of 3)
Part D: 5 mark questions (analytical/thinking type) [1 out of 2]

The Proposed pattern for the Practical assessment for the batches starting from 2022-23
Department of Biochemistry - SUBJECTIVE ELECTIVE
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 (average of 75% of assessed experiments which compulsorily includes one class test at the end of the semester)

Part B: Oral Viva: 05 marks. Written viva: 10 marks
Student must score 40% to have passed the practical course.

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